INSITU

Operator’s Handbook

Unmanned Aerial Systems

Setup, Launch, Flight, Retrieval

October 2006
2.1

Insitu
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Supplements

When handbook supplements are received (lists of changes or update pages), record the required information in this table, and insert pages as instructed by the supplement

Change #	Date of Change	Date Change Entered	Signature
2.1-EX	**1 November 2006**	**5 November 2006**	John Doe
2.1-01	1 February 2007	1 February 2007	Inserted by Insitu
2.1-02	21 May 2007	21 May 2007	Inserted by Insitu
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2.1-04	28 September 2007	28 September 2007	Inserted by Insitu
2.1-05	15 May 2008	15 May 2008	Inserted by Insitu
2.1-06			

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The Insitu Group, Inc.

Founded in 1994, Insitu is a pioneer developer of long-range, unmanned aircraft. Insitu's *Aerosonde*, displayed in Seattle's Museum of Flight, is the first unmanned aerial vehicle to cross the Atlantic Ocean.

Insitu's innovative UAV development is the catalyst for a wide range of missions, leveraging payload flexibility, long endurance, stabilized ISR data, and near-vertical recovery for remote areas and maritime use. Using commercial off-the-shelf, cutting-edge technology in the production of its UAV, Insitu provides unique flexibility and expandability.

Headquartered in Bingen, Washington, in the scenic Columbia River Gorge, Insitu is a dynamic team of engineers and professionals committed to innovation and excellence.

Our Mission

To offer economical, autonomous, miniature aerial platforms for long-endurance surveillance missions through the innovative exploitation of advanced technologies.

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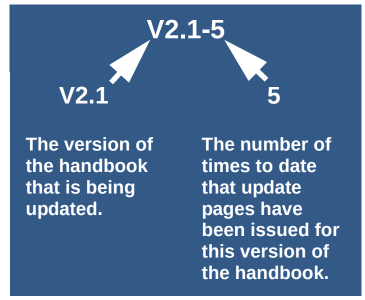
Changes to Operator’s Handbook V2.1-05

Version Explanation

The version number is 2.1-05, where 2.1 is the version of the handbook that is being updated, and 5 is the number of revisions that have been released.



Summary of Changes

All substantive changes are marked with a red change bar in the left margin, as shown here.

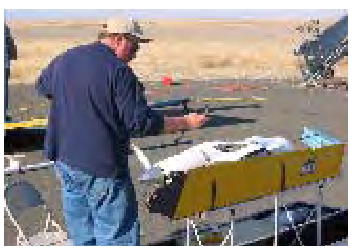
Summary of Changes	Updated Pages
Table of Contents: Updated	i to ii
Chapter 1 Overview, Section 1.2 Standards and Limitations: Updated the Operating Limitations Matrix	1-15 to 1-16
Chapter 2 Setup, Section 2.5 Aircraft: Changed "Functional Check Flight (FCF)" to "Systems Check", and "Aircraft Preflight Inspection Checklist" to "Aircraft Preflight/Postflight Inspection Checklist"	2-75 to 2-78 2-85 to 2-86
Chapter 3 Programming, Section 3.1 Aircraft Parameter Files: Updated with new procedures related to I-MUSE 5.3 release	3-1 to 3-20
Chapter 3 Programming, Section 3.3.1 Programming the Aircraft and If/C: Updated with new procedures related to I-MUSE 5.3 release	3-41 to 3-50
Chapter 3 Programming, Section 3.4 Simulation - HIL (Hardware in the Loop): Removed from handbook	N/A
Chapter 4 Preflight, Section 4.1 Checklists: Changed "Functional Check Flight (FCF)" to "Systems Check", and "Aircraft Preflight Inspection Checklist" to "Aircraft Preflight/Postflight Inspection Checklist"	4-3 to 4-4
Chapter 6 Flight, Section 6.2 I-MUSE: Changed "Functional Check Flight (FCF)" to "Systems Check"	6-15 to 6-16
Chapter 6 Flight, Section 6.2 I-MUSE: "Auto-Follow" map functionality has been renamed as "Auto-Scale"	6-33 to 6-34

Contents

Welcome

0.1 In This Handbook

This handbook is designed to provide operators (of all system components) with easy-to-use instructions and guidelines for setup, launch, flight, and retrieval.

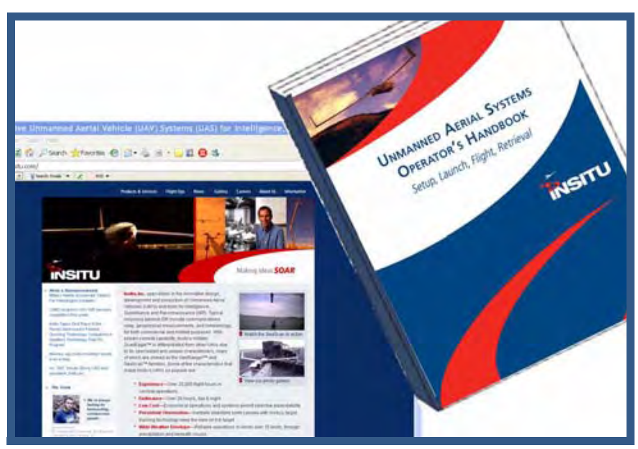


The step-by-step instructions contained in this handbook, along with specifications, limitations, emergency procedures, and troubleshooting information, equip the operator with general rules for system operations. Although each mission's scenarios and requirements may vary, the foundations presented in this handbook assist the operator in correctly assessing and responding to each UAV flight situation.

Insitu handbooks are available in electronic format and hardcopy.

Printed copies are available from Insitu.

Electronic PDF copies are viewable and printable with Adobe Acrobat, and are available via restricted access on Insitu's website: www.Insitu.com. To view online and print Insitu's full set of the most current documentation online, contact Insitu to request a password.



0.2 Conventions

The following icons are used throughout this handbook:

WARNING!

Identifies potentially fatal hazards to personnel.

CAUTION: Identifies hazards to equipment.

Note: Contains important or helpful information about the current task.

0.3 Intended Audience

This handbook is intended for any person operating any system component for an A-15 or A-20, including the aircraft, launch system, retrieval system, ground control station, and software.

0.4 Additional Resources

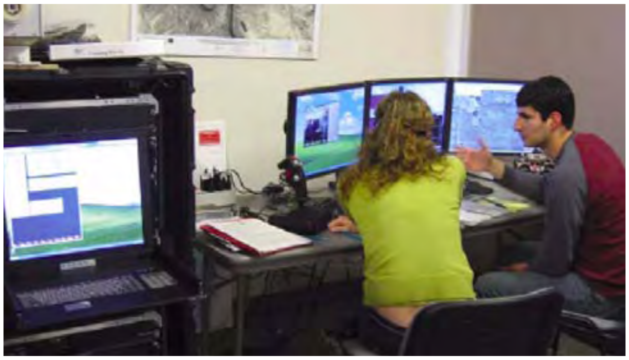
Documentation

Insitu provides the following additional resources:

- Maintenance Handbook – instructions for the analysis, repair, and scheduled routine maintenance of all system components.
- Pocket Handbook – charts, handy guidelines, and checklists for setup, operations, and emergency procedures.
- Software documentation – instructions and reference information, provided online or in individual handbooks (as needed).
- I-MUSE – reference information on I-MUSE is accessed by selecting Contents from the Help menu on the I-MUSE toolbar, or by pressing the **F1** key.
- www.Insitu.com – Insitu's website, with access to the latest news, publications, and services.
- Engineering assistance – analysis, advice, guidance, and solutions by phone or email.

Operator Training

Insitu has developed, and complies with, an intensive qualification program for operators. Qualification requirements are based on the level of operation.



All training is closely monitored and evaluated by Insitu-authorized instructors, and only operators who meet all requirements become qualified.

Basic Qualification Course

The Basic Qualification Course primarily consists of three phases:

- **Ground school**: scheduled classes lasting approximately one week concentrating on learning I-MUSE (Insitu's Multiple UAV Software Environment).
- **Simulator training**: HiL (Hardware-in-the-Loop) simulator system checks and simulated flights with an instructor.
- **Flights at our training facility**: actual flights of the A-20 with an instructor at our Arlington training facility.

There are also written tests and solo flight requirements, along with concurrent training that is scheduled throughout the course. Daily opportunities to perform aircraft maintenance and programming are available for those individuals who seek to improve their knowledge base.

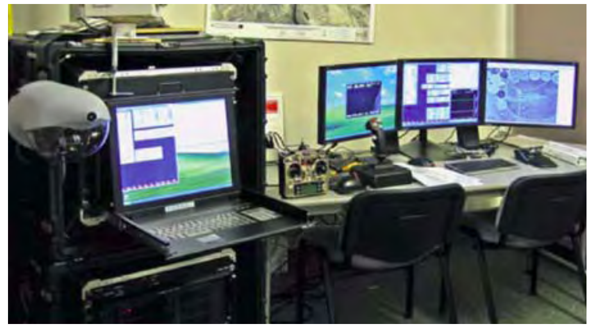
Additional instruction and evaluations are available for special-interests such as maritime, Forward Eyes, and mission command operators.

Ground School

In-class training introduces students to the fundamentals of aviation, theories and procedures for UAS takeoffs and approaches, emergency procedures and safety responses, and advanced navigation and flight planning.

Simulator Training

Using Insitu-developed HiL, any flight condition can be created or recreated from flight telemetry files. Emulators include a full avionics package, control surface servos, EO camera and camera turret, and directional antenna. Students work with an instructor on pre-arranged mission scenarios.



Flight Training

Students are taken through the entire process of conducting actual flights, from mission planning, to equipment setup and preflight checks, to post-flight procedures and clean-up. Safety, air crew discipline, and situational awareness are emphasized throughout.

0.5 Contact Us

For further information about Insitu's products or services, contact us at:

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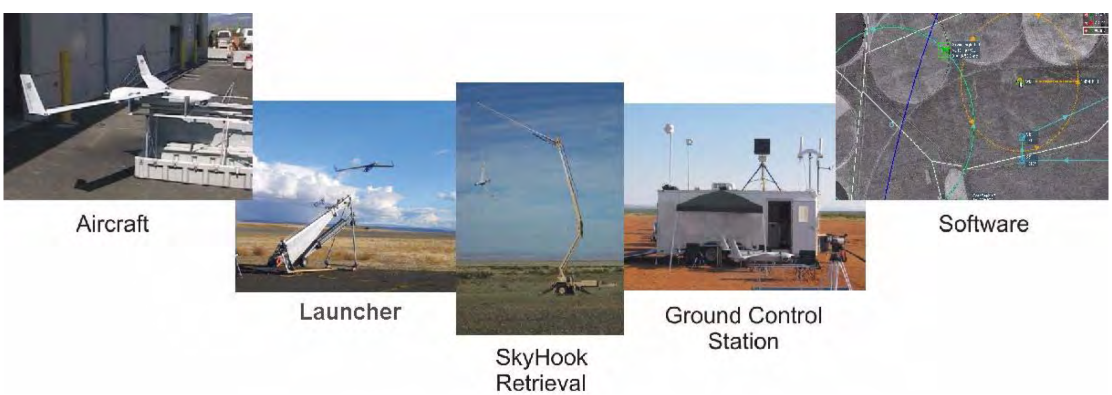
We welcome your comments! Please utilize the *Feedback Form* inside the back cover of this handbook to assist us in monitoring and improving our products and documentation.

1

Overview



Aircraft
Launcher
SkyHook Retrieval
Ground Control Station
Software

1.1 System Descriptions

In this section:

- Aircraft
- Ground Control Station (GCS)
- Launch systems
- Retrieval systems
- Software

Insitu’s UAS (unmanned aerial system) is configured for land- or sea-based operations, and includes the aircraft, launcher, retrieval system, Ground Control Station (GCS), software, associated spares, and auxiliary equipment.

The platform is flexible, expandable, and can be quickly reconfigured in the field. For maritime operations, each system component is custom-installed aboard ship.

The UAV (unmanned aerial vehicle) is built to carry customer-supplied sensors and processors, and to provide a flexible aerial platform with power, communications, and volume for additional payloads.

The aircraft is designed to handle multiple, highly persistent sensing roles, including:

- Intelligence, surveillance, and reconnaissance (ISR).
- Communications relay.
- Battle damage assessment (BDA).
- Customer-supplied sensing and surveying missions.

The UAS crew is a team of highly-trained operators who plan and execute operations from launch, through flight, to retrieval. Operators become qualified by successfully completing Insitu’s intensive training program.

- In addition to learning how to plan and conduct operations under normal conditions, a UAS crew is trained to handle difficult situations and unexpected problems.
- Although operators can readily experiment with adverse situations or failure modes while practicing on simulators, when a real aircraft is flying, the operator must thoroughly know the systems and procedures.
- Operators are trained thoroughly on what is going on behind the ground system interface. An operator doesn’t have to be an engineer, but does understand the workings of the software and hardware, and the performance of aircraft and autopilot systems.
- Operators are skilled in performing careful maintenance and inspection of hardware components.

- Operators must demonstrate good airmanship. As users of an airspace, they must act as any qualified pilot or air-traffic controller. This calls for a thorough knowledge of rules of the air, air traffic in the area of operations, air-traffic regulatory authorities, and weather and its effects on performance. Above all, airmanship calls for safety consciousness and critical preparation and execution, so that risk is always acceptably small. There is no room for taking careless risks that put other aircraft or people in danger.

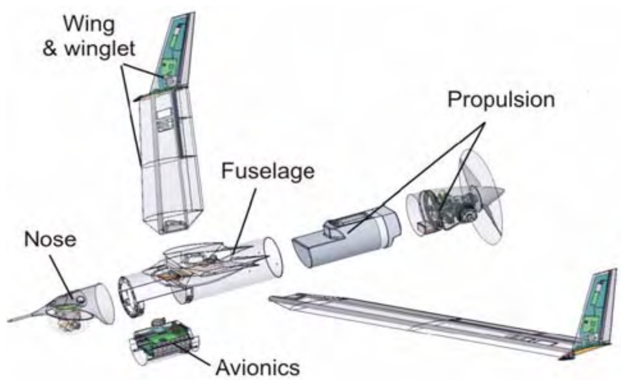
One operator can direct multiple aircraft and handoff operations to others without calling the aircraft in.

Minimum Crew Requirements	
Land	▪ 1 UAV Land Operator ▪ 1 Launcher/SkyHook Operator
Sea	▪ 1 UAV Land & Maritime Operator ▪ 2 Launcher/SkyHook Operators

The system can be operated by a two-person crew. Crew requirements may vary, depending on the type of mission. On a minimal two-person crew, the UAV Operator is required to assist in the SkyHook retrieval process after capture of the aircraft.

Aircraft

The A-15 and A-20 aircraft are long endurance UAV composed of five to six major modules that are replaceable at the field site. The most common payload, an inertially-stabilized camera turret, allows for the tracking of a target of interest for extended periods of time, even when the target is moving and the aircraft nose is seldom pointed at the target.



The A-15 and A-20 aircraft feature a high aspect ratio swept wing, shoulder-mounted on a cylindrical fuselage using blended fairings. The aircraft are tailless, with a rear-mounted engine driving a pusher propeller. The structure is carbon fiber composite with fiberglass winglets. Two sets of elevons on the wings provide pitch and roll control, with rudders on the winglets at the wingtips for directional control. The aircraft design is tightly integrated and provides redundancy where experience has indicated the need.

Ground Control Station (GCS)

Flight operations with Insitu UAS are generally in two classes: those handled either by stationary or transportable ground control stations (GCS and TGCS). The non-moving GCS (a fixed unit that is stationary) is the most common for land-based operations. The moving TGCS is used for sea-based operations, and for land-based operations that require mobility (in a vehicle, such as a HMMWV).

The involvement of the TGCS varies; ship-based operations might require the TGCS to have full control (including launch and retrieval), while a land-based TGCS might only be used for part of a mission (i.e. no launch and retrieval) using omni antennas.

GCS software includes operator interfaces for preflight checks, operating, flying, monitoring multiple aircraft on independent missions, and simulating flight operations to facilitate training and mission planning.

A standard PC, running the Microsoft Windows operating system, is connected to an Interface Computer (If/C) that provides interconnection and control logic between the operator’s control station and other GCS components.

Launch systems

The patented SuperWedge™ launcher gives Insitu’s UAV its initial velocity and rate of climb.

The catapult requires approximately 45-75 psi (depending on weight and wind) to charge the cylinder. On firing, the launcher accelerates the aircraft at 12 g, and at the end of the rail the aircraft is launched at takeoff speed, about 50 knots (25 m/s).

The pneumatic catapult is charged from the air compressor attached to the launcher. The air compressor is operated remotely. During preflight operations, a safety pin is installed to prevent inadvertent activation. Once the safety pin is removed, the catapult is manually activated using a pull trigger which is controlled by the launch and recovery technician.

The launcher comes standard with a wheel set for easy positioning. A frame mounting kit is also available for shipboard or semi-permanent mounting.

Retrieval systems

SkyHook – Land-based operations

The patented SkyHook retrieval system captures the aircraft, providing near-vertical recovery. The SkyHook system shipped from Insitu includes a GPS receiver and antenna, which the aircraft uses to make an accurate approach via data relayed through the control station. The aircraft is snagged by flying into a rope suspended from approximately 45 feet (14 m) above the surface. A hook on the wingtip catches the line and quickly stops the aircraft.

The SkyHook can be deployed easily and keeps the aircraft clear of hazards. If the aircraft misses, it circles on a clear path and makes another approach. This is called a wave-off or go around.

SkyHook – Maritime operations

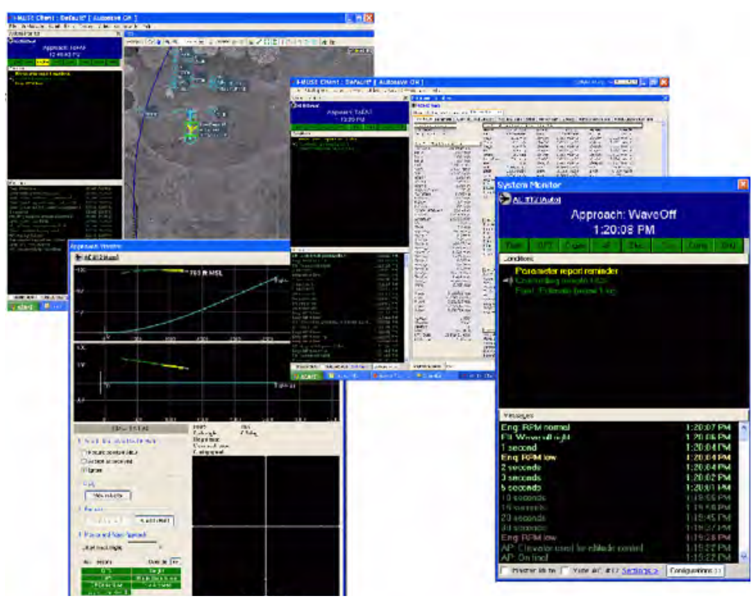
The maritime recovery system is a self-erecting and stowing mast/ boom assembly. An externally-provided electrical source powers a contained hydraulic power pack.

Runway

The aircraft is capable of a belly landing when necessary. This is not recommended for most configurations or situations, but with skill the aircraft will not sustain flight critical damage upon belly landing, and will require only minor adjustments, replacement parts, and inspection to fly again.

Software

All UAS software runs on a standard PC using the Microsoft Windows XP operating system.The ground software includes operators' consoles for preflight checks, operations, flight, and monitoring of multiple aircraft on independent missions, as well as simulating flight operations to facilitate training and mission planning. Software provided with the UAS includes I-MUSE, FlightSim, ObjectTracker, and utility code for each programmable element of the system.



System Descriptions		
Aircraft		
Modules	**Avionics**	Avionics canister has three slots for electronics. (Standard configuration: one slot open for expansion.) Structurally integrated into fuselage to reduce weight.
	Fuselage	Carbon fiber shell with avionics bay forward, propulsion/fuel tank bay at rear, shoulder-mounted wing adapter fairings, and an access hatch between wings.
	Nose	Standard nose module slings inertially stabilized camera underneath in transparent hemispherical dome, with a pitot tube/ probe (front-most) for measuring air data.
	Payload extension	Optional fuselage plugs stacked fore and aft of the wing offer additional payload capacity.
	Propulsion	Engine, generator, engine mount, engine control board, and fuel tanks.
	Wing & winglet	Carbon fiber wing with dual elevons and commercial servo actuators; field-replaceable winglets house communications options and vertical control surfaces.
Payloads	**900 Mhz repeater**	The FreeWave 900 MHz repeater can act as a node in a communications network, and can allow two-way data transmission, for example, passing messages and still images to troops on the ground.
	EO camera (electro-optic)	Standard camera payload offers excellent daylight imaging detail with the ability to hold frame on objects of interest for extended durations. Features include: Color, 25x zoom (newer models are 36x zoom), 640x480 resolution, 30 fps, FoV: 45^o to 1.8^o, and IR light filter.
	EPLRS repeater	The Enhanced Position Locating Reporting System (EPLRS) provides the military with means for identification, positioning, and navigation. This system also provides a data link for weapon systems integration.
	IR camera (infrared)	The Alticam 600-6000 infrared option has a 640x480 pixel sensor and supports a 7.5° digital zoom. The thermal IR-160 option offers video without requiring ambient light. Good at low altitudes, for dusk to dawn ops. Features include: Basic thermal night vision, 160x120 pixel sensor, 30 fps, and FoV: 15^O. Also available, higher resolution IR cameras provide detection of finer detail or flight at higher altitudes. IR-320 provides improved thermal IR, 320x240 pixel sensor, 60 fps, and FoV: 18^O. IR-640 provides high resolution thermal IR, 640x480 pixel sensor.
	L-band transmitter	The ROVER-Compatible L-Band Avionics unit (ROVER Avionics) allows transmission of video for viewing on a ROVER-III ground receiver. The ROVER Avionics transmits unstabilized video without overlays over an analog L-band wireless link.
	Magnetometer	A magnetometer in the nose, and vector magnetometers in each winglet, provide optimized sensing.
	Meteorology	Meteorological capabilities include: wind calculations, outside air temperature sensing, sea surface temperature sensing, and barometric pressure sensing. Additional meteorological payloads can be added easily.

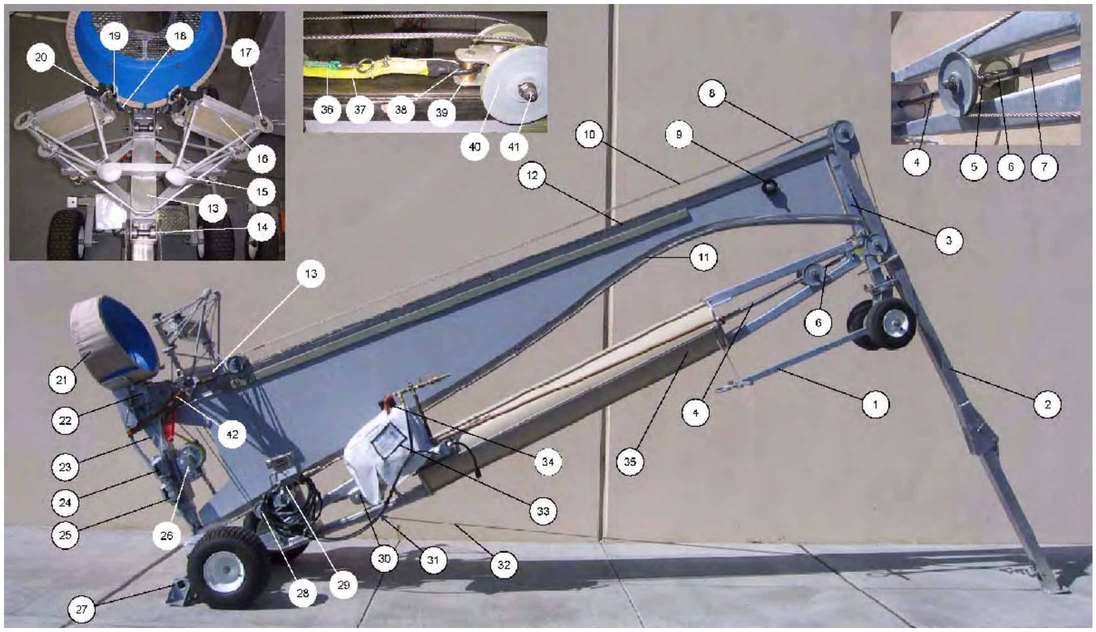
System Descriptions		
Aircraft		**(cont.)**
Payloads (cont.)	**Transponder**	The ultra-light transponder is programmable during flight. The transponder can be deactivated at any time during the flight for situations where detection might compromise the mission.
Mission types	**Combined sensor**	Multiple sensors and communications relays can be combined in one aircraft. However, it will often be more effective to operate a fleet of UAV with different complementary sensors for achieving mission goals. The redundancy, inherent in multiple vehicles, and the elimination of potential sensor incompatibilities, support mission success.
	Communi-cations relay	The UAS can perform as a virtual communications tower for a mobile or fixed unit. Multiple aircraft can extend the range of communications over the horizon.
	Electro-optic (EO) camera	The primary application of the UAS is visual surveillance of designated places and tracking targets of interest. The aircraft is equipped with an advanced, very light-weight camera turret that is inertially stabilized. The camera can look forward, back, down, and to the sides, while the aircraft is maneuvering. The aircraft can keep a target in view either from an orbit overhead, to the side, or from a standoff distance. The Sony EO sensor (EX780) has an IR light filter in place. Remove and reinsert the filter using **night vision** in I-MUSE (**filter IR** in Groundbase). Night vision mode lets in more light, and has been found to be very useful in low light situations.
	Infrared (IR) camera	During night operations, an infrared sensor camera can be mounted on the inertially stabilized turret. This camera provides images of a fixed field of view at night, in the infrared range of the spectrum. During the day, these images can enhance a corresponding visual light image by providing information about the heat emitting from the objects in the view – in particular, vehicles and individuals.
	Magneto-meter payload	The UAV can accommodate sensors for magnetic sensing and mapping operations, to provide extensive mapping of large areas and complement manned surveys.
Specifi-cations	**Dimensions**	Dimensions vary by configuration. The UAV is approximately 5 feet long (1.5 m) with a 10 foot (3 m) wing span and 7 inch (0.2 m) diameter fuselage. For precise data, refer to the **Dimensions** page of the aircraft parameter file spreadsheet.
	Performance	Max level speed 72 knots 37 m/s Cruise speed (max wt.) 49 knots 24 m/s Service ceiling 19,400 ft 5,913 m Endurance 15 hours 15 hours Climb rate (max wt.) 400 ft/min 2 m/sec Still air range / No reserves 1,100 nm 2,000 km
	Weights	UAV (empty weight) 26.5 lbs 12 kg Fuel and payload 13.2 lbs 6 kg Max fuel 12.1 lbs 5.5 kg Max takeoff weight 44 lbs 18 kg

System Descriptions			
GCS			
Components – Major components	**Telemetry radio modem**	The standard TT&C (Tracking, Telemetry, and Control) link is provided by a two-way radio (freewave modem), installed in the winglet of the aircraft.	
	Tracking antenna	Air/ground communication is provided by a mix of omni-directional and high-gain antennas tailored to the frequency bands of operation requested by a user.	
	SkyHook GPS receiver	The SkyHook includes a GPS (Global Positioning System) receiver and antenna, which the UAV uses to make an accurate approach for retrieval.	
	Weather station (optional)	The optional weather station provides users with information on local conditions. The standard system provides data on wind speed, wind direction, temperature, pressure, and humidity. This is useful for takeoff and retrieval consideration.	
	Clear-to-land switch	The Clear-to-land switch (CTL) is a safety device used in retrieval. The aircraft will make autonomous decisions about the safety of its approach, and wave off if appropriate. The CTL device allows a ground observer to force a wave off if the situation is unsatisfactory or unsafe. The CTL switch is a rugged pistol-style trigger that provides the safety pulse. It generally plugs into the outside of the GCS.	
Launch systems			
Specifi-cations	**Height (deployed, with aircraft)**	10 feet	3.05 m
	Height (stowed)	6 feet	1.83 m
	Length (deployed)	21 feet	6.4 m
	Length (stowed)	16 feet	4.88 m
	Weight – desert configuration (approx.)	1,200 lbs.	544 kg
	Weight – maritime configuration (approx.)	1,500 lbs.	850 kg
	Width (no aircraft)	4.3 feet	1.31 m
	Width (with aircraft)	10.5 feet	3.2 m
	Power (external air source)	100 PSI, continuous	
	Power (attached air compressor)	110 VAC, 20 A, 60 Hz, Single Phase	

System Descriptions

Launch systems (cont.)

Land-based configuration launcher nomenclature

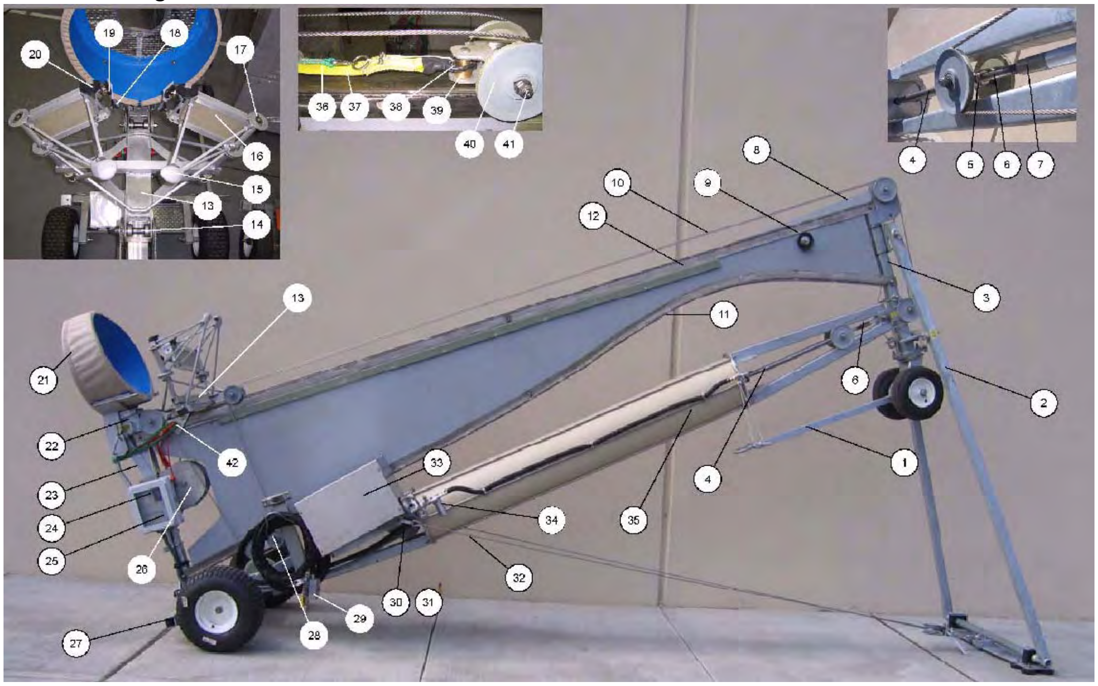


1. Drawbar	15. Gripper hooks	29. Remote
2. Aluminum kickstand	16. Grippers	30. Erection winch
3. Forward post	17. Brass brake adjustment nut	31. Erection cable stop
4. Piston rod	18. Lower gripper feet	32. Erection cable
5. Buttress saddle	19. Upper gripper feet	33. Compressor
6. Buttress	20. Pusher blocks	34. Air filter
7. Buttress jam nut	21. Prop guard	35. Air cylinder
8. Ski ramp	22. Dog house	36. Trigger line (green rope)
9. Arresting pulley	23. Aft post	37. Cocking winch strap
10. Transmission cable	24. Speedo	38. Release shackle
11. Lower track	25. 120 VAC 60Hz outlet	39. Brass pull-back roller
12. Upper track	26. Cocking winch	40. Pulley (qty: 8 large, 6 small)
13. Upper carriage	27. Outriggers	41. Stud axle (qty: 7)
14. Titanium rollers (2 upper carriage, 2 lower carriage)	28. Lower carriage (bogey)	42. Safety pin (red rope)

System Descriptions

Launch systems **(cont.)**

Marine configuration launcher nomenclature



1. Drawbar	15. Gripper hooks	29. Remote
2. A-frame kickstand	16. Grippers	30. Erection winch
3. Forward post	17. Brass brake adjustment nut	31. Erection cable stop (not pictured)
4. Piston rod	18. Lower gripper feet	32. Erection cable
5. Buttress saddle	19. Upper gripper feet	33. Compressor
6. Buttress	20. Pusher blocks	34. Air dryer
7. Buttress jam nut	21. Prop guard	35. Air cylinder
8. Ski ramp	22. Dog house	36. Trigger line (green rope)
9. Arresting pulley	23. Aft post	37. Cocking winch strap
10. Transmission cable	24. Speedo	38. Release shackle
11. Lower track	25. 120 VAC 60Hz outlet	39. Brass pull-back roller
12. Upper track	26. Cocking winch	40. Pulley (qty: 8 large, 6 small)
13. Upper carriage	27. Marine configuration does not require outriggers	41. Stud axle (qty: 7)
14. Titanium rollers (2 upper carriage, 2 lower carriage)	28. Lower carriage (bogey)	42. Safety pin (red rope)

System Descriptions			
Retrieval systems			
Specifi-cations – SkyHook	**Boom length (deployed) (approx.)**	27.5 feet	8.4 m
	Height (mast)	approx. 45 feet	approx. 14 m
	Height (stowed)	4 feet	1.22 m
	Length on deck (deployed)	12 feet	3.66 m
	Length on deck (stowed)	25 feet	7.62 m
	Power requirement	110-240V, 9 A, 50-60Hz, single phase	
	Weight	weights vary – see manufacturer's serial plate	
	Width (deployed or stowed)	4.2 feet	1.28 m
	Width (with aircraft)	10.5 feet	3.2 m
Software			
Bootloader	The bootloader is a software program that is installed on the aircraft and on the If/C. The bootloader provides an interface for reprogramming software, changing modem settings, and testing certain hardware. On the aircraft, the bootloader is also used to reprogram parameter files. On the If/C, the bootloader is also used to specify how the modem(s), GPS, tracking antenna actuator, and AHRS (Attitude and Heading Reference System) are connected to the If/C.		
Cursor-on-Target	Cursor-on-Target (CoT) is a standard developed for the military that is used to exchange target and situational awareness information between different systems. I-MUSE supports both sending and receiving targets and situational awareness.		
FlightSim	FlightSim is Insitu's software tool for development and simulation of onboard and ground elements, operator training, mission planning, and some elements of aircraft design. It provides a means for pre-testing flightplans and conditions, as well as assisting development of training and design.		
Global Mapper	Global Mapper is a stand-alone application that is installed on the GCS. It is used to customize map data to reduce the processing power involved in map display.		
Helmsman	Helmsman is the software program that runs on the aircraft avionics. Functions include flying the aircraft, navigation, and communications.		
If/C	The If/C software runs on the If/C computer. The If/C interfaces with I-MUSE, modem(s), ground GPS, tracking antenna actuator, AHRS, and the pilot's console.		
I-MUSE	I-MUSE is Insitu's Multiple UAV Software Environment for flight planning, monitoring, and operation. The graphic interface provides operators with comprehensive and easy-to-use tools for all phases of flight.		
I-MUSE server	The I-MUSE server connects to an If/C (using the Groundbase program and a serial port) in order to communicate with the aircraft and ground components. I-MUSE Client connects to the I-MUSE server using a network connection and provides the interface that allows an operator to control the aircraft and ground components. Multiple I-MUSE Client instances can connect to a single I-MUSE server, or a single I-MUSE Client can connect to multiple I-MUSE servers and display multiple aircraft on screen.		

System Descriptions	
Software	**(cont.)**
MPEG server	Video data stabilized in I-MUSE or ObjectTracker is streamed to the MPEG server in analog format. MPEG-4 converts the video to digital format and sends it over the network. Anyone connected to the network can view the MPEG-4 stream.
ObjectTracker	ObjectTracker is an image processing program designed to keep the target of interest within the camera's field of view. Thus, it helps to reduce operation workload as it automatically points the camera for the pilot.
Parameter files	Parameter spreadsheets contain specifications for aircraft characteristics, communication protocols, and mission details.
S-VEST	S-VEST is the video exploitation system. It is a combination of software components that captures and displays video information for third-party analysts.

1.2 Standards & Limitations

In this section:

- Engine temperature requirements
- Launcher limitations and tolerances
- Operating limitations
- Weather limitations

This section provides charts and tables of important operating standards and limitations. This information is also available on laminated cards upon request.

The aircraft should be able to sustain any maneuver that the ground software allows. However, some maneuvers are more dangerous than others. These include:

- Large changes in manual turn rate (through command or CWS), especially at low speed.
- Non-zero flap setting use.
- Large speed changes while near ground altitude.
- Step airspeed command changes of more than 7.77 knots (4 m/s) (prohibited with software version 4.20 or older).

Engine temperature requirements

Normal operating range is 80-120^{o} C (176-248^{o} F). On deck**,** cylinder head temperature (CHT) may be controlled by engine RPM and external cooling. Airborne, CHT may be controlled by True Air Speed (TAS) and throttle position. To avoid unsafe engine temperatures, routinely adhere to these requirements:

Standards & Limitations		
Engine temperature requirements		
On deck: **If CHT ≥**	150° C (302° F)	Shut engine down immediately and allow to cool (to 176° F / 80° C or less) before proceeding.
	165° C (329° F)	Shut engine down immediately and do not fly aircraft until engine has received thorough inspection and full system check.
In flight: **If CHT is below**	50° C (122° F):	Set min throttle to ≥ 3800 RPM. Discontinue flight operations unless able to keep engine RPM consistently above 3800.
	35° C (95° F):	Discontinue flight operations immediately.

CAUTION: Failure to adhere to these requirements can result in power plant failures that could lead to serious damage to the aircraft.

Note: Increasing TAS cools the engine. Increasing electrical load may raise CHT to prevent low temperatures.

Launcher limitations & tolerances

The maximum indicated speedometer reading on launch is 28 m/s. Failure to obey this limit can result in failure or massive deformation of the gripper system. In particular, note that this represents a relaxation of the previous maximum limit of 27 m/s (52 knots), so operators must be extremely careful to inspect the launcher after every launch that approaches the limit.

The maximum bunk pressure for aluminum grippers is 40 +/- 10 lbs. Bunk pressure in excess of this figure may place too much pressure upon the UAV fuselage during the over-center release, and the fuse may crack.

The following failure modes are known, when pressure exceeds 80 PSI or speed exceeds 28 m/s (54 knots):

- The crossbeam on the welded chassis may bend downward, resulting in reduced over-center squeeze force on subsequent launches.
- Grippers may over-rotate upon release and damage each other. Gripper brake performance needs to be monitored very carefully.

WARNING!

Exceeding manufacturer's limits may result in injury to personnel and damage to equipment.

Operating Limitations Matrix 5/2008

	Variable	Config.	Minimum	Maximum	Description / Notes
ENGINE	RPM @ min/max Throttle	24i	3800-4000	5800-7700	
		28i (flight)	3600-3800	6000-8500	Use **flight** settings for takeoff and during flight. Reduce **recovery** values as needed only when preparing for approach and during approach.
		28i (recovery)	3300-3500	6000-8500	
	RPM Limiter Settings	24i	3600	7600	
		28i (flight)	3500	8400	
		28i (recovery)	3200	8400	
	CHT	24i	50°C/122°F	150°C/302°F	
		28i	50°C/122°F	160°C/320°F	Low caution is 52°C/125°F. High caution is 150°C/302°F.
		28i (active CHT)	50°C/122°F	180°C/356°F	Low caution is 90°C/194°F. High caution is 160°C/320°F.
VOLTAGE & CURRENT	V(gen)	24i	14 V	34 V	Generator voltage
		28i	18.5 V	20.5 V	
	I(gen)	All	0 A	4.7 A	Generator current
	V(bat)	All	19 V	25 V	Battery voltage (Battery lasts up to 60 min. without external power (load dependent))
	I(bat)	All	-0.15 A	0.5/1.0 A	Battery current (Battery will discharge without shore power or generator input). *High*: 0.50 for onboard charger; 1.0 for external chargers.
	V(13v)	All	12.75 V	13.25 V	13 volt supply voltage
	I(13v)	All	0.5 A	5.5 A	13 volt supply current
	V(5v)	All	4.8 V	5.2 V	5 volt supply voltage
	I(5v)	All	0.6 A	4.5 A	5 volt supply current
	V(3.3v)	All	3.1 V	3.5 V	3.3 volt supply voltage
	I(3.3v)	All	0.24 A	0.36 A	3.3 volt supply current
TEMP.	T(av)	All	-40°C/-40°F	65°C/149°F	Avionics Bay Temperature
	OAT	All	-10°C/14°F	50°C/122°F	Ambient Air Temperature
WEIGHT	C.G.(x)	EO	-1.97 in (-0.050 m)	-2.87 in (-0.073 m)	Center of Gravity from datum (x axis)
		IR/DB/GR	-1.97 in (-0.050 m)	-2.76 in (-0.070 m)	
	Weight (T/O max)	24i		41lbs/18.5kg	Maximum take off weight

	Wind type	Config.	Catapult (Launch)	SkyHook (Retrieval)
WIND LIMITS	Max wind	All	35 knots (18 m/s)	40 knots (21 m/s)
	Max tailwind	All	Slight tailwind OK **only** if launcher can compensate	Never land with a tailwind
	Max crosswind	All	10 knots (5 m/s)	20 knots (10 m/s)

Standards & Limitations

Operating limitations **5/2008 (cont.)**

ERRORS & OFFSETS	Type of setting	Config.	Limit	Description / Notes
	Max TAS error at zero airspeed and zero wind (pitot and static ports sheltered from wind)	All	+/-11.7 knots (+/-6 m/s)	Corresponds to 1.9 knots (1 m/s) of error at 39 knots (20 m/s) actual TAS.
	Max roll, pitch, yaw rates at rest (before takeoff)	All	+/-0.57 deg/s (+/-0.010 rad/s)	
	Max allowable correction to gyros	All	+/-2.87 deg/s (+/-0.050 rad/s)	
	Max split between Barometric and GPS altitude	All	+/-33 feet (+/-10 m)	<16 ft (5 m) desired; >33 ft (10 m) action as required
	# of dropouts	All	200 per 10 min. "Rx CRC2 errs"	Check all 4 columns. For rates greater than 50 in 10 min., check for interference or check modem settings.
	Max accelerometer offset	All	X-axis: +/-0.03 G (0.3 m/s^2) Z-axis: +/-0.05 G (0.5 m/s^2)	When level and not moving, accelerometers should read: X: 0.00 G (0.0 m/s^2) Z: -1.00 G (-9.81 m/s^2)
	Max allowable offset for pitot pressure	All	20 Pa	
	Max allowable temperature offset for static pressure	All	2000 Pa	

SENSOR NOISE	Sensor	Config.	Max	Std Dev
	Pitot	All	50 ADC counts	20 ADC counts
	Altitude	All	16 ft (5 m)	10 ft (3 m)
	Accelerations	All		0.01 G (0.1 m/s2)
	Rotation rates	All		0.11 deg/s (0.002 rad/s)

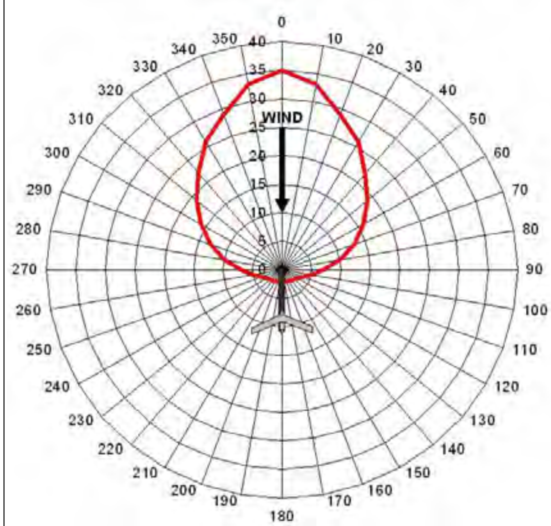
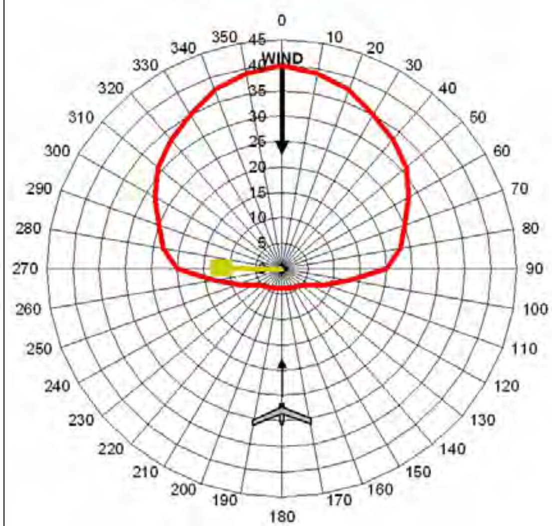
KNOWN LOADS	3.3v Bus	5v Bus	13v Bus
	Flight computer 0.325A	Servos 0.1A grnd ea. 0.2A air ea. Ignition on 1.00A Ignition off 0.01A Engine board & gen 0.04A GPS receiver 0.57A GPS antenna 0.06A Flight computer 0.18A	Freewave RX 0.28A Freewave TX 0.8A Freewave Idle 0.065A Analog Video TX 1.25A ea. Video Turret 0.385A Batt Chrgr 0.835A 5v analog regulators 0.250A ROVER transmitter 1.05A 5v Bus 3.3v Bus

GENERAL	Important guidelines
	▪ Download a parameter report every 30 min. of flight. ▪ Flight in icing conditions is not approved. ▪ Manual flight control is not approved. ▪ Use of flaps severely affects maneuverability. ▪ Prolonged flight in heavy rain is not recommended.

Standards & Limitations			
Weather limitations – General			
Extreme conditions	No violent gusting or wind-shear		The UAS has been designed for routine use in storm penetration and weather reconnaissance, so wind conditions do not normally impose limitations. Violent gusting or wind-shear conditions, however, are of concern and should be avoided.
Icing	No icing		The aircraft can be equipped with icing detection capabilities, to enable the operator to exercise avoidance. However, the currently fielded model is not equipped with detection or anti- and de-icing capabilities, so icing conditions should be avoided if possible.
Launch system	Minimum ceiling	0 ft. AGL	The system's autonomous launch capability minimizes the impact of weather.
	Minimum visibility	0 nm	
	Maximum gusting headwind component	35 knots (18 m/s)	The aircraft normally uses a catapult launcher for takeoff. The catapult can be easily aligned into the wind, so, space permitting, wind is not normally a limiting factor for launch operations.
	Maximum gusting downwind component	2 knots (1 m/s)	
	Maximum crosswind component	10 knots (5 m/s)	
Phase of mission	Minimum ceiling	0 ft. AGL	Although the aircraft has an IR payload capability, the primary sensor is an EO camera payload, which normally imposes limits on the minimum ceiling and visibility.
	Minimum visibility	0 nm	
	Maximum wind conditions	40 knots (20 m/s)	
Rain	No heavy rain		Avoid flying in extended heavy rain conditions.
Retrieval system	Minimum ceiling	0 ft. AGL	The system's autonomous retrieval capability minimizes the impact of weather, however it is recommended that a safety observer be present as normal practice.
	Minimum visibility	0 nm	
	Maximum headwind component	40 knots (20 m/s)	The aircraft normally uses a SkyHook arrested recovery system. The SkyHook system can be easily oriented with the wind, so, space permitting, wind direction is not normally a limiting factor for recovery operations.
	Maximum downwind component	0 knots	
	Maximum crosswind component	20 knots (10 m/s)	

Standards &Limitations

Weather limitations – Effect of wind

Takeoff – Launch systems	**Landing – Retrieval systems**
This polar diagram shows maximum allowable wind speed vs. wind angle off the bow of the launcher. The red line represents the maximum wind (distance from the origin) for each angle forward of launcher. **Note: When approaching crosswind speed limits, reorient launcher into the wind, providing obstacles are not in the launch path.** **Maximum Allowable Wind Speed (Kts)** versus **Wind Angle off the Bow of the launcher** 	This polar diagram shows maximum allowable wind speed vs. aircraft approach angle to SkyHook retrieval system. The red line represents the maximum wind (distance from origin) for each angle forward of retrieval system. **Note: When approaching crosswind speed limits, reorient retrieval system perpendicular to the wind, providing obstacles are not in the retrieval path.** **Maximum Allowable Wind Speed (Kts)** versus **Aircraft Approach Angle to the SkyHook** 

Weather limitations – Guidelines for adverse weather conditions

	Note: For final determination of operations in adverse weather conditions, weigh importance of the mission tasking. The aircraft is robust, operated in demanding environmental conditions.
Air-conditioned storage	Aircraft are not required to be in air-conditioned storage in hot environments. Store aircraft in an environment with similar temperature and humidity to that in which the aircraft will operate. For long term storage, it is recommended that the aircraft be stored in a relative humidity of 50%-70%, and a max temperature of 50º C (122º F). Aircraft stored in air-conditioned environments, then operated in high temperature and high humidity have a tendency for condensation to form on the inside of the camera dome, impacting camera clarity. Use of desiccant packs is required in humid environments. **CAUTION: The aircraft should not be flown with an accumulation of dust or dirt on any surface. Dust or dirt on the aircraft can impair aerodynamic performance. Clean the aircraft before takeoff.**

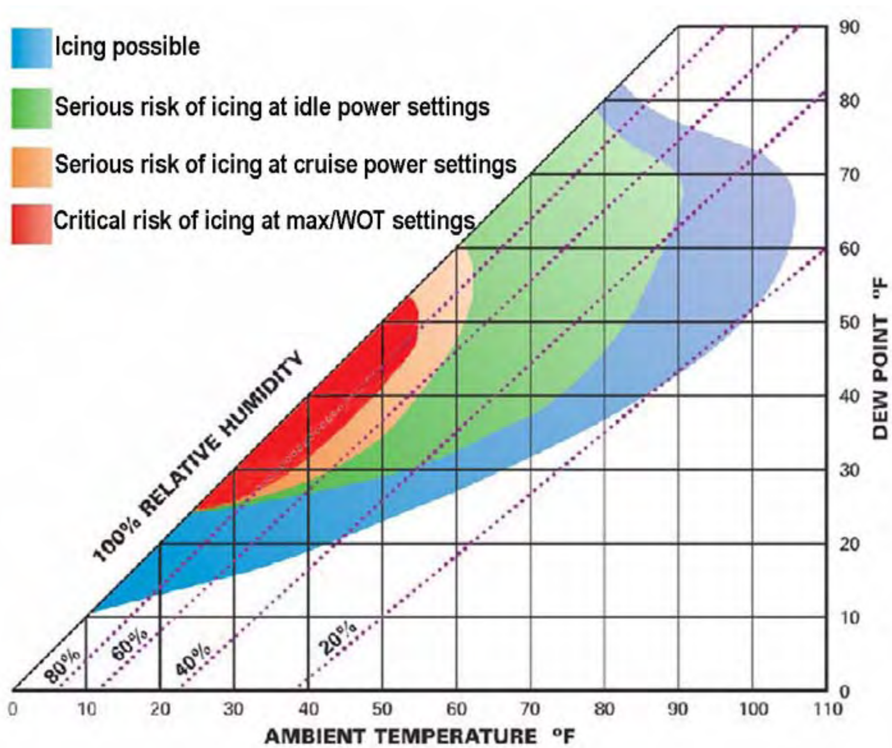
Standards & Limitations

Weather limitations – Guidelines for adverse weather conditions

Carburetor icing

All carbureted engines are capable of experiencing carburetor icing under certain atmospheric conditions. Carburetor icing occurs when moist air drawn into the carburetor is cooled to a temperature below 0° C by adiabatic expansion and fuel vaporization. Ice forms directly from water vapor on internal surfaces of the carburetor. Even in clear skies at ambient temperatures well above freezing, carburetor icing in the carburetor venturi and throttle valve can partially or totally block the flow of the fuel/air mixture.

Carburetor icing does not fundamentally limit operations. Based on experience to date with the current engine, the threat of carburetor icing is not significant enough to warrant a strict rule regarding temperature and humidity as the basis of the decision to fly. Exercise caution when flying in conditions that are potentially conducive to the onset of carburetor icing. Conditions for potential carburetor icing at various throttle settings are shown.



Note: **The risk of carburetor icing is greater at lower throttle settings. For example, the red area shows a critical risk of icing at max/WOT settings. If operating with less power under the atmospheric conditions shown in the red area, the risk of carburetor icing is further increased.**

CAUTION: When carburetor icing is possible, use vigilance to detect it at the onset by paying careful attention to engine RPM. Partial loss of power or complete engine failure may be signs that carburetor icing is inhibiting or haulting the flow of the fuel/air mixture. If carburetor icing is suspected, command full throttle and climb to a higher altitude to find colder, drier air.

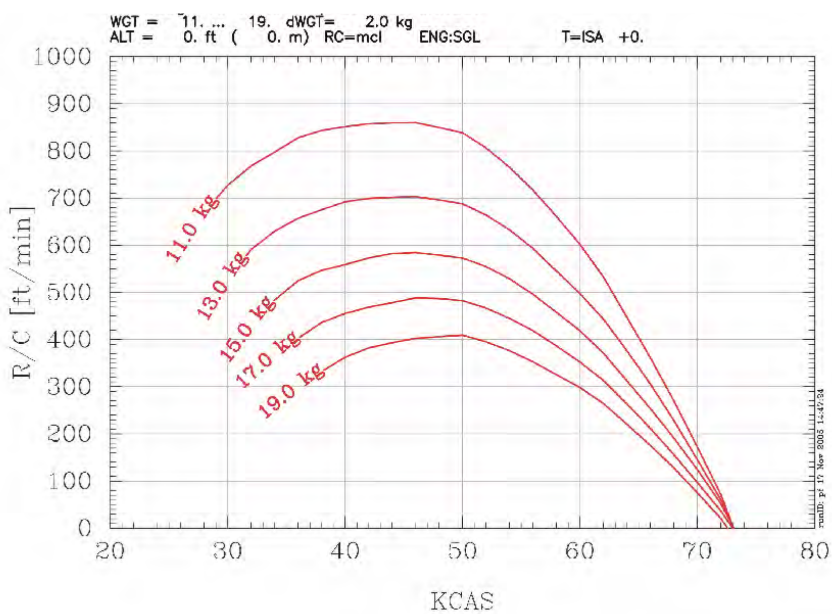
Standards & Limitations	
Weather limitations – Guidelines for adverse weather conditions (cont.)	
Cold weather	Ensure the minimum engine temperature is achieved before beginning run up. With the exception of an increase in initial climb performance, flying characteristics of the aircraft are not affected by cold weather.
Engine start	Engine start is not significantly affected by the presence of snow, ice, rain, fog, and slush. To aid in engine start, the engine should be pre-heated prior to start when temperature is below 32º F (0º C).
Ground operation	Extended ground operations during hot weather can cause overheating of avionics (65º C/149º F max). Closely monitor system temperatures during such conditions.
Hot weather, desert operation	Hot weather and desert ground operation require that added precautions be taken against damage from dust, sand, and high temperature. Particular attention should be given to those components and systems (engine, fuel, oil, pitot-static, etc.) that are susceptible to contamination, malfunction, or damage from sand and dust. During conditions of blowing sand and dust, aircraft hatches should be closed and sealed, and all openings should be covered or closed when the aircraft is not in use. When not in use, aircraft should be stored in its storage box. A reduction in climb rate will increase airspeed and aid in engine cooling. Hot weather also raises density altitude. The higher the temperature, the higher the density altitude. Warm air is less dense than cool air and as a result aircraft performance can be significantly reduced during hot weather operations. For example with an OAT of +35º C (95º F), at 1,000 ft. (305 m) MSL, the aircraft will perform as if it's flying at 3,500 ft (1,067 m) MSL. Engine performance will be degraded, as will the amount of lift produced by the airfoil. The result will be a reduced climb gradient and lower true airspeeds. Take care to ensure adequate climb performance is available if obstacles are present. **Mitigating techniques for extreme hot weather operations** During ground operations (maintenance engine runs and engine runs while the aircraft is on the launcher), engine cooling air is required. During the climb, monitor systems closely, and as CHT nears the maximum CHT limit noted earlier in this section, reduce power by small throttle command/airspeed percent increments (5-10%). Several power reductions may be necessary to attain adequate climb performance and maintain the CHT below the recommended limit.
Icing	**Effects** All accumulation of snow, ice, or frost must be removed before flight. The aircraft is not equipped with de-icing or anti-icing systems. Operation of the aircraft into known icing conditions is not approved. If icing is encountered during flight, climb or descend to exit icing conditions, or recover aircraft as soon as possible. Aircraft will need to be operated at a higher airspeed if airframe icing has occurred. Air frame icing causes higher drag, increased weight, and increased stall speed. **CAUTION: The aircraft has no redundancy in the pitot static system. Some indications that these systems are affected by ice are: difference between GPS and barometric altitudes, degraded engine performance, abnormal attitude, abnormal airspeed indications, or a combination of any of these.** **Carburetor** See *Carburetor Icing*.

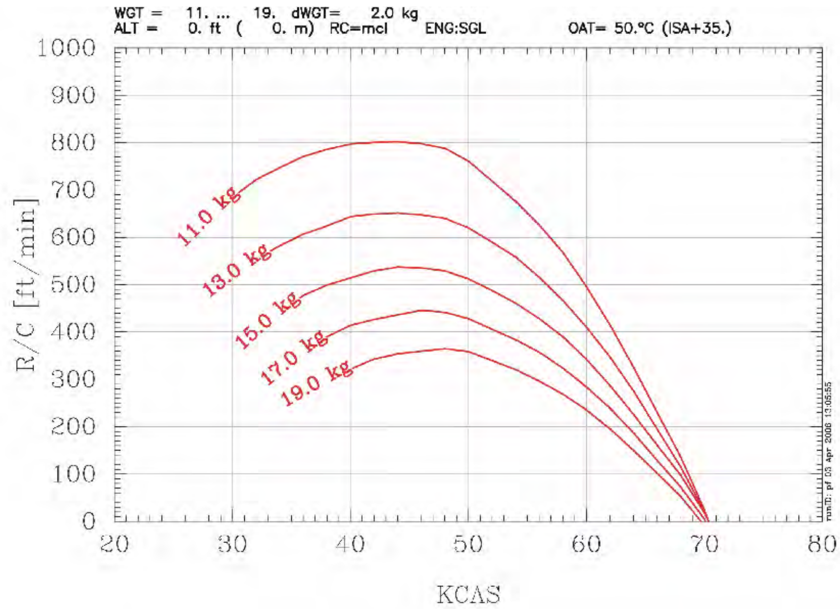
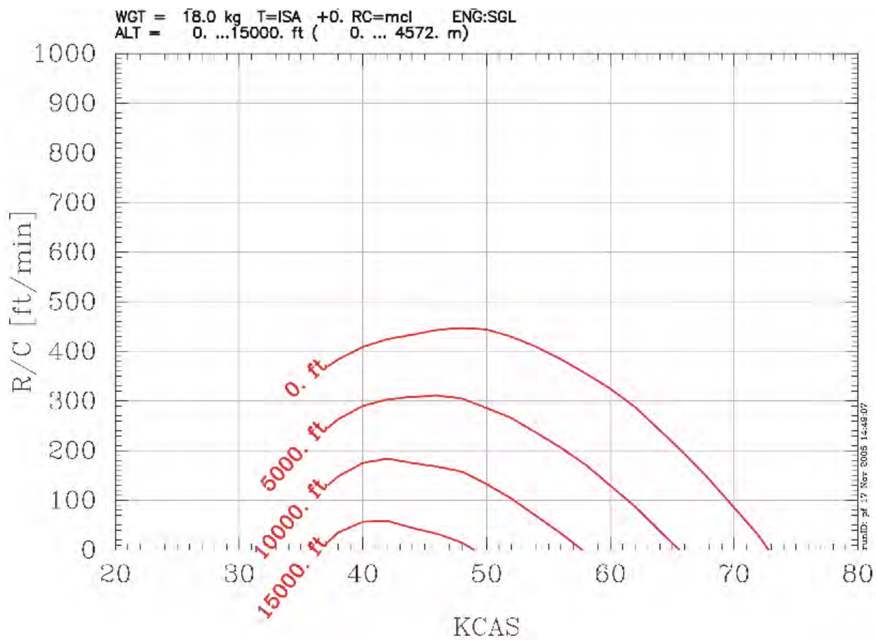
Standards & Limitations	
Weather limitations – Guidelines for adverse weather conditions	**(cont.)**
Lightning	**Effect on GCS, SkyHook, and flight crew** Operation of the aircraft into observed areas of lightning is not recommended. A direct lighting strike could seriously damage or destroy the aircraft. The effects of lightning striking close to the aircraft may interrupt the datalink/GPS system for short periods of time. GCS power and data lines are equipped with surge protection systems that are designed to protect GCS equipment against nearby lightning strikes. Ungrounded GCS structures have limited lightning protection. Lighting strikes to the GCS could damage the GCS or injure operators. Ground and flight crews should immediately seek safe shelter away from this equipment whenever a lightning threat appears. **WARNING!** **Ground crews must avoid activity near the SkyHook if lightning is observed nearby.**
Rain	Flight in rain is permitted. Prolonged flight (>30 minutes) in heavy rainfall rates exceeding 0.5 inches per hour (1.27 cm/hr) should be avoided. GPS hatch and avionics seams should be sealed with tape during preflight to minimize water penetration. Ensure tail numbers prior to 06-180 have been retrofitted with a rain-resistant static system if operating in prolonged rain.
Salt water operations	Flying above salt water in salt spray conditions for prolonged periods (>30 minutes) at low altitudes (<200 ft (61 m) above sea level) at times of high wind should be avoided. **CAUTION: Salt spray can lead to fouling of the static ports and make altitude readings unreliable. Clean aircraft after exposure to salt spray.**
Turbulence, thunder-storms	Operation of the aircraft into actual turbulence greater then moderate should be avoided. If aircraft enters turbulence, limit exposure to turbulent conditions as much as practical. Set **maneuvering mode** to **smooth** (I-MUSE 5.0.X and earlier: adjust **max yaw/(g/V)**) and expect a larger than normal turn radius and seek smooth air. During certification testing the aircraft did not experience structural failure until +19 g/-5 g (+186 m/s^2 / -49 m/s^2). Operators should consult available forecasts, AIRMET and SIGMET advisories for convective or low level wind shear turbulence. Flight in and around thunderstorm activity is not recommended except in support of critical mission objectives.
Wet conditions	In humid conditions, fogging of the camera dome may reduce visibility.
Wind shear	Wind shear is caused by sudden change in wind speed or direction over a short distance. A microburst is a sudden downward blast of air usually associated with convective activity. When these phenomena occur, any aircraft operating near the surface can be adversely affected. Extreme caution should be exercised when operating in areas where wind shear or microburst conditions are reported or observed. Loss of the aircraft is possible in extreme microburst or wind shear conditions. During launch and recovery, pay close attention to rapidly changing weather, thunderstorms, passing storm fronts, and high gusty winds. If mission requirements or fuel state allows, wait for favorable weather for launch and recovery.

1.3 Performance

In this section:

- Rate of climb
- Gradient of climb
- Climb performance
- Climb path
- Payload endurance
- Glide range
- Range – Endurance and range vs. loiter speed
- Stall speeds
- Speed envelope

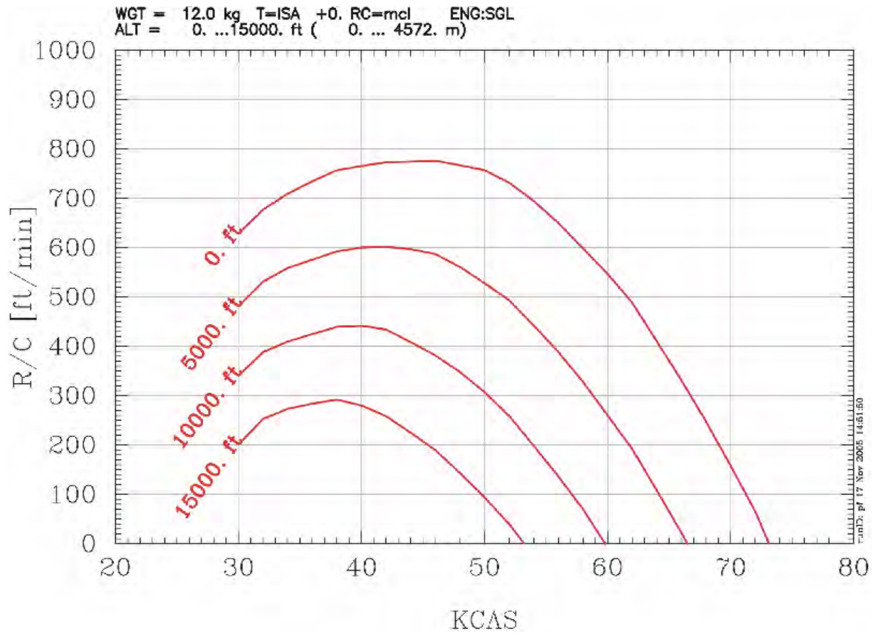
Performance	
Rate of climb	
Performance shown with variations of weight, altitude, and temperature. Engine setting (rating code RC) is max power; extracted power is typical for a standard EO payload and aircraft system. Charts for high temperature are based on standard engine power correction, but have not yet been substantiated by flight test.	
Altitude (fixed) = sea level/ISA	

Performance	
Rate of climb	**(cont.)**
Altitude (fixed) = sea level/ISA + 35	
Weight (fixed) = MTOW, ISA	

Performance

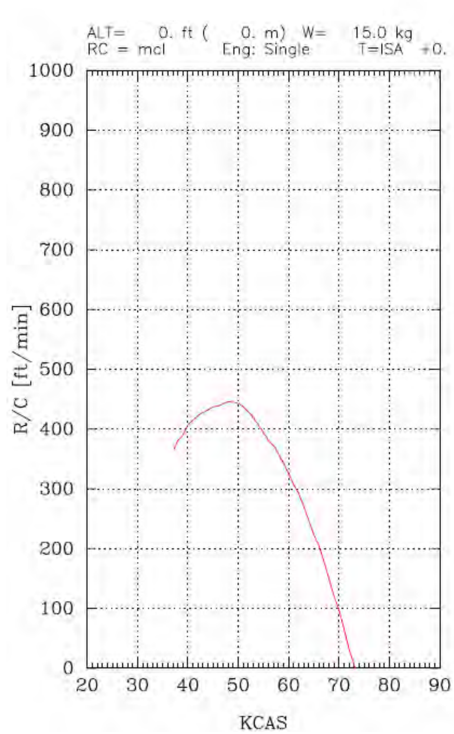
Rate of climb (cont.)

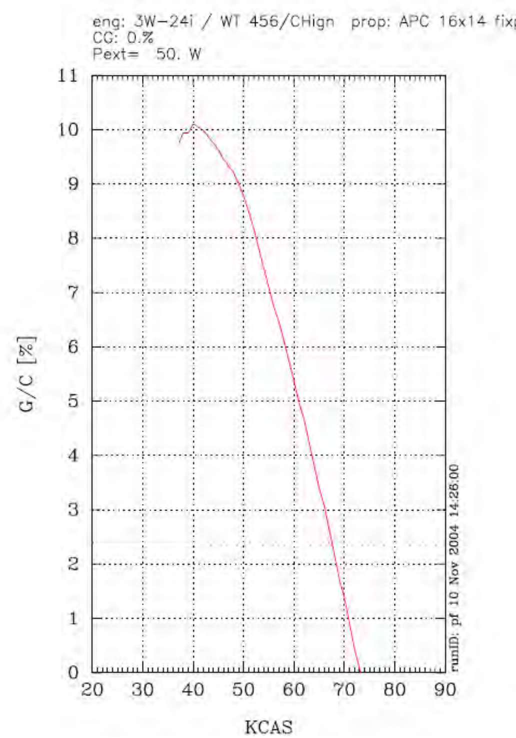
Weight (fixed) = Minimum flying weight, ISA



Gradient of climb

This chart shows the ability to clear obstacles for maximum takeoff weight at sea level and ISA. The climb speed is best rate of climb speed VY with typical payload power on.



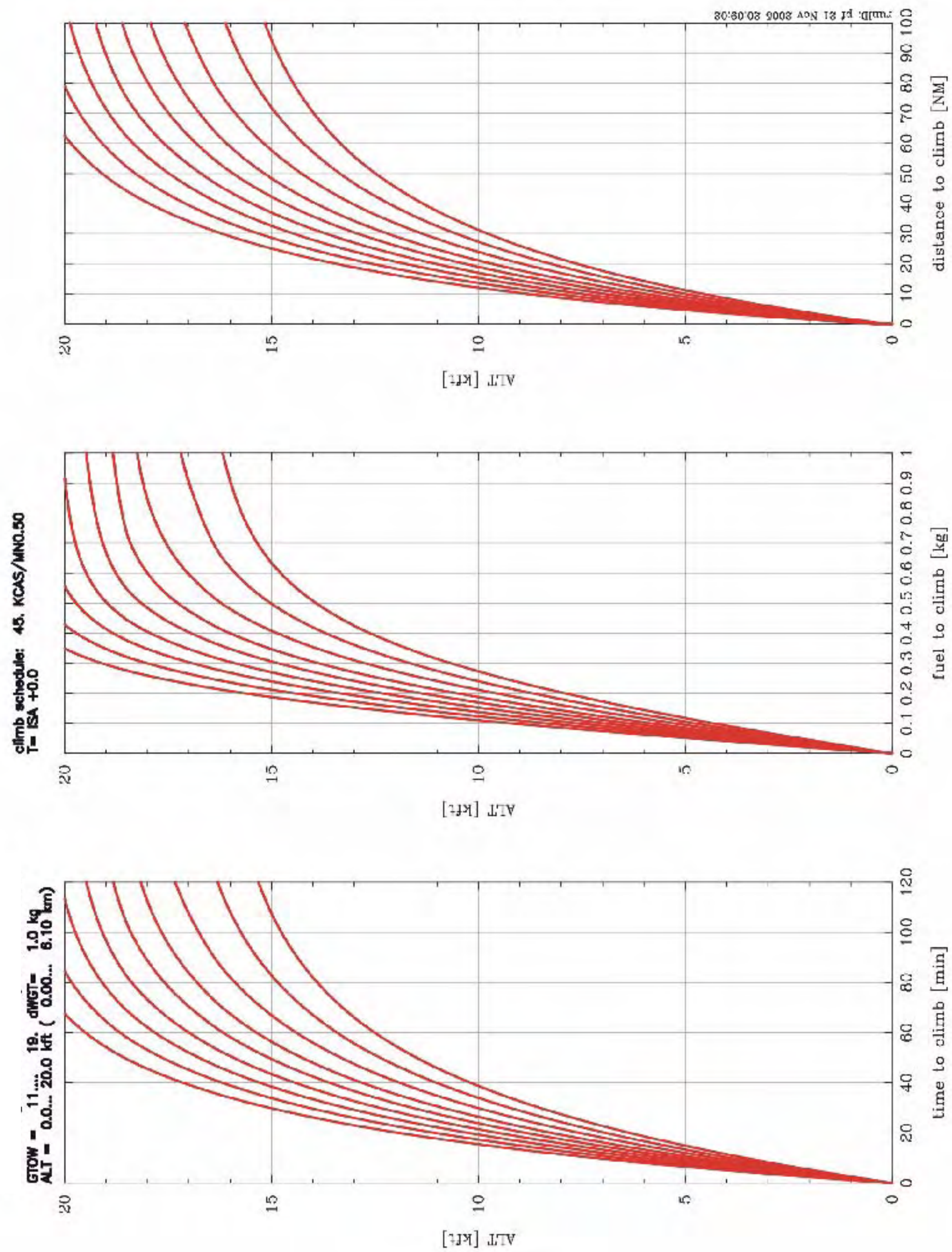


Performance

Climb performance

These charts show unrestricted climb performance, time required, fuel consumed, and distance traveled for the standard weight range, standard temperature, and payload power on. The climb speed used for these chart is best rate of climb speed VY. Lower takeoff weights result in shorter climb times.

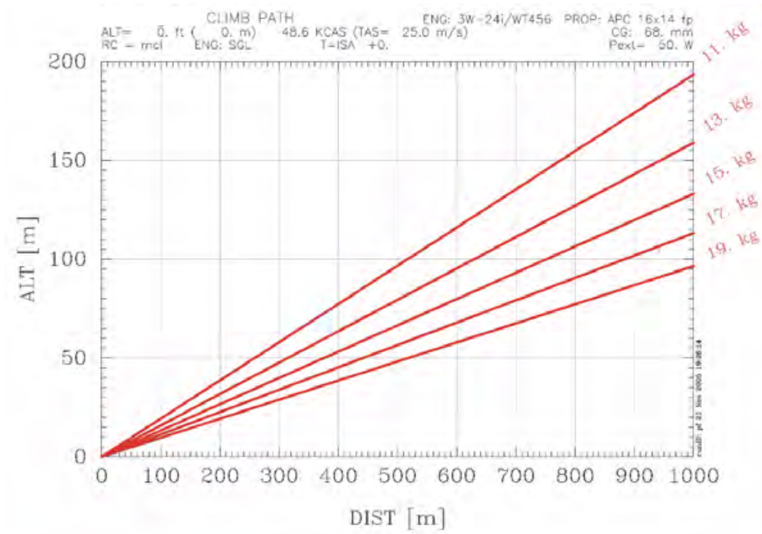
- Time to climb from sea level to 10,000 feet, at MTOW: 34 feet.
- Time to climb from sea level. to 15,000 feet at MTOW: 82 feet.



Performance

Climb path

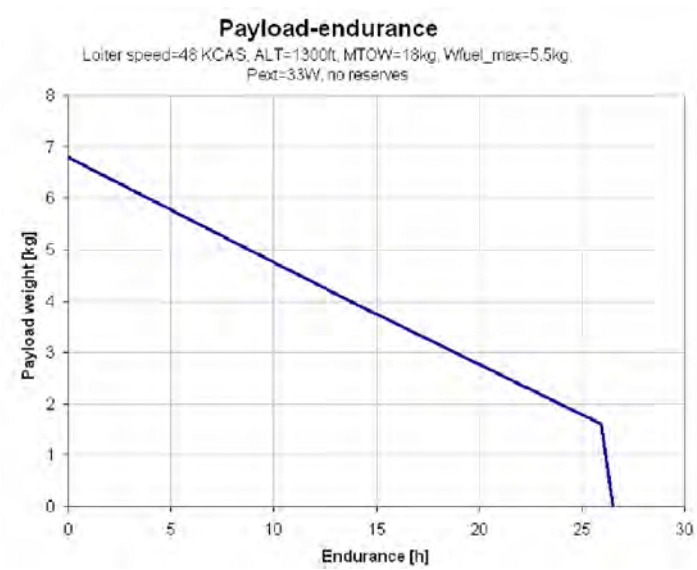
This chart shows climb profile for a standard EO aircraft at maximum power and nominal TAS = 25 m/s (~49 knots), no wind.



Payload endurance

This chart shows endurance based on a basic mission profile with a short climb, loiter at best endurance speed at 1,300 feet, a typical extracted power Pext = 33W, and a short descent. The configuration is standard EO video camera and dome, video, and data link. Max fuel is defined by our largest actual tank configuration with a maximum usable fuel of 5.5 kg (12.1 lbs). The endurance shown is the maximum possible endurance without any reserves.

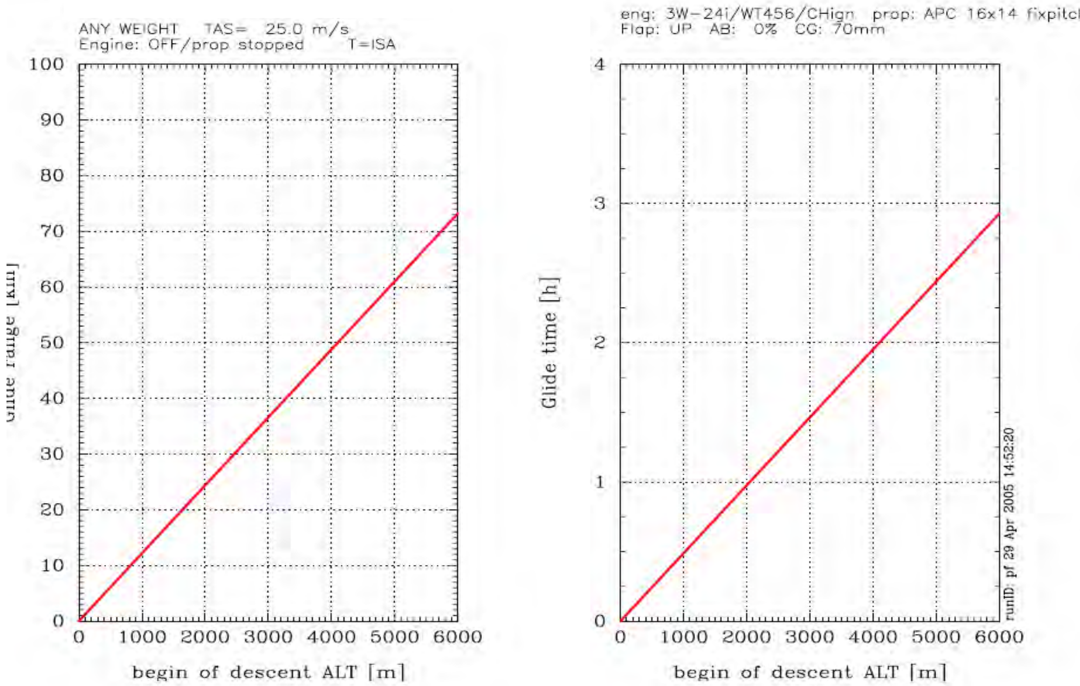
The standard payload (EO or IR video and video link) with fuel weighs about 13.2 lb/6 kg. Higher payload weights can be accommodated (e.g. dual bay video, multiple sensors, etc.) but have to be carefully integrated for weight & balance and volume trade.



Performance

Glide range

This chart shows distance and time for a standard EO aircraft with engine OFF (propeller stopped/not windmilling), NO wind.



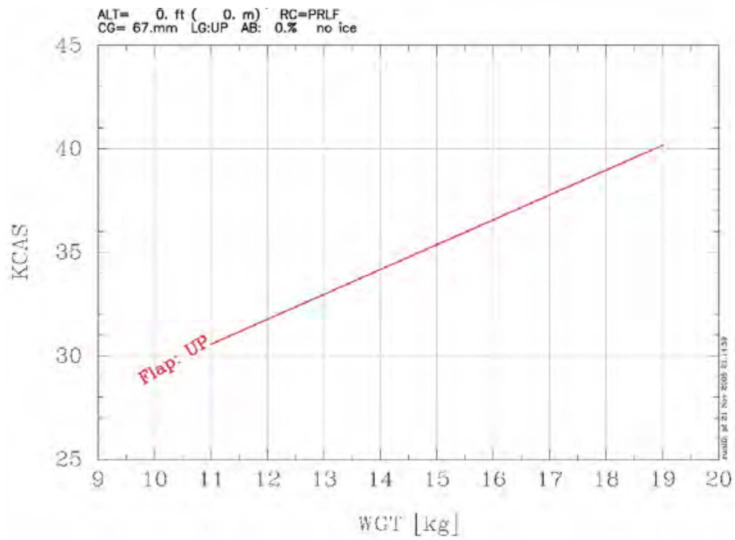
Range – Endurance and range vs. loiter speed

This chart shows endurance and range for a basic mission profile (short climb to 1,300 feet (~400 m)), constant (true air) speed cruise and descent with a typical payload power. Range is of course given for zero wind. The lowest allowable speed for max endurance is limited by stall margin, and best range speed occurs around 48 KCAS.

Performance

Stall speeds

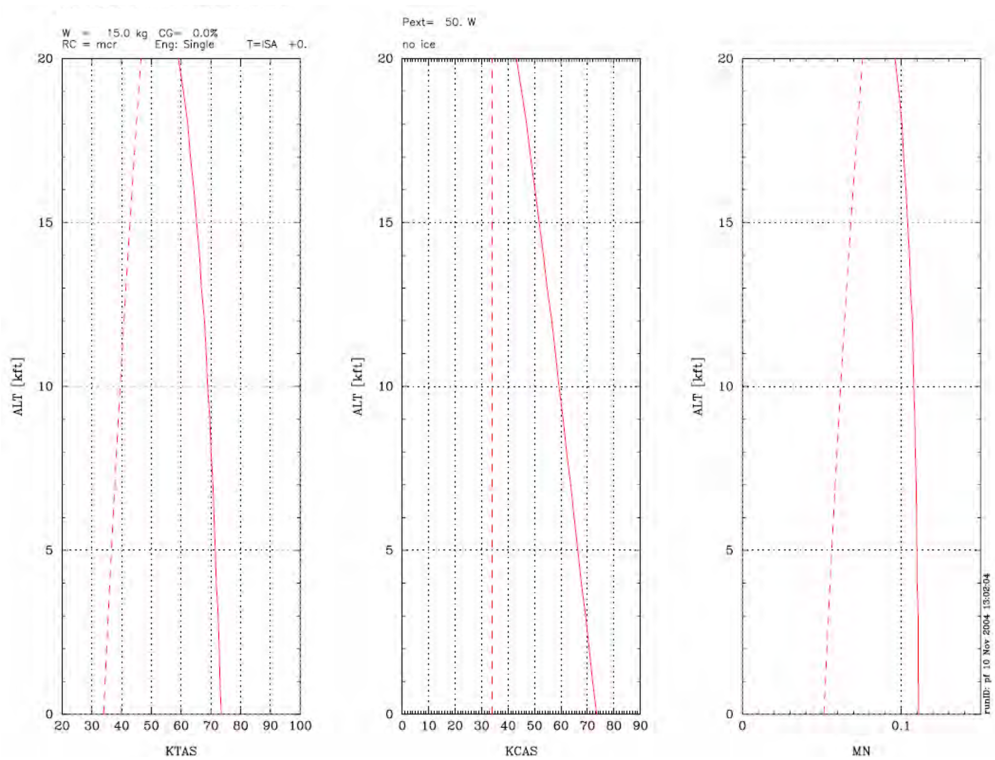
This chart shows stall speeds in function of weight. Since the aircraft has no flaps for a low speed configuration, there is only one line (labeled Flap UP). This chart has been substantiated with flight tests is conservative for all power settings, and is good for nominal center of gravity (CG) location. In practice, a speed margin with factor 1.25 is applied for the allowable minimum flight speed. The maximum allowed lift coefficient is stored in the flight parameter file and is usually set to C_L = 0.68 providing the required speed margin to stall.



Speed envelope

The following chart shows the usable speed range in both true and calibrated airspeeds, and in function of altitude for maximum engine power. The maximum speed shown here is the maximum achievable level speed in function of flight altitude.

For this aircraft, a maximum operating speed limitation (VMO) is not defined. Instead, a minimum CL = 0.20 is set via aircraft parameter file, which corresponds to 85 KCAS at MTOW. The stall limit is valid for the mass indicated in the header.



2

Setup

Chapter Map

2.1 Location

In this section:

- Site survey
- Site survey notes
- Mission risk assessment worksheet
- Maritime operations

Prior to setting up a ground control station (GCS) in a new location, the site must be surveyed to identify and resolve any site issues. Conduct the site survey as soon as practical for any planned location. This section provides guidelines for handling site issues and conditions that need to be considered and addressed prior to a GCS being set up in a new location. Many of these items can be accomplished or researched prior to the actual site survey taking place. However, the site survey should still be conducted as soon as practical for any planned location.

Note: If the system being operated is located inside an Insitu shelter, review the logbook, if one exists, for that shelter as it contains important operational information.

Each system installation on a mobile ground station has different restrictions, such as the availability of space, options on modifying the structure, etc. The launcher may be fixed, or mobile for use on a flight deck that needs to be kept clear. As long as the launcher can point into the wind, have a safe firing direction, and allow simple logistics, it can be placed anywhere. With maritime operations, the SkyHook is normally placed over the side of the ship for safety, and should allow a clear space forward and aft for retrieval maneuvers.

Location

Site survey

Communica-tions

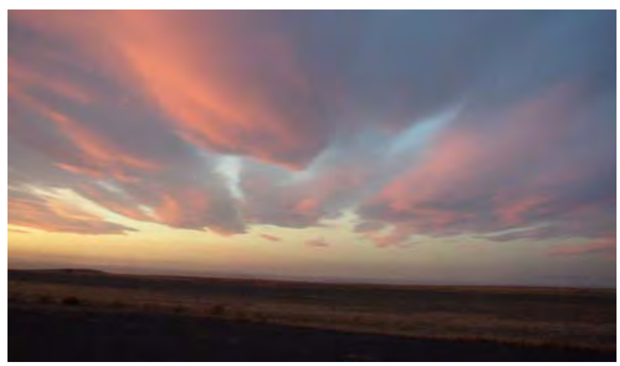
Be aware of the following considerations and requirements regarding communications:

Note: **Before agreeing with the customer about a site location, local frequencies should be checked for interference with system frequencies. These include wireless networks, radars, microwave data-links, and UHF or VHF radios. Currently, the system uses frequencies in the 2400MHz region for video, and either 900MHz or 1300MHz for communication. GPS signal frequencies are in the L band, at approximately 1200-1600MHz.**

- The communications network is a primary topic for discussion for each new location with multiple customers.
- Each GCS has a local intercom system. This is used for launch and retrieval.
- Many sites provide other networks to link to. These may include VOIP (Voice over IP), chat, UHF, VHF and landlines.
- If Forward Eyes is being used, establish a communications protocol for contacting operators.
- Likely bodies that will be in communication are:
    - ATC (Air Traffic Control)
    - Tasking/Customer
    - Analysis
    - Other users of the area

Contacts

If a team is traveling to an unfamiliar location, the appropriate local authorities need to be identified to:



- resolve any potential issues and conflicts, such as special use airspace and security, among others.
- determine the location of services, facilities, and other site amenities.

Having a knowledgeable, local authority on-hand during the site survey is a great time-saver.

Footprint – physical footprint

The physical footprint of a site varies, based on needs and restrictions.

- Optimally, an area approx. 164 feet (50 m) x 328 feet (100 m) is required.
- At a minimum, most setups need a site of about 50 feet square (15 m square).

Important restrictions apply to the positioning of the equipment and the required clearance from obstacles as the aircraft launches or recovers autonomously.

Location	
Site survey	**(cont.)**

Footprint – physical footprint	▪ Optimally, the launch and recovery area is oriented with the wind.
	▪ Optimally, there are no obstacles higher than:
	    ▪ 100 feet (30 m) within 3,300 feet (1,000 m) of the launch and recovery site, along the axis of the intended recovery.
	    ▪ 30 feet (10 m) within 700 feet (200 m) of the launch and recovery site, along the axis of the intended recovery.

Fuel	▪ The availability and quality of fuel needs to be verified. ▪ If fuel is not available, arrangements must be made for fuel to be delivered.
Internet	▪ Having access to the Internet is important for good communication. ▪ Internet access allows contact with Insitu for troubleshooting, updates, and advice. ▪ The Internet may also be used locally for video distribution, tasking, telecommunications via voice over internet protocol (VOIP), etc. In some locations, SPRNET may be used (requires appropriate personnel clearances).
Launch & recovery	A thorough check of the launch and recovery area must be done by the Team Lead. When the site survey is conducted, make sure that you bring with you: ▪ Notepad and pens ▪ Handheld GPS unit ▪ Digital video camera ▪ Digital still camera ▪ A laptop PC loaded with Falconview or local maps When the site survey is conducted, the Team Lead will check the following items: ▪ Predominant winds ▪ Atypical winds (seasonal) ▪ Obstacles for both normal and emergency landing strips ▪ Conflicting operations (ground or flight) ▪ Airspace restrictions or requirements ▪ Locations for cabling and access to telephone, Internet, and power ▪ Various coordinates for emergency runways

Location	
Site survey	**(cont.)**
Misc.	The survey includes: Taking all necessary photographs to accurately describe the location. Shooting videos from both the SkyHook and GCS locations. Videos, at a minimum, could simply be a matter of turning very slowly in the given location while providing a verbal description of the entire area in the viewfinder (e.g. "Now pointing towards the approach direction," etc.). When this visit is complete, the mission file is created, verified, and then loaded onto every aircraft that flies from that site. The mission file defines the emergency runways, the lost comm flightplan, kill radius, and uplink failure timeouts. Using the *Mission Setup Spreadsheet* will help accomplish this task. For additional information about the Mission File, refer to Chapter 3, *Preflight.*
Power	**Note: This item can require significant time and energy to determine and set up. Plan ahead and be prepared.** Requirements vary for GCS and equipment power. The local availability needs to be considered, as well as the type (110/220 V, 50/60 Hz). Many GCS will have their own generator, but may need back-up power, or power for other support equipment. Typical power requirements for a GCS, S-VEST, or HiL setup might be 110 V 60 Hz on a 20 A circuit (max draw around 16 A). Depending on the site configuration, there may be other requirements. For example: ▪ **Shelter:** May be 110 or 220 V, 50 or 60 Hz, drawing between 10 and 40 A. Some shelters have internal generators. Normally, the largest draw is the environmental control unit (ECU). ▪ **Trailer:** Small trailers often use a 5500 to 7500 W generator. **Note: UPS systems installed in the GCS, S-VEST, and HiL are rated 110-240 V, 50-60 Hz. Operation at non-standard US (110, 60 Hz) levels is, as of yet, untested.**
Shipping	The best method of shipping items to and from Insitu and the site should be evaluated and set up.

Location		
Site survey notes		
GCS location	Lat:	Lon:
SkyHook location	Lat:	Lon:
GCS & SkyHook altitude		
Runway heading		
Prevailing winds		
Normal approach		
Expected heading(s)		
Pattern altitude		
Other anomalies		
Emergency runway #1		
Threshold	Lat:	Lon:
Touchdown	Lat:	Lon:
Runway length		
Runway width		
Touchdown altitude		
Emergency runway #2		
Threshold	Lat:	Lon:
Touchdown	Lat:	Lon:
Runway length		
Runway width		
Touchdown altitude		
Safety limits		
Minimum altitude		
Safe altitude		
Housekeeping flightplan		
Waypoint 92	Lat:	Lon:
Waypoint 93	Lat:	Lon:
Waypoint 94	Lat:	Lon:
Waypoint 95	Lat:	Lon:
Waypoint 96	Lat:	Lon:
Waypoint 97	Lat:	Lon:

Location

Mission risk assessment worksheet – Unmanned aerial systems

Date: ______________________________

Mission: ______________________________

Assessor: ______________________________

		Points Assigned
Mission Type	[Range/Local=1; Maint/Test Flt=2; Tactical=3;]	_____
Crew Assessment		
Planning Time	[In Depth=1; Adequate=2; Minimal=3]	_____
Mission Commander Experience	[>50 Hrs=1; < 50 Hrs= 3]	_____
Operator Experience	[>50 Hrs=1; < 50 Hrs= 3]	_____
Crew Duty Day	[8Hrs=1; 8-12Hrs=2; 12-16Hrs=4]	_____
Length of Rest Period	[8Hrs=1; 4-8Hrs=3]	_____
M/C Flt Time in Area	[>20Hrs=1; 10-20Hrs=2; <10Hrs=3]	_____
Operator Flt Time in Area	[>20Hrs=1; 10-20Hrs=2; <10Hrs=3]	_____
Weather		
Visibility	[>7nm=1; 3-7nm=2; <3nm=3]	_____
Ceiling	[Unltd=1; <5,000=2; <1000=3]	_____
Thunderstorms	[None=1; Few=2; Scattered=3]	_____
Dust Storms	[None=1; Light=2; Occluded=5]	_____
Winds		
Headwinds	[<10kts=1; 10-20kts=2; >20kts=3]	_____
Crosswinds	[<5kts=1; 5-10kts=3; >10kts=5]	_____
Gusts	[<5kts=1; 5-10kts=3; >10kts=5]	_____
GPS Satellites	[4 or more=1; 3 or less=5]	_____
	TOTAL RISK ASSESSMENT	_____

Risk Assessment Action:

<25 Points [Low Risk]:	No Action Required
25-30 Points [Medium Risk]:	Notify Mission Liaison or Flight Director
>30 Points [High Risk]:	Notify Mission Liaison & Reporting Authority

Location	
Maritime operations	
Data – distribution of ISR data	There are inevitably demands for reproduction of video in various locations throughout a ship. In a convoy situation on land, the intelligence gained through the use of the aircraft needs to be distributed. There are a number of options for video distribution through raw video, networked video, Forward Eyes, and other methods. Expect each installation to vary in what is available (local networks) and requirements for remote display.
Deck requirements	The availability of space on deck should account for the need of: ▪ An observer for approach, handling wave-off with the Clear-to-land switch. ▪ Use of pilot's console to assist in control wheel tracking (CWT) if necessary. ▪ Preflight of the aircraft and tie-down of the handling box. ▪ Storage of tools, fire extinguishers, etc. ▪ Hands-free communication needs to be available between the operators on deck and the control room. ▪ Approach path that provides a safe distance between the aircraft and superstructure (i.e. heading offset).
Environment	The operating environment will be harsher than is normally expected on land, and requires the following considerations: ▪ Test electromagnetic interference (EM)I before flight, particularly with radars. ▪ In a marine situation, plan for salt water conditions, and design the ground station hardware with this in mind. ▪ Regularly check the aircraft, connectors, etc., for corrosion, and provide maintenance as needed. ▪ Manage operator duty time on the possibility of sea-sickness, if necessary. ▪ Ideally, situate ground station computers in a position where a view of the horizon is possible, as this minimizes motion sickness. ▪ If necessary, define restrictions on sea-state, visibility, wind, and precipitation.
Fuel load SOP	For operation on a mobile ground station, various factors can add up to increase the chance of unexpected situations arising. This could be due to issues with the SkyHook, other users, interference, or a potentially harsh environment. With this in mind, and the fact that at sea there is little chance for a successful belly-landing, standard procedure is to launch with plenty of extra fuel on board. With the ability to motor into the wind, the weight at which an aircraft can be launched is also increased, as this reduces the requirements of the launcher. The climb-out path is also likely to be free from obstacles, so a fast climb is not always necessary. The use of scales to measure fuel load on the aircraft might be difficult, especially at sea. This requires the use of a graded container to measure volume, not weight. As a rule, the specific gravity of oil mixed premium unleaded is about 0.74. This means 1 liter of fuel weighs 0.74 kg.

Location

Maritime operations (cont.)

Preparation & planning

Retrieval simulation

Before installation and deployment, perform a retrieval simulation with estimated base motion. Provide the following estimates for the simulation:

- Ground station speed
- Roll and pitch amplitudes
- Period at the expected retrieval point

There is a point where the expected base motion is too great to perform a reliable capture. In this situation, limits must be imposed on flying conditions to avoid damage or inability to land. The maximum cross-track amplitude that can be followed by the aircraft is:

$$Y_{MAX} = \frac{gP_{MAX}}{\left(\frac{2\pi}{T}\right)^3}$$

- where Y_{MAX} is in meters, P_{MAX} (roll rate) is 0.1 rad/s, and g 9.81 m/s^2; T = Roll period in seconds

With an imposed limit on roll rate of 0.1 rad/s while on final approach, a reference table can be composed as shown.

Ship Roll Period [sec]	Y_{MAX} [m]
5	0.49
8	2.02
11	5.26
14	10.85
17	19.43

Preparation & planning (cont.)

Mission file design

The potential for the ground station to move a long distance in flight requires some consideration in mission file design:

- It may be necessary to reprogram day-to-day if there is no plan to return for a while.
- For operation over water, the availability of suitable runways on land may need to be found, but it is likely that the timeouts will be set so that the aircraft stays in the holding flightplan for a long time before attempting to land. Runways could be located in open water.
- Keep the lost communication flightplan in a location where the ground station can access it before the timers run out. This may be the expected position of the ship at the end of scheduled flight.

Storage requirements

For installation into a new location, areas need to be set aside for storage and maintenance of aircraft and spares. Whenever possible, use dehumidified storage facilities.

2.2 Launch Systems

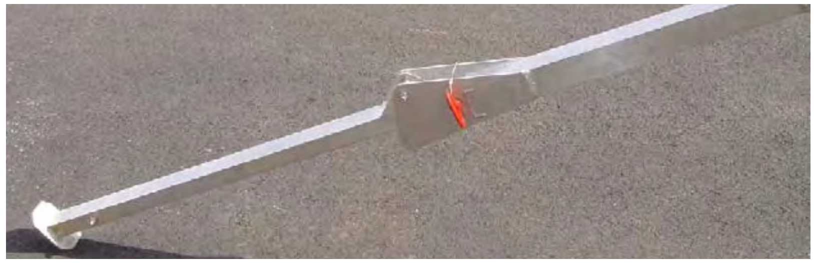
In this section:

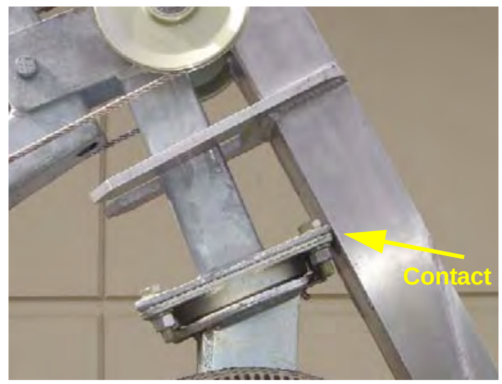
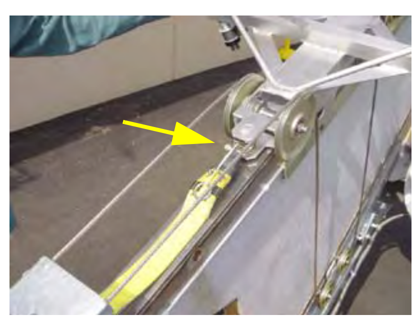
- Launcher setup
- Carriage installation

Prior to carrying out a launch, the operator must meet all requirements in preparing for the launch, performing inspections, and setting up the launcher correctly. Use the following instructions to set up the launcher for operation.

Launch Systems		
Launcher setup		
1	Roll onto a level field and face into the wind. (Picture shows launcher in stowed position.)	**Note: Launcher will roll forward as it is erected.** 
2	Extend outriggers and secure with pins.	
3	Rotate kickstand forward and lower it to the ground, keeping fingers away from the hinge.	**CAUTION: Take care when raising and lowering the leg. Always perform this task with two people.** 

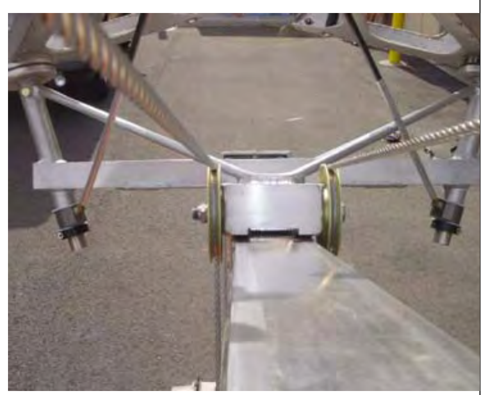
Launch Systems

Launcher setup	(cont.)
4 Fold the leg over to extend it, and then secure it with the red pin.	
5 Locate steel braided cable and winch on side of launcher.	
6 Extend cable, then hook to eye located under front leg. Ensure that the cable lies on the ground.	**CAUTION: Do not pass the erecting cable over the drawbar handle, as this will cause the rope to break, and the launcher will lurch and throw the handle.**   

<table>
<tr><th colspan="2">Launch Systems</th></tr>
<tr><th colspan="2">Launcher setup (cont.)</th></tr>
<tr><td>7 Turn winch handle clockwise to pull in cable. This lifts launcher to erect position.</td><td></td></tr>
<tr><td>8 Make sure post guides into slot as you raise launcher. Stop cranking launcher when caster plate contacts leg. Launcher will be erect.</td><td></td></tr>
<tr><td>9 Make sure carriage is pulled back. If not, locate cocking winch at rear of launcher and unwind strap. Feed strap through hole in aft post, then attach and crank back.</td><td></td></tr>
</table>

Launch Systems

Launcher setup (cont.)

10 Walk around the launcher and verify that the transmission rope runs through all pulleys and that the launcher does not lean excessively to one side when erect.	 
11 Verify bottom rollers are centered on bottom track, and upper rollers are centered on top track.	  

Launch Systems

Carriage installation

These instructions describe the installation of the upper and lower carriages.

Note: Two people are required to complete this procedure.

CAUTION: At all times during this procedure, an operator must support both the upper and lower carriages to prevent them from falling, while the other operator performs these steps.

1 Route the transmission cable on the launcher to prepare for carriage and bogey installation:

a. Begin at the looped swage.

b. Guide the cable through the 180-degree turn around the piston rod pulley.

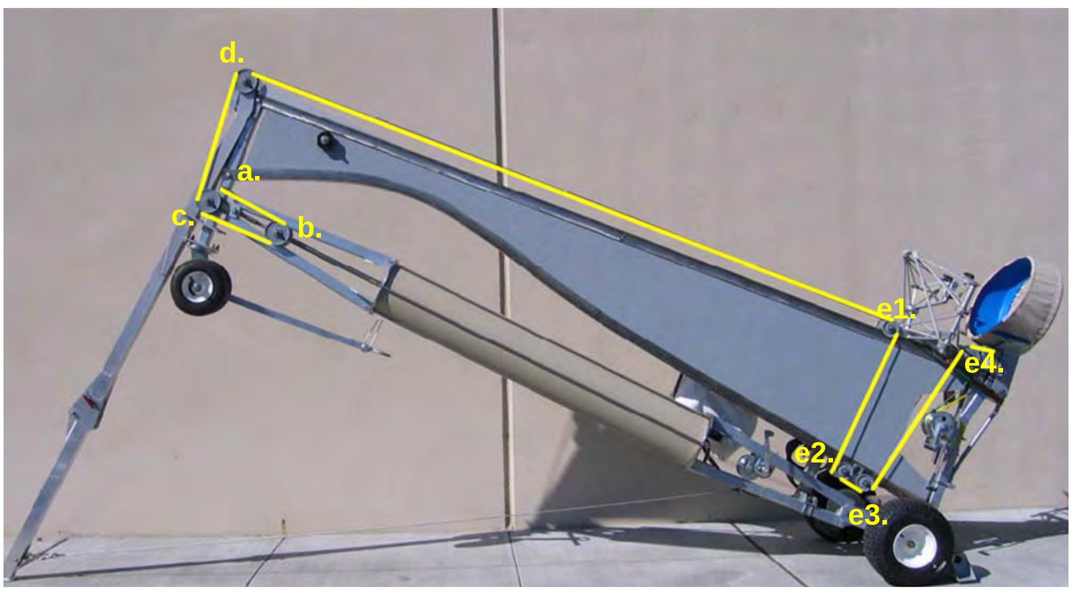
c. Guide the cable through the 90-degree bend around the lower pulley on the forward post.

d. Guide the cable through another 90-degree bend around the upper pulley.

e. Guide the cable through four final 90-degree bends

Note: When the carriage is not installed, the cable feeds directly to the u-turn pulley located in the dog house.

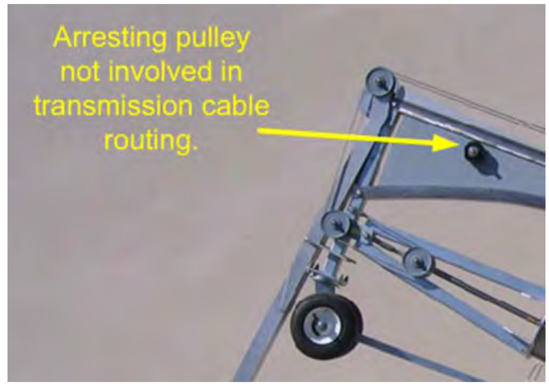
f. Repeat this step for the other side of the launcher.



Launch Systems

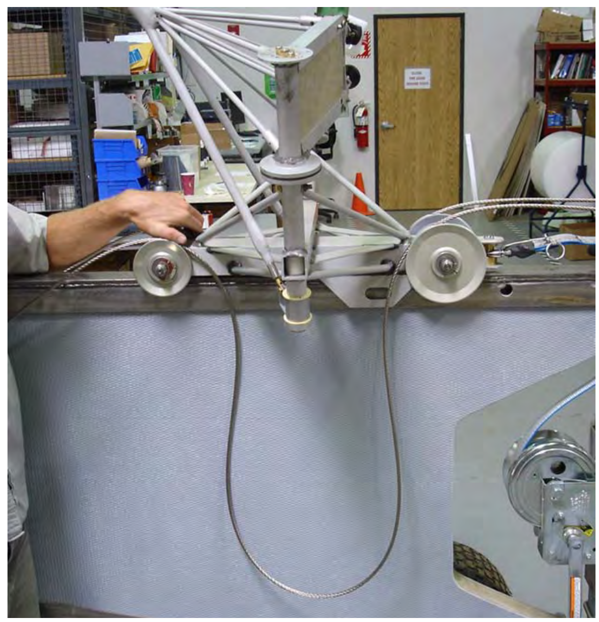
Carriage installation (cont.)

Note: **Transmission cable routing does not involve the black arresting pulleys located in the middle of the track.**



2 Place the upper carriage on the upper rail of the launcher. Attach the trigger release shackle to the brass pull back roller to minimize the distance the carriage will fall should it come off track.

CAUTION: At all times, an operator must support both the upper and lower carriages to prevent them from falling, while the other operator performs these steps.



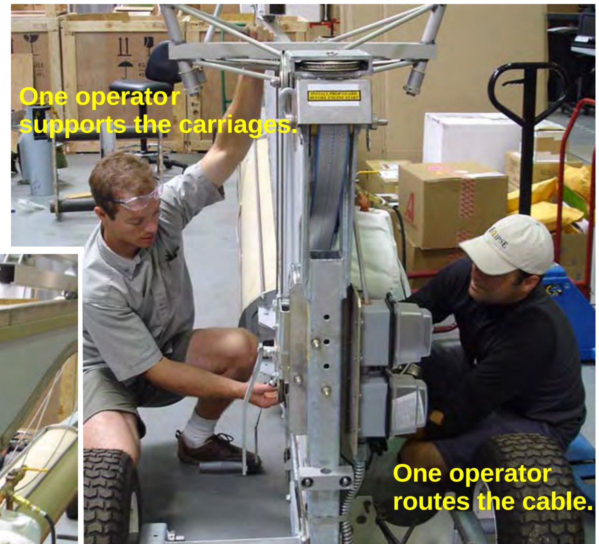
Setup 2

Launch Systems

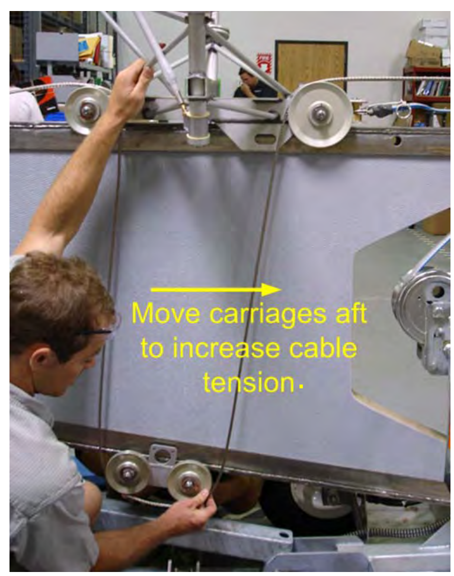
Carriage installation (cont.)

3 One operator simultaneously supports the upper and lower carriages while the other operator routes the cable.

Position the lower carriage and route the cable.



Note: If the cable is too tight to position over the pulleys, move both the upper and lower carriages forward several inches. This decreases the distance between carriages, thus decreasing cable tension. Once the cable is routed over the pulleys, carefully move both upper and lower carriages aft to increase cable tension until both carriages are secure against the track.



4 Ensure that the transmission cable is running over all of the 15 pulleys. (There are 14 paired pulleys and one u-turn pulley.)

5 Winch the carriage to the home position against the dog house, insert the safety pin, and check that the rollers are centered on track

2.3 Retrieval Systems

In this section:

- Location and environment evaluation
- SkyHook function tests
- Boom system assembly

Retrieval setup is comprised of the three segments in this section. Prior to operating a retrieval, the operator must set up the SkyHook correctly. The patented SkyHook retrieval system captures Insitu's UAV. The aircraft approaches using the SkyHook's GPS unit and antenna, via a signal relayed through the If/C (interface computer).

Approach

Snagged

Retrieved

When the aircraft comes in contact with the SkyHook rope (suspended from 49 feet (15 m) above the surface), a hook on the aircraft wingtip grabs the line and quickly stops the aircraft. The aircraft then hangs suspended from the rope, until lowered by the SkyHook operator.

Retrieval Systems	
Location and environment evaluation	
Note: When planning and locating SkyHook, in addition to these guidelines, consider wind, weather, and obstacles	
Crosswind – strong	An on-track SkyHook approach in a strong crosswind is likely to lead to the rope lodging at the wing root, instead of cleanly snagging the aircraft as planned. This is caused by the rope hitting the downwind side of the fuselage, where it slides to the wing root and stops. The sawing action of the rope could cause the aircraft to pitch wildly and fall. **Note: For operation limitations in crosswinds, refer to the *Standards & Limitations* section of Chapter 1, *Overview.***
Site inspection	Site inspection assists in determining if a site is suitable for safe operation. Read and remember these hazards, then watch for and avoid them while moving, setting up, and operating the machine: ▪ Drop-offs or holes ▪ Bumps or debris ▪ Slopes that exceed the machine's leveling capability ▪ Unstable or slippery surfaces ▪ Overhead obstructions and high voltage conductors ▪ Inadequate surface support to withstand all load forces imposed by the machine ▪ Presence of unauthorized personnel ▪ Other possible unsafe conditions

Retrieval Systems	
SkyHook function tests	
Note: These tests are designed to discover malfunctions. Remove from service immediately a malfunctioning machine.	
Set up	1 Position the machine and set the parking brake. 2 Disconnect the trailer lights, safety chains, and brake cables from the vehicle. 3 Open the latch on the ball coupler. 4 Pull the jack release handle and rotate the tongue jack to the lifting position. 5 Raise the tongue by turning the jack handle. 6 Be sure the boom hold-down latch is unlatched. 7 Be sure the batteries are connected.
Use the ground controls  	1 Insert the key and turn to Ground Control. 2 Pull out the red Emergency Stop button to the on position. **Auto level:** Push and hold yellow Function Enable button. Push and hold Auto Level button. Outriggers lower and adjust to level the machine and raise wheels off the ground. Level machine using only outriggers. Use the bubble level to ensure machine is level. **Manual level:** Push and hold the yellow Function Enable button. Push and hold each outrigger button to lower the outriggers. Adjust the outriggers to level the machine and raise the wheels off the ground. Level the machine using only the outriggers. Use the bubble level to make sure the machine is level. 3 Be sure the wheels and the tongue jack are not touching the ground. If wheels on tongue jack touch ground, crank the tongue jack up until the wheels are no longer on the ground. It may be necessary to re-level.
Test the tilt sensor	1 Locate the tilt sensor next to the forklift pocket on the side of the machine opposite the ground controls. 2 Press down one side of the tilt sensor. **The alarm should sound.** 
Test emergency stop	1 Push in the red Emergency Stop button to the off position. **All ground and platform control functions should not operate.** 2 Pull out the red Emergency Stop button to the on position.
Test boom functions and function enable	1 Do not push a Function Enable button. Attempt to activate each boom function button. **All boom functions should not operate.** 2 Push and hold the blue Function Enable button. Activate each boom function button. **Boom functions should operate.** 3 Push and hold the yellow Function Enable button. Activate each boom function button. **Boom functions should operate.**
Test outrigger interlock	1 Place the boom in the stowed position. 2 Push and hold the blue Function Enable button. Push and hold one outrigger button and raise the outrigger off the ground. 3 Push and hold the blue Function Enable button and activate each boom function. **All boom functions should not operate.** 4 Use the leveling buttons to lower the outrigger. 5 Repeat this procedure for each outrigger. 6 Use Function Enable and Auto Level buttons, or outrigger leveling buttons to ensure machine is level. 7 Raise the platform approximately 2 feet (60 cm). 8 Push and hold the blue Function Enable button and attempt to raise each outrigger off the ground. **All boom functions should not operate.**

Retrieval Systems

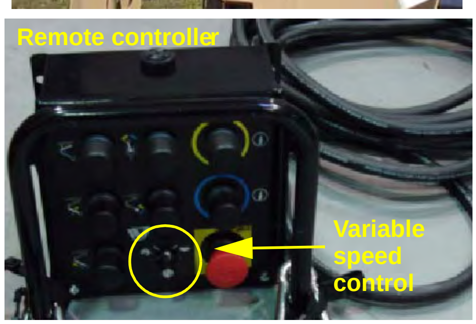
Boom system assembly

1 Note where the boom sections, crossbar, and king post are stowed. Remove any securing pins, and then remove these sections from their storage brackets before operating the machinery.

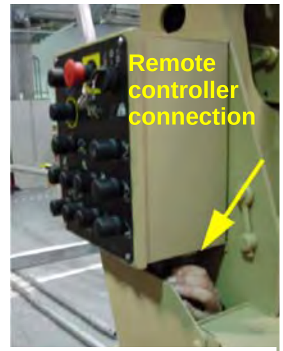
WARNING!

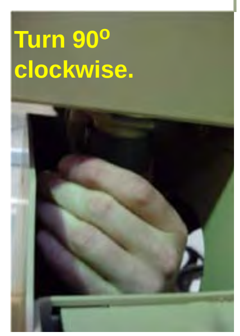
Never operate the SkyHook without first removing the boom sections, the crossbar, and the king post from their stowed locations. Failure to do so will damage the SkyHook and could seriously injure personnel.

Note: **SkyHook can be controlled from the remote controller or from the main console panel. In most instances, the remote controller, which is equipped with a variable speed control, is used.**

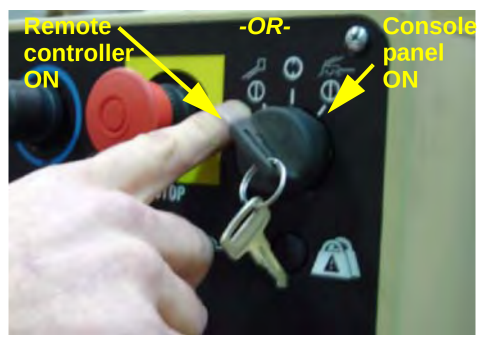


2 Connect the remote controller to the bottom of the main controller panel, and turn it clockwise 90^{o}, making sure it locks in place.





3 Turn switch on at console panel.



4 Lower legs using auto-level feature.

Setup 2

Retrieval Systems

Boom system assembly (cont.)

5 Install the crossbar and the king post on the SkyHook.

Note: Be sure to insert all hitch pins and secure with cotter pins.

6 Insert the two hitch pins that secure the inner and outer boom section assemblies, and then secure with cotter pins.

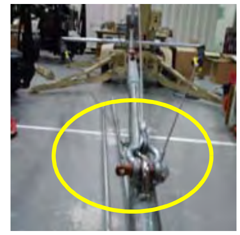
7 Install the inner boom section assembly and the outer boom section assembly.

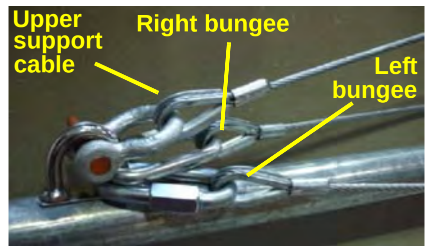
Note: Be sure to insert all hitch pins and secure with cotter pins.

Note: Ensure that crossbar is positioned symmetrically.

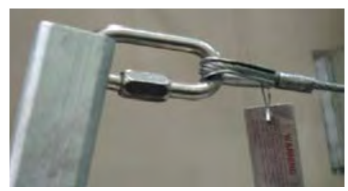
8 Ensure that there is slack in the GPS cable, so that it won't bind during operations.

9 Note cable configuration at boom connection point. The system is set up in this configuration when shipped.





10 Attach upper cable to king post.



Note: IMPORTANT! Threaded connectors should be fully-threaded closed before loading.

Note: Ensure that upper support cable does not get hooked on any part of boom system assemblies.

Retrieval Systems

Boom system assembly (cont.)

11 Attach side cables and lateral bungee loops as follows:

a. Operator #1 rotates the boom at the tip.

Note: Main boom needs to be resting in cradle to prevent rotation of turret.

b. Operator #2 attaches bungees.

c. After first bungee is attached, operator #1 rotates boom, stretching the attached bungee and allowing the attachment of the second bungee.

d. Force at boom tip will be ~75-100 lbs. (~34-45 kg) and needs to be sustained for up to 1 minute. A third operator should be present if this is outside the capability of operator #1.

e. Boom tip should continue to be held until oval threaded connector is completely threaded. Failure to do so could result in incomplete thread engagement and could cause failure.

WARNING!

Slow release of the boom is essential to prevent operator injury.

12 Check bungee compliance as follows:

a. Operator #1 holds a tape measure from center of boom tip out 2 feet (61 cm) laterally.

b. Operator #2 uses provided pull scale to measure force at one- and two-foot (30.5 cm and 61 cm) displacements, acceptable ranges are:

- 1 ft (30.5 cm) = 9-15 lbs (4-6.8 kg)
- 2 ft (61 cm) =18-27 lbs (8.1-12.2 kg)

c. Measure in both directions.

d. If boom compliance is outside of range, contact an Insitu representative.

Note: Main boom should be resting in the cradle when performing this test, otherwise the turret will rotate and throw off the measurement.

Retrieval Systems

Boom system assembly (cont.)

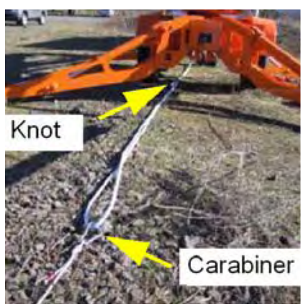
13 Using carabiners, attach a pulley to eyelets at inner and outer ends of the boom assembly. Feed capture rope through pulleys. Run out entire length of capture rope to ensure there are no kinks, knots, or twists.

14 Capture rope system assembly:

a. Capture rope assembly should be assembled after upper boom is complete, including GPS cable.

- Capture rope runs underneath upper boom and all cables, free from all obstructions.
- Both ends of capture rope should be tied in a figure-eight knot.

b. Three-foot lengths of chain attach to Genie. Lower capture line runs under SkyHook and attaches to Genie manlift at farthest point from lower pulley.



- One carabiner is used to lock the chain to the Genie. Wrap chain around Genie, and attach to a link in the chain, leaving a long length of chain to attach to the bungee.

- Use another carabiner to attach lower bungee to the last link in the chain (closest to the lower pulley). This will be used to adjust final capture rope tension after SkyHook is fully erect.
- Use another carabiner to attach capture bungee to figure-eight knot in capture rope.

Note: The knot in the bungee should reside near the midpoint of the bungee, not the ends.

c. Upper bungee chain attaches to one of the Genie outriggers opposite the boom, near foot of outrigger.

- Run chain through the outermost access hole in the outrigger.
- Attach bungee and capture rope in the identical manner as the lower bungee.

d. Temporarily secure, or have someone hold, the capture rope before raising the boom, so that it does not become entangled.

Retrieval Systems

Boom system assembly (cont.)

15 Ensure that the latch (next to the control panel) is unlatched before raising the boom.

16 Using remote, raise and extend all booms to full height. King post should be nearly vertical, resulting in boom being ~20^{o} from horizontal.

17 Position the capture line vertically from the tip of the boom. Use a carabiner to attach the pulley to a rope connected to a stake.

a. The distance from the base of the SkyHook to the stake will be approx. 25 feet (7.6 m).

b. Drive T-post into ground at a 20^{o}-40^{o} angle from vertical, away from the SkyHook.

Capture rope testing and adjustments

18 Perform a tension test on the capture rope. Make adjustments as needed. The tension test should be performed at the lower bungee-connection to the chain.

a. Pull and release the capture rope several times, via vertical capture rope, and observe that the capture rope is translating correctly through all pulleys. Note that the upper and lower bungee is extending relative to the pulling force, without snags.

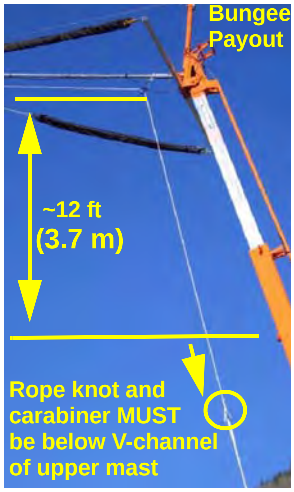
b. Hook scale to lower bungee spring snap and pull 1-2 inches (2.5-5 cm) or until measuring full pre-tension force (18-20 lbs. / 8-9 kg). This can be checked by pulling with 35 lbs. (16 kg), which should result in a displacement of 18-24 inches (45-61 cm).

c. If correct adjustment can not be achieved using upper and lower chain adjustments, the capture rope may need to be shortened by tying figure-eight knot further down the rope. Set chain adjustment at last chain length prior to shortening rope to allow for full adjustment range after rope shortening.

Retrieval Systems

Boom system assembly (cont.)

d. Bungee payout: 12-16 feet (3.7-4.9 m) of bungee payout must be present in system, both upper and lower bungees. This is the distance between knot in the capture rope and nearest pulley.

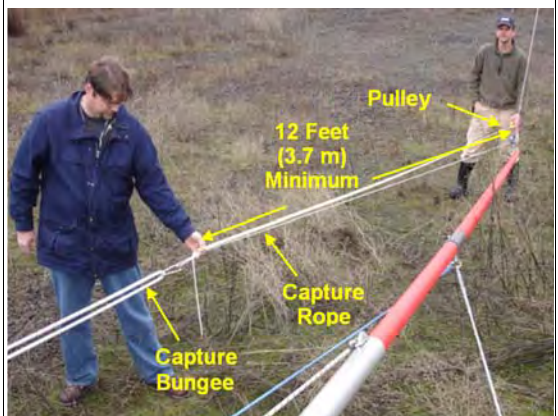


Note: IMPORTANT! This must be measured after the correct rope tension is achieved.

e. Rope condition: Capture rope can become locally frayed at capture point after weeks or months of use, depending on operating and storage conditions. Swap upper and lower rope ends to provide a new unfrayed rope length for the aircraft capture.

Note: Replace deteriorated capture rope.

f. Lower capture rope payout: The capture rope is required to have at least 12 feet (3.7 m) of uninhibited payout to capture an aircraft without inducing damage. The locations of 12 feet of payout on the lower end of the capture rope is shown.



CAUTION: If there is not enough payout distance and the carabiner attaching the capture rope to the capture bungee is allowed to impact any of the pulleys, damage may occur to the aircraft.

SkyHook assembly checklist

- ❑ Capture rope is not binding.
- ❑ Booms are fully extended.
- ❑ Capture rope tension is correctly adjusted.
- ❑ GPS is installed and cable is connected.
- ❑ Capture bungee payout is ample (12-16 ft / 3.7-4.9 m).
- ❑ Capture rope is in good condition.
- ❑ Capture bungees are 17 feet (5.2 m).
- ❑ Capture rope is 90-100 feet (27-30 m).
- ❑ King post is vertical.

Retrieval Systems

Beacon – Optional EO/IR Beacon

The Skyhook recovery system may include an infrared (IR) beacon and/or a visual red (EO) beacon. For ease of use, the IR beacon has an integrated clamp that allows the unit to be positioned in a variety of locations. The optimal location is on the upper portion of the SkyHook kingpost.

Note: Ensure that the unit is firmly clamped before operation.

Maritime SkyHook – Adaptation for land use

The maritime SkyHook can be set up for land-based captures using the Land Adaptation Kit.

Note: There are three options for SkyHook setup when used in this manner.

The Land Adaptation Kit includes:

- T-post
- T-post rope
- Post driver
- Post puller

Option 1

1. Rig the maritime SkyHook, including lower boom and lock bar, using normal setup procedures.
2. When capturing aircraft, the SkyHook turret must be rotated ±90°, and the turret lock pin must be installed.

Retrieval Systems

Maritime SkyHook – Adaptation for land use

Option 2

NOTE: A T-post and T-post rope must be used with this option.

1. Rig the maritime SkyHook, including lower boom and lock bar, using normal setup procedures.
2. Rotate to desired capture position.
3. Install T-post into ground directly below tip of lower boom.
4. Tie T-post rope between stake and tip of lower boom.

Option 3

NOTE: A T-post and T-post rope must be used with this option

1. Completely remove the lower boom and lock bar from the SkyHook.
2. Rig the SkyHook according to land-based SkyHook procedures, with the T-post and T-post rope supporting the lower capture rope pulley.

2.4 Ground Control Station Hardware

In this section:

- Layout
- Antennas
- If/C
- I-MUSE machine
- ObjectTracker computer
- Video A/B switch
- Video channel settings
- ROVER Avionics

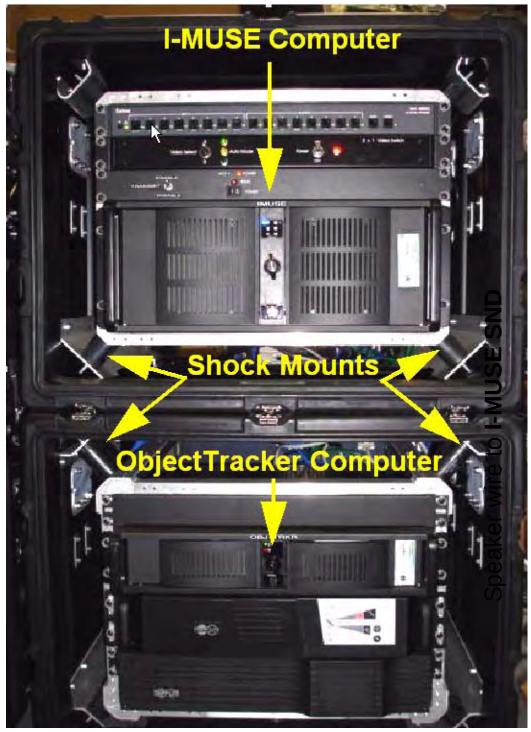
The components and operations of each GCS vary depending on the project. The equipment, layout, and procedures are established by the commanding unit in charge, and training is provided on a project-by-project basis. Use the latest approved checklists for GCS Assembly, Startup, and Shutdown. The checklists are found:

- On Insitu's Extranet.
- In the *Pocket Handbook.*

The Transportable Ground Control Station (TGCS) and the Ground Control Station (GCS) use essentially the same setup procedure for installing and connecting the cables. This section provides general GCS setup instructions.

Layout

Each shock-mounted case with transportable racks is extremely durable, carrying up to 200 lbs. (90 kg). The corners of the cases are fitted with shock mounts to isolate the components from shock and vibration.



Though the cases can be set side-by-side, customarily, they are stacked on top of each other.

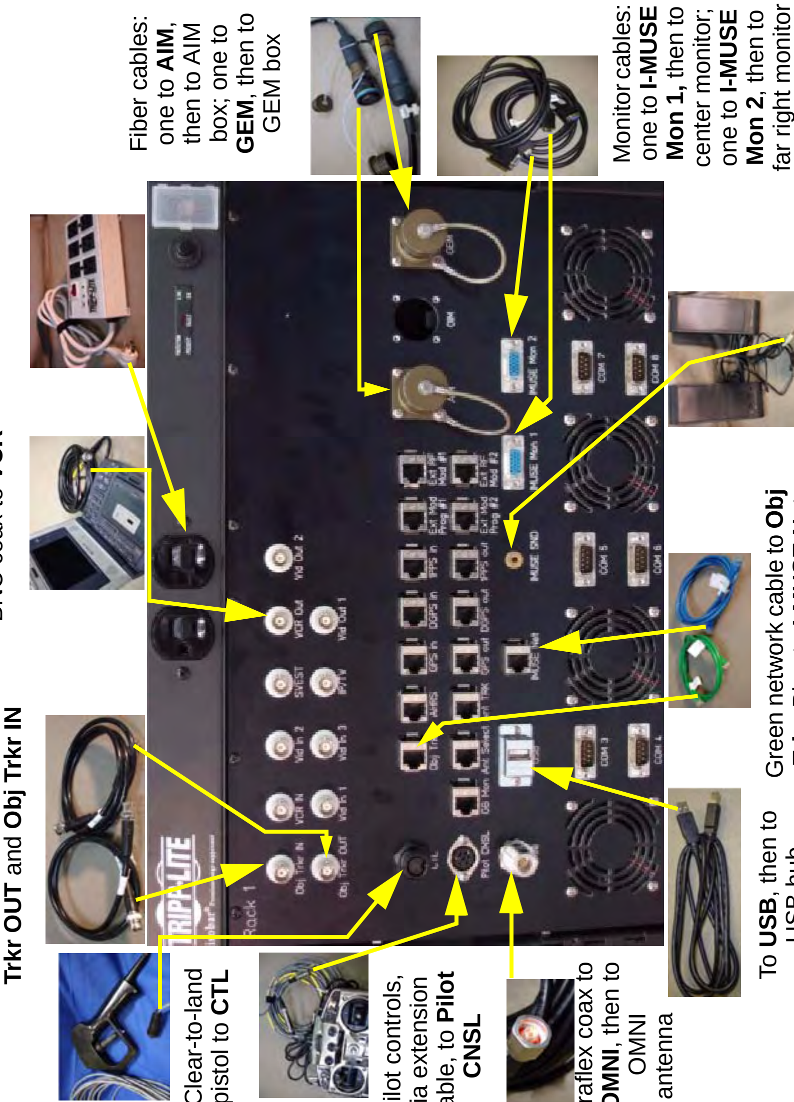
- The top case, *Rack 1*, houses the I-MUSE computer
- The bottom case, *Rack 2*, houses the ObjectTracker computer

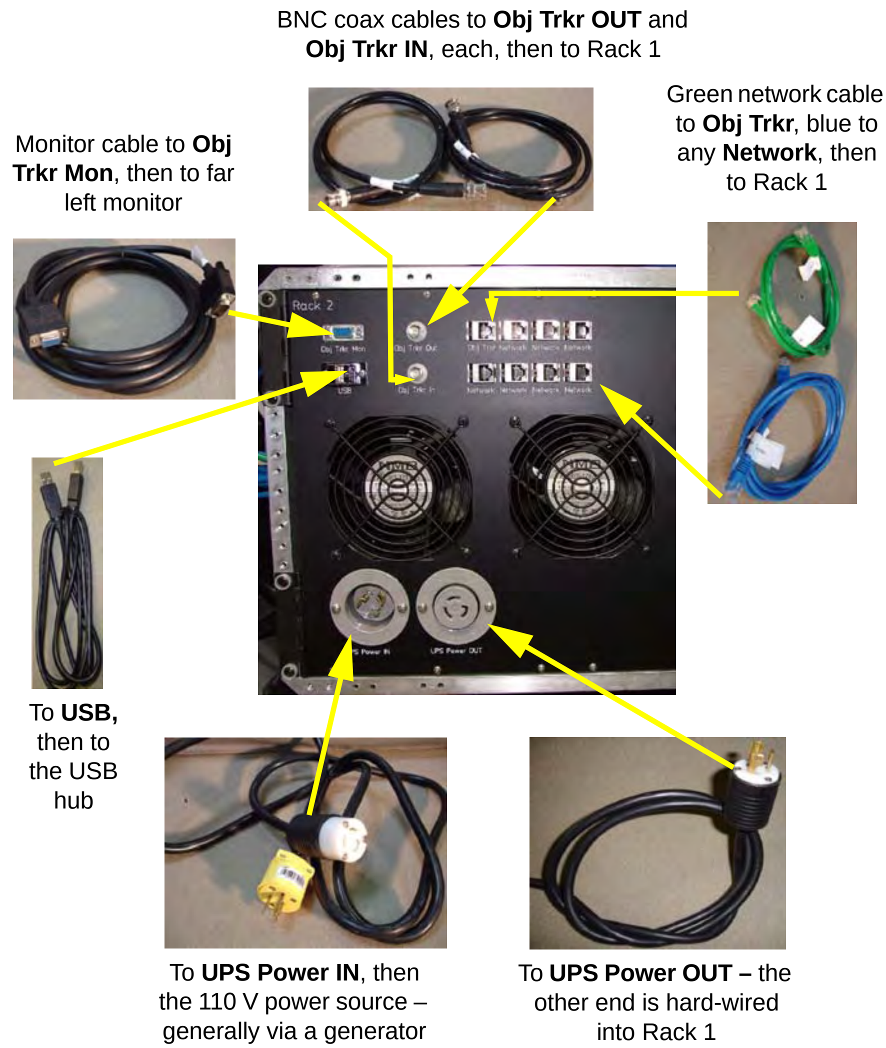
The cases have extra space around the computers to stow and transport cables and gear necessary to connect all the different components of the GCS. The lids house large zipper pouches that can be used to store additional items such as wheels, documentation and cables.

On the side of each case, there is a pressure-release button/valve which equalizes pressure within the sealed box if the outside air pressure changes dramatically, thereby protecting the contents.

Note: Throughout this section, for clarity, the I-MUSE computer (Rack 1) will be on top;the ObjectTracker computer (Rack 2) will be on bottom.

Ground Control Station Hardware	
Layout – Front	
Rack 1	 Components: ▪ **8 x 8 Video Matrix Switch** – Accepts video inputs and directs it to various other components. ▪ **2 x 1 Video Select Switch** – Determines the best video source channel. The **Auto** setting senses the channel with the best video signal, or the operator may force selection to channel **A** or **B**. ▪ **If/C** – An interface box that combines various data and comm signals and directs them to the appropriate destination. ▪ **I-MUSE computer** – The flight computer housed in the bottom section.
Rack 2	 Components: ▪ **Blank plate** – Not used ▪ **ObjectTracker computer** – Used for imagery, payload control, video stabilization, and screen capture. ▪ **Bottom two boxes** – House the uninterruptible power supply (UPS). The bottom box is an auxiliary battery; the upper box is the unit controller and battery. In the event of a power outage, the two-box unit supplies full system power for at least 20 minutes. This backup power allows time to locate the cause of the power outage or to land the aircraft. **Note: All system power flows through auxiliary power units. When powering up or powering down the system, push and hold the power up button for at least two seconds.**

<table>
<tr><th colspan="2">Ground Control Station Hardware</th></tr>
<tr><th colspan="2">Layout – Jack locations</th></tr>
<tr><td colspan="2">Rack 1 contains a surge-protected power strip, video-in/out, If/C in/out, and the I-MUSE computer. Connections are either to: Rack 2, peripherals, or antennas.</td></tr>
<tr><td>Rack 1</td><td>
</td></tr>
</table>

Ground Control Station Hardware	
Layout – Jack locations	**(cont.)**
Rack 2 contains the ObjectTracker computer, network switch, and the back-up power unit for the entire system. Connections are either to: Rack 1, peripherals, or power	
Rack 2	

Ground Control Station Hardware

Layout – Cable connections

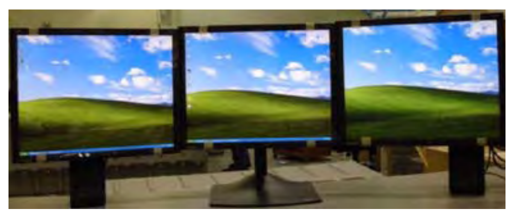
Rack 1

1 Connect one power strip to the other power strip.

Note: Both power strips have surge protectors and receive power via the back-up power unit in Rack 2. It is important to plug all peripherals into these power strips so they will function if there is a power failure.

2 Using the supplied adapter, connect BNC coax to **VCR Out**, then to the recorder.

3 Connect one monitor cable to **I-MUSE MON 1**, then to the center monitor; connect the other monitor cable to **I-MUSE MON 2**, then to the far-right monitor.



4 Connect the USB cable to **USB**, and the other end to the USB hub.

5 Connect the Clear-to-land pistol to **CTL**.

Ground Control Station Hardware

Layout – Cable connections (cont.)

Rack 1 (cont.)

6 Connect the pilot controls, via an extension cable, to **Pilot CNSL**.

7 Connect the ultraflex coax to **OMNI**, then to either the 900 MHz or 1.3 GHz OMNI antenna.

8 Connect one fiber cable to **AIM,** then to the AIM box; one fiber cable to **GEM,** then to the GEM box.

Note: 492 feet (150 m) of fiber is stored on each reel.

9 Connect the speaker wire to **I-MUSE SND**. (See *Layout – Jack locations,* earlier in this table.)

Rack 1 is now complete.

Ground Control Station Hardware

Layout – Cable connections (cont.)

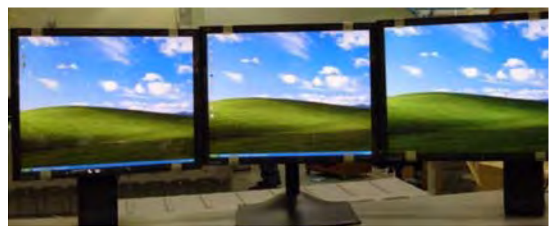
Rack 2

1 Connect one BNC coax cable to **Obj Trkr IN** and the other cable to **Obj Trkr OUT**. Connect the respective ends to Rack 1 – if **OUT** on Rack 2 then **IN** on Rack 1 and vice versa.

2 Connect the green network Cat 5 cable (serial communication) to **Obj Trkr**, and the other end to Rack 1 **Obj Trkr**.

3 Connect the blue Cat 5 cable (network communication) to any **Network** jack, and the other end to Rack 1 **I-MUSE Net**.

4 Connect monitor cable to **Obj Trkr Mon**, and the other end to the far left monitor.



5 Connect the USB cable to **USB**, and the other end to the USB hub.

6 Connect the power cord hard-wired into Rack 1 to **UPS Power OUT**.

7 Connect the final power cord to **UPS Power IN**, and the other end to the 110 V power source – generally via a generator.

Rack 2 is now complete.

Ground Control Station Hardware

Layout – Arranging peripherals (cont.)

The following diagram shows a typical arrangement for a right-handed operator.

Layout – Connecting peripherals

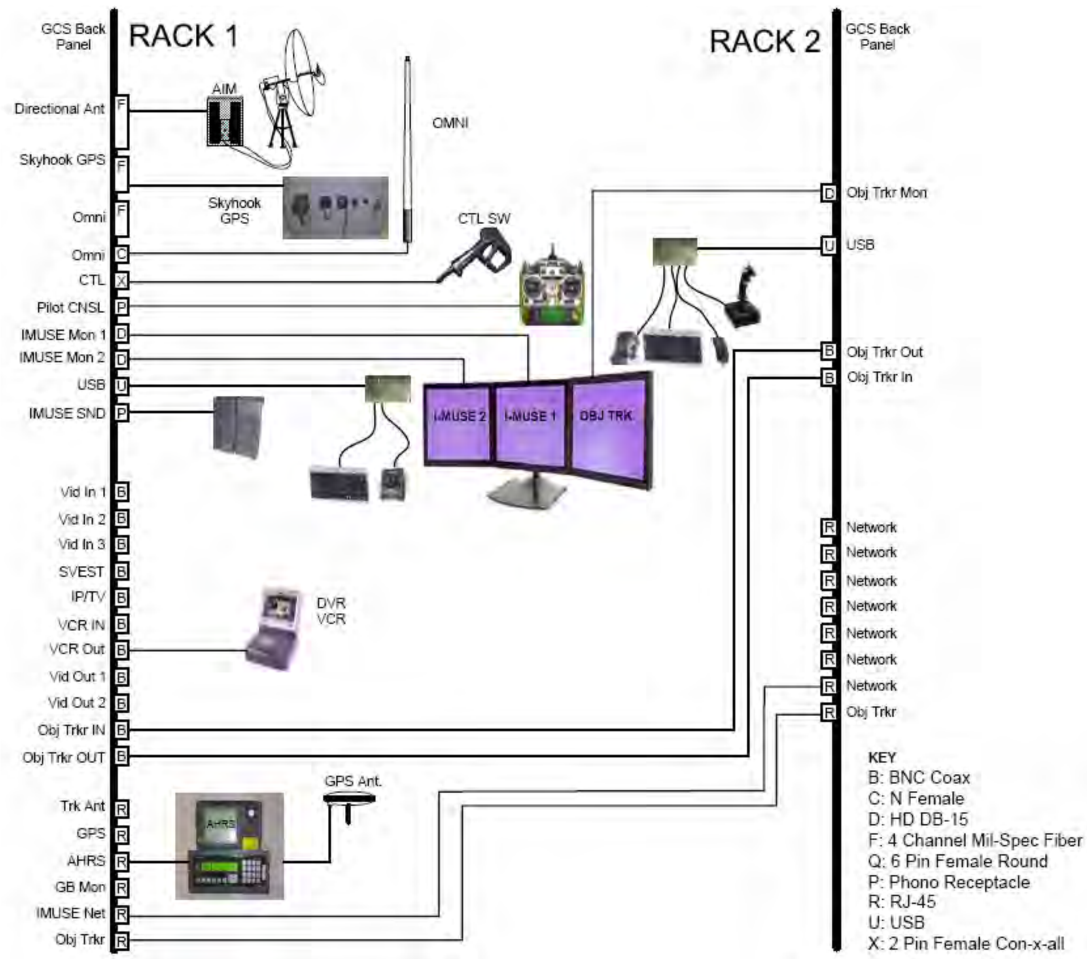
The following diagram details which USB hub each peripheral utilizes. The speakers and video recorder (both from the I-MUSE computer) do not use a USB hub.

1. On ObjectTracker (Rack 2) USB hub, connect keyboard, mouse, fighter stick, and Nostromo pad.
2. On the I-MUSE (Rack 1) USB hub, connect the keyboard and four-button expert mouse.

CAUTION: If a peripheral requires power, use the supplied power strip so it will continue to function if there is a power outage. Remember, the battery unit supplies 20+ minutes of reserve power for the complete system.

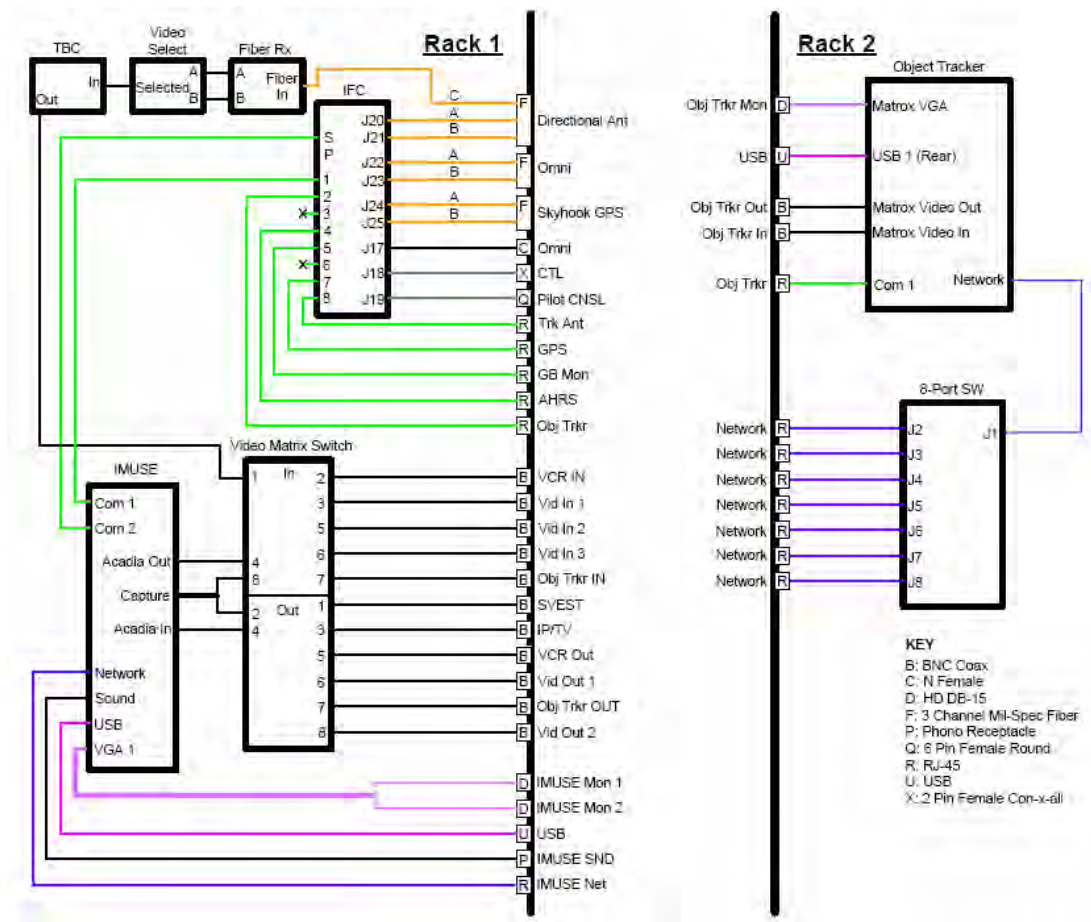
Ground Control Station Hardware

Layout – General connections (cont.)

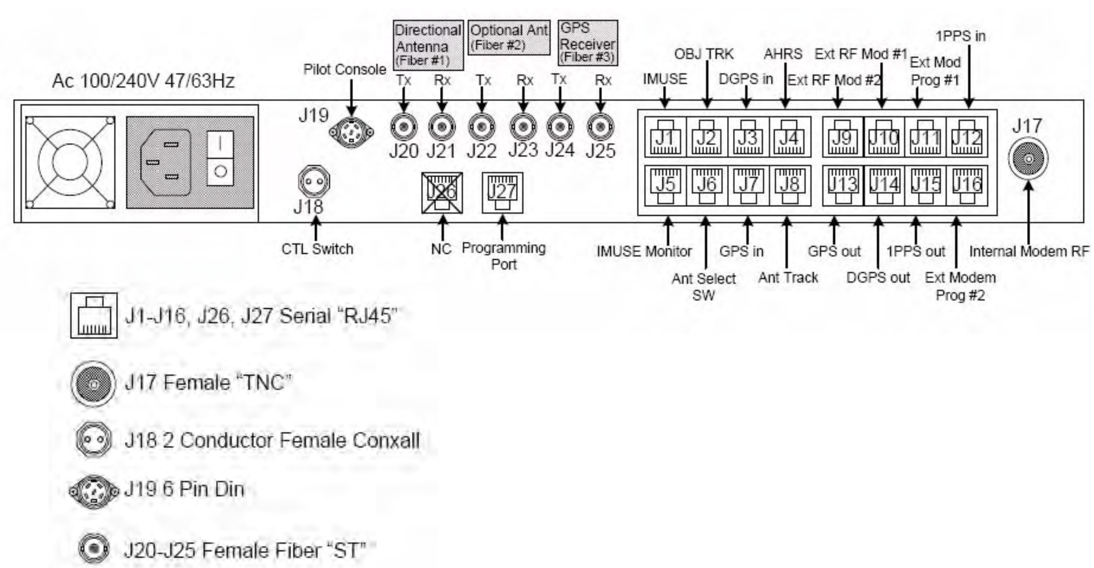


Ground Control Station Hardware

Layout – TGCS internal connections



Layout – If/C port configuration

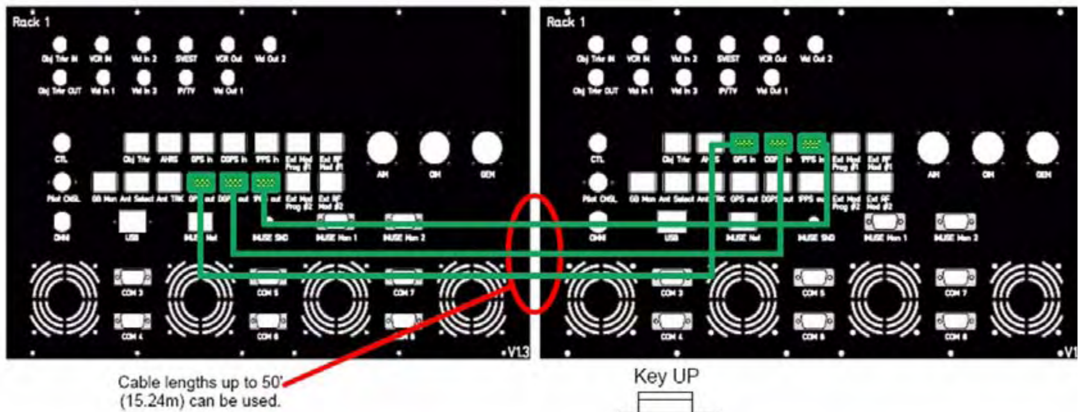


Ground Control Station Hardware

Layout – GPS pass-through (cont.)

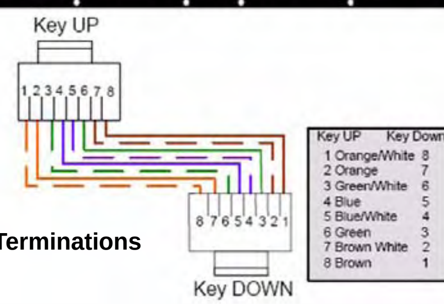
When two GCS share one GPS antenna, and GEM box, from the SkyHook, GPS pass-through cables must be connected between master GCS and slave GCS using Cat 5 cables terminated as shown.

Back of Rack 1 – GCS Master **Back of Rack 1 – GCS Slave**



Note: **To operate slave GCS, the master If/C must be powered on.**

If/C port mapping for slave GCS needs to be configured to read GPS data from RJ45 connectors.



Cable Terminations

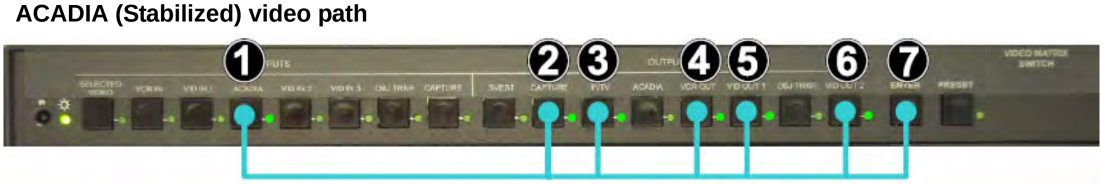
Layout – Standard matrix configuration

For raw, stabilized, and ObjectTracker video, press the keys in the order shown.

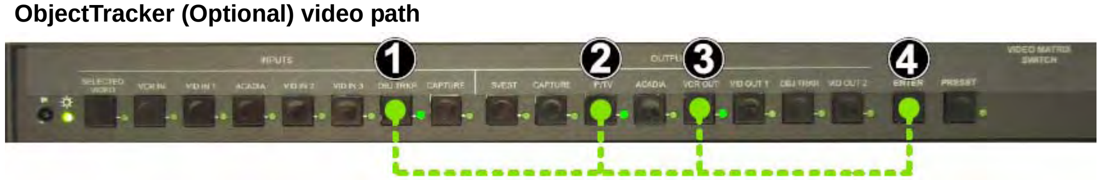
Note: **The <u>Preset</u> key clears all key entries and the switch.**

Selected (RAW) video path

ACADIA (Stabilized) video path



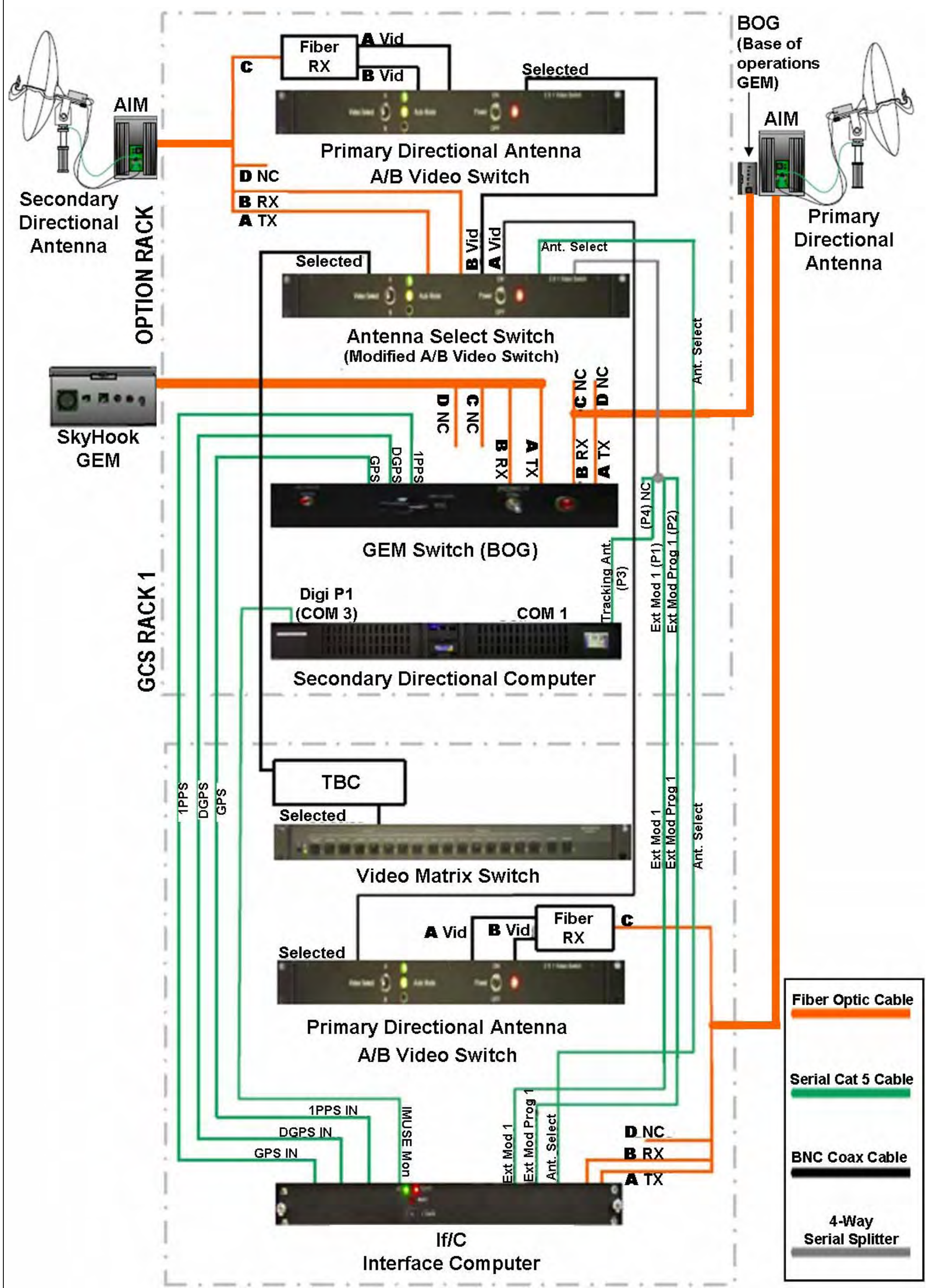
ObjectTracker (Optional) video path



Note: **Some mission commanders prefer to see the ObjectTracker overlay. In this case, change <u>ACADIA</u> outputs to <u>OBJ TRKR</u> outputs.**

Ground Control Station Hardware

Layout – Dual directional antenna option (cont.)



Ground Control Station Hardware

Antennas (cont.)

Accessories

The case labeled "Antenna Accessories" contains the following items:

- Wind/dust skirts for each antenna tripod. These can be wrapped around the tripod after setup in order to minimize wind load, dust incursion, and solar heating of the RF electronics cases.
- Spare antenna actuator cable and test umbilical. The test umbilical can be used to command the antenna actuator from a laptop computer using the manufacturer's standard user interface.
- Fiber optic power meter (for testing the fiber connections). The power output of a fiber optic transmitter can be measured and compared to the power at the other end of the cable. Losses should be less than 10 dB.

Directional antenna setup

Tools:

- Socket wrench or crescent wrench for 5/16-inch and 7/16-inch
- Allen wrench for 1/4-inch bolts
- Level
- Hand-held GPS receiver
- Azimuth calculation S/W (Excel spreadsheet)

Parts / Materials:

- Cable ties

Each parabolic dish antenna should be set up with its tripod level and its pan/tilt motor drive facing a known location – preferably in the general direction of operations.

Note: The command trailer should be behind the antenna. The SkyHook should not be behind the antenna.

If using two antennae, they should be separated by a distance of 100 feet (30.5 m) to ensure that they do not create a potential for mutual blockage.

Use the following procedures to set up each antenna.

1 Pick a suitable location that offers an unobstructed view to the horizon in all directions, such as a small rise or rooftop. Consideration should be given to cable runs. Ideally, sites should be selected such that heavy vehicle traffic over the cables is minimized.

   - If an unobstructed site is not available, find a location with minimum obstructions.
   - Blockage from the other antenna or ground vehicles is not a concern if they are more than 100 feet (30.5 m) away. Ideally, select a location away from a road or parking area where a vehicle could block the antenna.

Ground Control Station Hardware

Antennas (cont.)

Directional antenna setup (cont.)

2 Set up the tripod with the pan/tilt motor on top of the tripod, oriented as follows:

a. In the general direction of the most-likely area of operation.

b. The command trailer is generally behind the antenna. (This will minimize the potential for RF interference from the command trailer during flight operations.)

c. The SkyHook is not directly behind the antenna. (This will minimize the likelihood of a cable unwrap during important operations.)

d. The directional antenna mounting plate is physically leveled with a spirit level with the quickset head in the home position.

Note: The Quickset power and data plug marks 180 degrees (3.14 rad) if the Quickset head is in the home position (0 pan, 0 tilt). The cannon plug will be opposite the area of operation. Additionally, an arrow on the side of the pan/tilt motor indicates the front.

3 Attach the antenna mounting plate to the pan/tilt motor (if not already mounted), so that the antenna mounting bracket is oriented with the front of the dish facing the same direction as the Front arrow on the pan/tilt motor. If the system contains an antenna amplifier, attach it to the antenna mounting plate (if not already mounted). Mount the antenna dish to the mounting bracket and insert the antenna feed support (with feed attached) through the center hole of the antenna. Remove packing material from the feed assembly and adjust the feed support so that the feed is at the focus of the parabola.

- There is a mark on the feed support indicating proper registration with respect to the pipe straps used to hold the feed support in place, and a registration pin to ensure correct alignment. (Nominally, assuming no distortion to the dish, the smallest plate of the feed assembly should be approximately 29 inches (74 cm) from the center of the dish.)
- Verify that the feed assembly is mounted with its center axis aligned with the center axis of the dish (i.e., facing into the dish and not twisted to one side or the other).
- When viewed from directly in front of the antenna, the feed assembly should block the observer's view of the center of the dish, and appear centered in the antenna.

Ground Control Station Hardware

Antennas

Directional antenna setup (cont.)

4 Attach the 6-foot (1.8 m) RF antenna cable to the RF connector on the back of the largest plate antenna feed (this is the telemetry feed; hand tighten until snug); attach one of the 16-foot (4.9 m) cables to the buried RF connector using the barrel extender.

Note: Hold the extender securely when attaching the RF connector, as it will spin when hand-tightening.

a. Mark both ends of the telemetry cable (if not already marked) so that they can be distinguished from the video feed cable.

b. If the cables are not already passing through the dish, pass the cables: 1) through the mesh at the center of the dish, 2) under the antenna mounting plate, and attach:

- The video feed, running it back to the strain relief tube at the back of the antenna mounting plate. Allow enough slack in the cables so that the bends in the cables at the feed head are no tighter than approximately 10 inches.
- The telemetry feed to the antenna amplifier port (**ANT IN**). Another 16-foot coaxial cable connects the antenna amplifier (**AIM IN**) to the **AIM COMM** port

c. Dress the cables along the feed support using cable ties. The cable run should be tight against the support, but do not compress the cable.

d. Attach the DC power cable to the antenna amplifier, route the cable through the strain relief tube, and attach to the Antenna Interface Module (AIM).

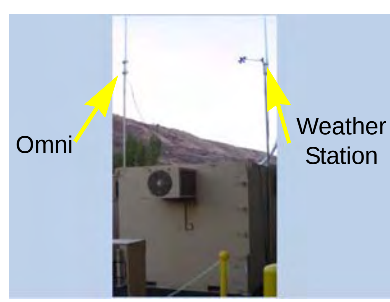
Note: Some systems may not be configured with antenna amplifier boxes. Therefore, the 16-foot (4.9 m) telemetry cable runs straight from the patch feed to the AIM.

5 Using the manual antenna control capability in the ground station, move the antenna right and left by small amounts, and up and down, while an observer checks for clearance and proper cable handling. Expand the motions until completing checks for full rotation in each direction, and up to the maximum degrees in elevation.

Note: The pan/tilt motor should be pre-programmed with a software stop at -5 to +70 degrees (-.087 to 1.22 rad) elevation and -190 to +190 azimuth. It may be desirable to change this depending on the specific mounting situation.

OMNI antenna setup

The OMNI antenna is vertically polarized and designed to create an omni-directional broadcast pattern. Depending on the requirements, the antenna supplied for the GCS is either 900MHz or 1.3GHz.



1 Choose a mounting location clear of any obstructions. If the antenna is mounted on the side of a trailer (instead of above), the broadcast pattern will be blocked on the trailer side.

2 Mount the antenna vertically for optimal performance.

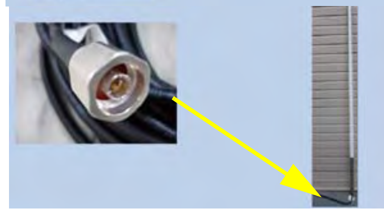
Ground Control Station Hardware

Antennas

OMNI antenna setup (cont.)

3 Attach the antenna to a mast or similar mount using 1-1/2 inch or 2-1/2 inch U-bolts, or saddles.

4 Connect the ultraflex coax cable, hand-tight. It is recommended to seal the connection with dielectric grease and electrical tape to prevent moisture or other elements from affecting performance.



Tracking antenna – calibration, alignment, and positioning

This section describes the procedure for determining and testing the tracking antenna alignment, calibration, and positioning on a fixed or mobile platform.

Note: Mobile platforms should be stationary for this procedure.

Note: This procedure may be repeated for multiple antennas used in some systems.

Values To Be Determined			
Data Item		**Value**	
Quickset + pan soft limit [deg]			
Quickset - pan soft limit [deg]			
Quickset + tilt soft limit [deg]			
Quickset - tilt soft limit [deg]			
pan stop **[deg]**			
+ / - [deg]			
Max Pan **rate [rad/sec]**			
Max Tilt **rate [rad/sec]**			
pan || x **[deg]**			
tilt || x **[deg]**			
Fixed Antenna		**Mobile Antenna**	
Data Item	**Value**	**Data Item**	**Value**
ref lat **[r]**		GPSant @x **[m]**	
ref lon **[r]**		GPSant @y **[m]**	
ref hgt **[r]**		GPSant @z **[m]**	
Ship/GCS true heading	**0**	**Ship/GCS true heading**	

Ground Control Station Hardware

Antennas

Tracking antenna – calibration, alignment, and positioning (cont.)

The antenna coordinate system for a fixed system is as follows: x axis is north, y axis is east, and z axis is down.

The antenna coordinate system for a mobile system (the ship's coordinate system) is as follows: x axis is along the long axis of the ship (+ towards bow), y axis is across the ship (+ towards starboard), z axis is vertical (+ down).

Note: IMPORTANT! Match the level of the AHRS to the level of the ship (roll). Pan offsets can be saved in the AHRS. After installing, the AHRS roll, pitch, and heading must match the ship readings (if available).

The Quickset soft limits should be set so the antenna does not damage itself or point in undesired directions.

Note: The tilt down limit is normally set to -5 deg (-0.087 rad), but it should be set lower if possible on a mobile system to allow for ship roll and pitch motion when tracking a target on the horizon.

The antenna setup data is located in the **Antenna Settings and Limits** table. To access this table, select **Standard Tables** from the **Tables** menu on the **I-MUSE** toolbar, then select the **Ground/IfC** tab.

Antenna Settings and Limits	
Max Pan	0.000 rad/s
Max Tilt	0.000 rad/s
pan stop	180.0 deg
+/-	-10.00 deg
pan || x	0.0 deg
tilt || x	0.0 deg
trk if R >	164 ft
I/O Via	*If/C*

pan stop and **+/-** can be determined directly from the Quickset pan soft limits. For example, if the soft limits are +190 and – 190, pan stop is 180, and +/- is -10. +/- is positive for a "forbidden zone", and +/- is negative for an overlap.

1. **Max Pan** and **Max Tilt** rates can be directly read from the I-MUSE UI after running a calibration sequence.
2. **pan || x** is how far the antenna needs to be panned (internal "Quickset" coordinates) to be pointed parallel with the x axis. This can be estimated and then checked using the following procedure:
   a. For Mobile GCS: Determine ship true heading using two GPS points and the target manager in I-MUSE.
      - Create two targets: one using the antenna position, and one using the antenna target position
      - Set the I-MUSE bullseye to the first target: antenna position
      - Select the second target: antenna target position
      - Record the bearing from the bullseye to this target

   b. Note: For a ship of sufficient length, survey the GPS positions of ship centerline at the stern and ship centerline at the bow. Ship true heading is the heading from the stern centerline to bow centerline. Alternatively, an accurate AHRS heading could be used.

   c. Pan and tilt the antenna so that it is pointed at a distant point (at least 328 feet (100 m), preferably 656 feet (200 m) away). Check alignment by looking through the antenna sighting tube. Survey the GPS positions of the antenna and the distant point:

Ground Control Station Hardware

Antennas

Tracking antenna – calibration, alignment, and positioning (cont.)

- When recording a GPS position, hold the GPS receiver away from the body and allow about one minute to stabilize.
- It is important to record the two positions as close together in time as possible to avoid random variations in GPS positions.

d. Using the I-MUSE target manager determine true antenna direction/ azimuth.

- **pan || x** = **ant ax pan** + **ship true heading** - **true antenna direction/ azimuth**

Note: For a fixed system, ship true heading is zero.

- An alternate method is to set all of the other tracking antenna information in the tracking antenna table, and then adjust **pan || x** with the antenna tracking until the antenna is pointed at a known target (e.g. an aircraft).

e. To check: When **ant ax pan** is set to **pan || x**, the antenna should be pointed parallel with the x axis (north for a fixed system, or in from stern-to-bow direction for a mobile system). The magnitude of the **pan || x** value is the number of degrees from Quickset home position (gimbal angle = 0) to true north in the clockwise direction when viewed from above the Quickset.

3 **tilt || x** is how far the antenna needs to be tilted to be parallel with the x-y plane (i.e. level) when the GCS/ship is level. Level can be determined using: 1) a spirit level, and 2) (with a mobile GCS) AHRS output. Hopefully these are consistent (roll angle and pitch angle zero). Antenna level should be determined using a spirit level. Antenna level should be tested at two or more pan angles 90 degrees (1.57 rad) apart (e.g. at 0 deg and 90 deg). **tilt || x** is usually less than +/- two degrees.

CAUTION: tilt || x is utilized for antenna sag only, and must not be utilized to compensate for deviations in mast leveling.

4 For a fixed antenna, the antenna latitude, longitude, and altitude should be determined using a combination of GPS survey and examination of map and elevation data.

For a mobile GCS, antenna position (x, y, z), relative to the ground (SkyHook), GPS antenna position should be determined.

- At close range, this can be estimated with a measuring tape.
- At greater range, GPS points (and trigonometry) is recommended.
- GPS points and trigonometry data is located in the **Antenna Location** table. To access this table, select **Standard Tables** from the **Tables** menu on the **I-MUSE** toolbar, then select the **Ground/IfC** tab.

Antenna Location	
ref @	
ref lat	0.0000000 deg
ref lon	0.0000000 deg
ref hgt	0 ft
@GS GPS	0
GPSant @x	0 ft
GPSant @y	0 ft
GPSant @z	0 ft

Trigonometry example: if the GPS receiver is 5 m more toward the bow than the antenna, and 10 m more towards port than the antenna, and 4 m below the antenna, **GPSant @x** is 5, **GPSant @y** is -10, and **GPSant @z** is 4.

Note: Multiple x, y, and z values may need to be recorded if the ground GPS antenna position will change relative to the tracking antenna (e.g. when the SkyHook is deployed/lowered, or if another GS GPS receiver will be used at times).

Ground Control Station Hardware

Antennas

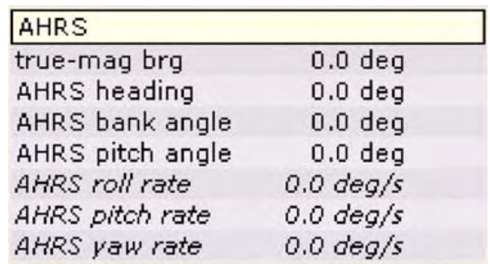
Tracking antenna – settings

Step 1 – Testing

In addition to the tests listed here, set up the tracking antennas using the values determined in the *Tracking antenna calibration, alignment, and positioning* section of this table.

Note: With a TGCS, ref should be set @GS GPS.

AHRS data is located in the **AHRS** table. To access this table, select **Standard Tables** from the **Tables** menu on the I-MUSE toolbar, then select the **Ground/IfC** tab.



Set target at a known distant target. This could be an aircraft or a surveyed position. For a TGCS, if the AHRS is not accurate, the AHRS should be disconnected and the ship's true heading should be entered as **AHRS heading**, and **true-mag brg** should be set to **0**.

Using **FGS** for a fixed system or **RGS** mode for a mobile system, the antennas should be boresighted to make sure they are aligned with the target. Repeat for a different target so that the antenna will point at a different true direction/azimuth to confirm the values.

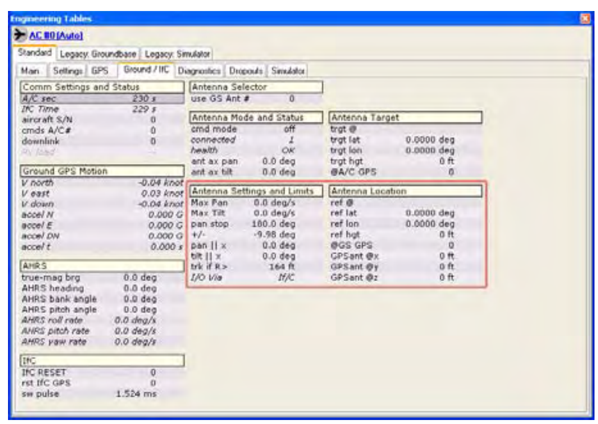
Step 2 – Recording

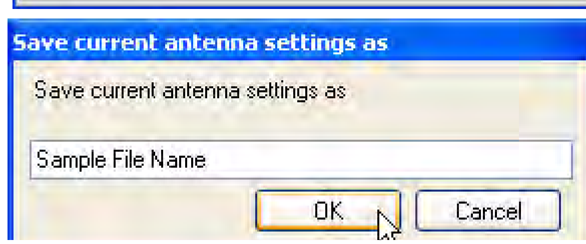
The values determined using this procedure should be recorded in the GCS logbook and in a convenient place such as a computer desktop text file or on a laminated reference card.

Step 3 – Saving

Beginning with I-MUSE 5.0.09, data entered in the **Antenna Settings and Limits** and **Antenna Location** tables can be saved.

Note: For earlier versions of I-MUSE, data must be re-entered when I-MUSE is restarted.





Ground Control Station Hardware

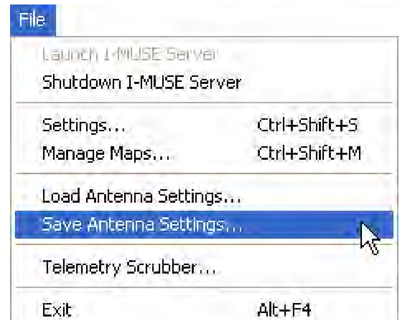
Antennas

Tracking antenna – settings (cont.)

Step 3 – Saving (cont.)

1 After inputting the desired values, navigate to the File menu and select **Save Antenna Settings....**

2 Enter a file name and click **OK**.

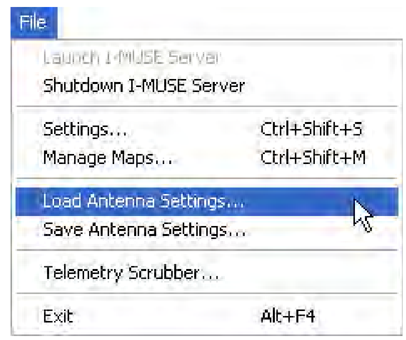


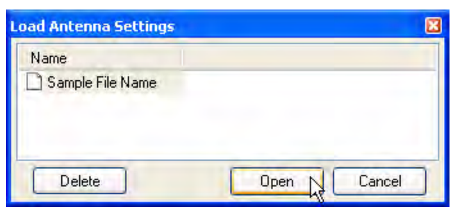
Step 4 – Loading

To load saved antenna settings:

1 Navigate to the **File** menu and select **Load Antenna Settings...**.

2 The name(s) of the previously saved antenna settings appear(s). Select the desired file name and click **Open** to load the settings.

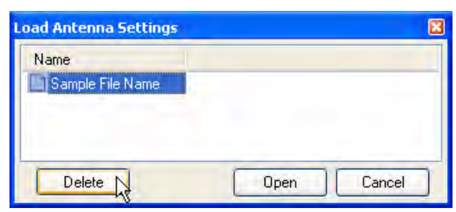




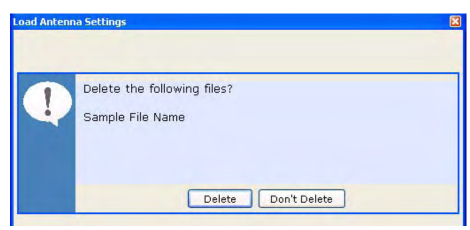
Step 5 – Deleting

To delete saved antenna settings:

1 From the Load Antenna Settings table, and select **Delete**.



As a safeguard, a prompt verifies that the file
is to be deleted. select **Delete** to remove the saved antenna settings.



2 Setup

Ground Control Station Hardware	
Antennas	
Long range comm and video performance	There are two techniques to optimize link performance at long range: ▪ Adjustments to antenna pointing ▪ Adjustments to aircraft height to avoid excess attenuation Typically, these procedures may be considered at ranges in excess of 31 miles (50 km) **Background** Both video and tracking, telemetry, and control (TT&C) are supported by a 1.8 m parabolic dish antenna that is steered to follow the aircraft. Video and TT&C use the same dish, but the difference in operational frequency means that the gain and beamwidth is different for the two subsystems.

Subsystem Gain & Beamwidth

Subsystem	Frequency Band	Nominal Antenna Gain	Nominal Antenna Beamwidth
Video	2300-2400 MHz	30 dBi	5 degrees
Com	1350-1390 MHz	23 dBi	10 degrees
Com	902-928 MHz	20 dBi	15 degrees

The nominal gain and beamwidth assume that the antenna is in good repair. Distortions of the parabolic reflector, misalignment of the feed assembly, bends in the feed support, and other impairments, can reduce the gain and/or beamwidth, and can also distort the angle of the beam relative to the nominal boresight. An error in antenna alignment at setup can also lead to mispointing. Finally, the antenna pointing algorithm uses a nominal Earth radius assumption, but atmospheric refraction typically causes radio waves to propagate as if the Earth has a larger radius; the signal may appear to arrive at a higher elevation angle than expected based on geometry.

As the aircraft flies away from the ground control station, signal strength and length margin are reduced. An error in antenna alignment will initially manifest as degradation in video quality at long range.

Note: Video will appear to degrade first since its beamwidth is narrower than the TT&C beamwidth.

Even if the antenna is correctly aligned, atmospheric refraction can cause the incoming signal to shift a few degrees in elevation. In addition, as the aircraft approaches the horizon, the radio signal will experience excess signal loss as it propagates close to the Earth's surface

Adjustments to antenna pointing

Note: This technique requires the use of tracking mode. Pan || x and tilt || x only affect actuator pointing when in a tracking mode – FGS or RGS, not Gimbal.

The tracking antenna offsets can be adjusted by changing the **pan || x** and **tilt || x** fields in the I-MUSE engineering tables, tracking antenna control table on the ground If/C page. Increases in **pan || x** pan the actuator clockwise, and increases in **tilt || x** tilt the actuator up.

Ground Control Station Hardware

Antennas

Long range comm and video performance

Note: In some circumstances, these values may already be non-zero, such as if the values have already been used to account for an arbitrary antenna alignment. For example, if pan || x is already at 70 degrees, in order to nudge 2 degrees left, enter 68.

If the video signal is marginal or broken up during long-range operations, attempt to refine the antenna pointing system by manual adjustment of the **pan || x** and **tilt || x** fields.

1. Log the scenario data and the current values of both **pan** and **tilt** in the in the *GCS Logbook*.
2. Working first with tilt, adjust upward and downward in one-degree steps until the optimized offset can be identified. Typically the required adjustment will be less than five degrees. If desired, further refinement to the nearest 0.5 degrees can be attempted. Resolution finer than 0.5 degrees is not required.

CAUTION: Adjustments larger than six degrees should not be attempted with this technique during any single flight, since larger shifts could adversely affect beam centering for telemetry, command, and control. Larger shifts can be considered following calibration and alignment at short range.

3. Optimize the pan offset using the same technique as the tilt offset.
4. Log the optimized values in the **Adjusted Offset** columns in the *GCS Logbook*.

Note: The optimized values may differ by site, and may also differ by time of day and atmospheric condition.

While the adjusted offsets may turn out to be of general and long-term utility, it is also possible that the optimized offset will vary with operational site of the aircraft and time of day. The optimized offset may also vary over a period of weeks due to such factors as shifts in the antenna mount. If significant differences are noted following a month of operation, a copy of the log should be delivered to Insitu for analysis – ATTN: Avionics Group.

Adjustments to aircraft height to avoid excess attenuation

The nominal radio horizon is tabulated as a function of ground station antenna height and aircraft height. This is a geometric calculation. However, a radio wave will experience excess signal loss at long range and very low elevation angles. As a rule of thumb, this typically occurs when the aircraft range is more than 60-70% of the maximum line-of-sight range. Low ground antenna heights (3-10 ft / 1-3 m) cause a relatively early onset (50% of max range), whereas higher ground antennas (30 ft / 10 m or more) cause a relatively later onset (70-80% of max range). The signal loss increases smoothly as the aircraft flies to greater range and the elevation angle approaches zero, achieving a maximum value on the order of 20-30 dB of excess loss at the horizon, which is well beyond the link margin of the system. Moderate increases in aircraft height can significantly add to the effective horizon distance (See table: *GPS Antenna Height*). Operators should always seek to maintain margin with respect to the horizon.

Ground Control Station Hardware

Antennas

Long range comm and video performance

.

GPS Antenna Height

Line-of-sight range (horizon-limited) for spherical Earth and nominal refraction (4/3 Earth radius).

Ground Antenna Height (Meters)	Aircraft Height Above Terrain (Meters)							
	250	500	750	1000	1250	1500	1750	2000
1	69	96	117	135	150	164	177	189
2	71	98	119	136	152	166	178	190
3	72	99	120	138	153	167	180	192
4	73	100	121	139	154	168	181	193
5	74	101	122	140	155	169	182	194
6	75	102	123	140	156	170	183	194
7	76	103	124	141	157	171	183	195
8	77	104	125	142	157	171	184	196
9	78	105	125	143	158	172	185	197
10	78	105	126	143	159	173	186	197

	2250	2500	2750	3000	3250	3500	3750	4000
1	200	210	220	230	239	240	257	265
2	201	212	222	232	241	250	258	267
3	203	213	223	233	242	251	260	268
4	204	214	224	234	243	252	261	269
5	205	215	225	235	244	253	262	270
6	206	216	226	236	245	254	263	271
7	206	217	227	237	246	255	263	272
8	207	218	228	237	247	256	264	272
9	208	219	229	238	247	256	265	273
10	209	219	229	239	248	257	266	274

Notes: Line-of-sight range is listed in kilometers, while antenna and aircraft height are listed in meters.

There is typically 20-30 db of excess attenuation at the horizon (beyond free-space approximation).

To avoid or mitigate excess attenuation, gain altitude until signal is reliable.

Raising the height of the ground antenna will also mitigate excess attenuation, but it does not significantly increase the horizon distance.

For low ground station antennas (ground level: 3-10 ft / 1-3 m), aircraft height should be selected to yield a horizon distance that is twice that of the actual range between the aircraft and the ground station.

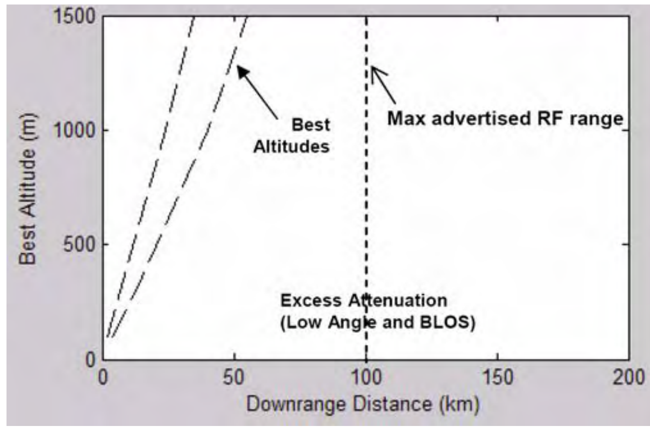
Ground Control Station Hardware

Antennas

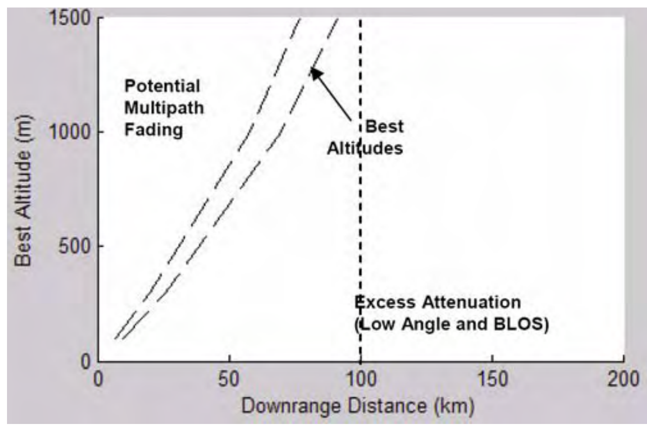
Long range comm and video performance

In addition to the excess attenuation experienced at long range close to the horizon, there can be excess attenuation at closer range if signal reflections off the ground or ocean lead to partial cancellation of the desired signal from the aircraft. These so-called multipath fades are not always present. However, they can occur in areas that serve as reflecting surfaces for the RF signals, such as water or large, smooth expanses of terrain. Between the limits imposed by the horizon and potential multipath fading, there is a region where the signal can be enhanced by as much as several dB under ideal conditions. Flying in this region will yield the greatest likelihood of good signal performance. The desired range of aircraft heights is illustrated as a function of distance from the ground station, for aircraft.

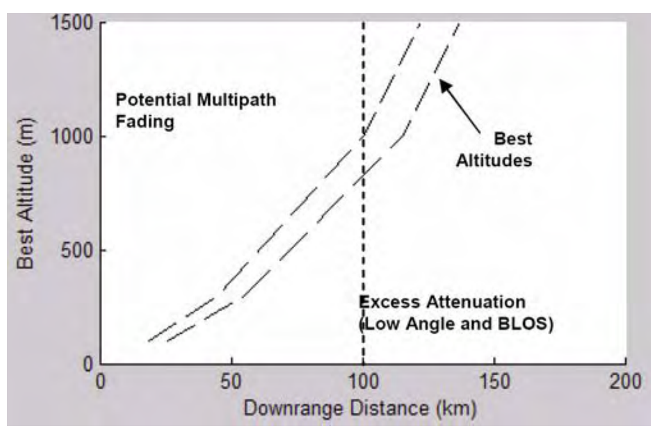
Ground Station Parabolic Dish Height: 3 feet / 1 meter



Ground Station Parabolic Dish Height: 10 feet / 3 meters



Ground Station Parabolic Dish Height: 33 feet / 10 meters



Ground Control Station Hardware	
Antennas	
Long range comm and video performance	Each panel represents a specific height of the ground station parabolic dish, measured from the center of the dish over the local terrain or ocean surface. Nominal heights are expected to be in the range of 10 to 100 feet (3 to 30 meters). Select the panel that most closely approximates the actual ground station antenna height. Each panel has two dashed curves. The left-most curve is constrained by the potential for multipath fading at high frequency (2400 MHz). The right-most curve is constrained by long-range, low-angle excess attenuation near the horizon at low frequency (1000 MHz). Between these curves, the signal strength may be slightly accentuated relative to free-space propagation. Consequently, best performance will occur when the aircraft height is between the two dashed curves. As an example, for a ground station antenna mounted 100 feet (30 meters) above the ocean, an aircraft at the maximum nominal range of 62 miles (100 km range) should be operated at approximately 1,500 feet (500 meters) in order to maximize link reliability. These recommendations are for guidance only. Propagation details may vary, and the link margin experienced in practice will vary depending on the terrain, soil type, and atmospheric conditions. It should also be recognized that flying outside the bounds will not necessarily result in bad performance. There is excess margin in the system which can overcome additional propagation losses if the magnitude of loss is not too great. Operators should give: ▪ Primary priority to flight safety, flying at the assigned altitudes or heights. ▪ Secondary priority to mission requirements, such as surveillance altitude and detection avoidance. ▪ Tertiary priority to link performance, optimizing link performance within the constraints dictated by flight safety and mission requirements.

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Ground Control Station Hardware

If/C

Remove

1. Power down the system.
2. Unplug GCS power cord.
3. Open the back panel on the top rack by removing the thumb screws.
4. Disconnect the cables from the If/C.

   a. Unscrew TNC coax from If/C (far right).

   Note: These are 1/4 turn connectors.

   b. Disconnect green RJ45 cables from If/C.

   c. Disconnect Fiber ST cables from If/C.

WARNING!

Do not touch the end of the fiber as this will affect the function of the fiber. Do not scratch the end of the fiber by allowing the face of the fiber to touch hard objects.

Note: It is important to note arrangement of fiber connections as plugging these in wrong will result in failure of the AIM and GEM to function properly.

   d. Disconnect the pilot console cable. (Do not pull on the cable; pull on the connector.)

   e. Disconnect the CTL Conexal cable.

   f. Disconnect the If/C power cord.

5. Remove the four Phillips head screws and nylon cup washers from the front of the If/C.
6. Slide the If/C out of the rack.

Ground Control Station Hardware

If/C (cont.)

Reinstall

1. Slide the If/C into the rack making sure there are no cables in the way. This is especially important when referring to the fiber.
2. Install the four Phillips head screws with nylon cup washers.
3. Connect the cables.

   a. Connect the power cord.

   b. Connect the CTL Conexal cable.

   Note: This is a 1/4 turn connector.

   c. Connect the pilot console cable with the screw facing up.

   d. Connect the green RJ45 cables.

   - For easier installation, plug in the bottom cables first.
   - Pay close attention to the order and placement of each cable.
   - All the cables are labeled with their position on the If/C.

   e. Connect the fiber ST connectors.

   Note: These are 1/4 turn, keyed connectors. Do not force them in.

   - Verify the fiber connectors are not kinked or stressed.
   - Verify position is correct: A goes to T, and B goes to R.

   f. Connect the TNC coax cable.

4. Close the swing out back panel and secure it with the thumb screws.
5. Plug in the GCS power cable.
6. Power on system.
7. Program If/C (boot loader, 555 code, port map, and Freewave modem).

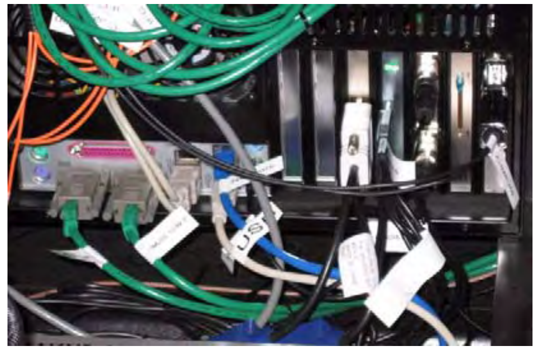
Note: If If/C is powered on and does not work, look at the PWR and ACC lights in front. If they are blinking back and forth slowly, the If/C is not properly programmed and it will need to be sent back to Insitu for programming.

<table>
<tr><th colspan="2">Ground Control Station Hardware</th></tr>
<tr><th colspan="2">I-MUSE machine</th></tr>
<tr><td>Remove</td><td>
1 Power down the system.
2 Disconnect the power cord from the GCS.
3 Unscrew the thumb screws on the back of the rack, and open the swing out panel.
4 Disconnect the cables from the I-MUSE computer:

a. Disconnect the USB cable.
b. Disconnect the serial port plug.
c. Disconnect the RJ45 network cable.
d. Disconnect the VGA splitter cable.
e. Disconnect the BNC video cables.
f. Disconnect the power cord.
g. Disconnect the DB25 from the capture card.
h. Disconnect the Digi DB9 breakout cable.


5 Unscrew the four Phillips head screws holding the I-MUSE in the rack.
6 Slide the computer out of the rack.
</td></tr>
<tr><td>Reinstall</td><td>
Note: The computer fits tight in the rack.
1 Secure computer into rack with four Phillips head screws and plastic washers.
2 Connect cables to computer.
a. Plug in power cord.
b. Plug in BNC video cables, ensuring labels match locations (Video in to Acadia in, Video out to Acadia out).


</td></tr>
</table>

Ground Control Station Hardware	
I-MUSE machine	**(cont.)**
Reinstall (cont.)	c. Plug in the VGA splitter cable and secure it with the thumb screws. d. Plug in the DB25 capture cable. e. Plug in the Digi DB9 breakout cable. f. Plug in the RJ45 network cable. g. Plug USB cable into any of the USB ports on the back of the computer. h. Plug in the DB9 to RJ45 serial cable (labeled COM 1) to the left most serial port. Secure with thumb screws.  i. Plug in the other DB9 to RJ45 serial cable (labeled COM 2) to the right serial port. 3 Close the back panel and secure it with the thumb screws. 4 Plug the GCS power cord back into the GCS.
ObjectTracker computer	
Remove	1 Power down the system. 2 Disconnect the power cord from the GCS back panel. 3 Take the thumb screws out of the back of the rack, and open the swing out panel. 4 Disconnect the cables from the ObjectTracker computer. a. Disconnect the USB cable. b. Disconnect the serial port plug. c. Disconnect the RJ45 network cable. d. Disconnect the VGA cable. e. Disconnect the BNC video cables. f. Disconnect the power cord.  

Ground Control Station Hardware

ObjectTracker computer (cont.)

Remove (cont.)

5 Unscrew the four Phillips head screws holding the ObjectTracker in the rack.

6 Slide the computer out of the rack.

Note: The computer fits tight in the rack.

Reinstall

1 Secure the computer into the rack with the four Phillips head screws and plastic washers.

2 Connect the cables to the computer.

a. Plug in the power cord.

b. Plug in the BNC video cables making sure to match the labels to the correct locations (Video in to Matrox in, Video out to Matrox out).

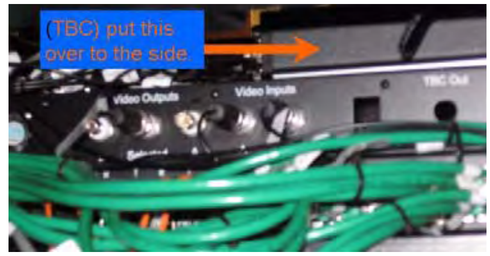
c. Plug in the VGA cable and secure it with the thumb screws.

d. Plug in the RJ45 network cable.Plug in the USB cable.

Note: You can plug this in to any of the USB ports on the back of the computer.

e. Plug in the DB9 to RJ45 serial cable to the left most serial port. Secure it with the thumb screws.

f. Plug the GCS power cord back into the GCS back panel.

Ground Control Station Hardware	
Video A/B switch	
Remove	1 Power down system. 2 Remove the thumb screws on the back of the GCS rack, and open the swing out panel. 3 Take the TBC off the top of the video A/B switch.  4 Disconnect the cables from the A/B switch. a. Disconnect the BNC video cables. b. Disconnect the power cord. 5 Remove the four screws holding A/B switch into rack.  6 Slide the A/B switch out of the rack.
Reinstall	1 Slide the video A/B switch into the rack. 2 Secure it with the four Phillips head screws and plastic washers. 3 Connect the cables to the video A/B switch: a. Connect the BNC, note the location. b. Connect the power cord. 4 Put the TBC back on top of the A/B switch. It is secured with Velcro.  **Note: If the A/B switch is new, and doesn't have the Velcro on it, put a small piece of adhesive-backed Velcro on the top, back, right corner of the A/B switch.** 5 Close the swing out panel, and secure it with the thumb screws.

Setup 2

Ground Control Station Hardware

Video channel settings

Note: Use these guidelines for minimal interference.

Recommendations

The current 2.4 GHz analog video systems have 16 channels available for use. The center frequency of each channel is different, but there is some additional transmission over a small range. This means that some channels bleed over onto others. The settings described here minimize the interference for a single dual aircraft ground station and two dual aircraft ground stations.

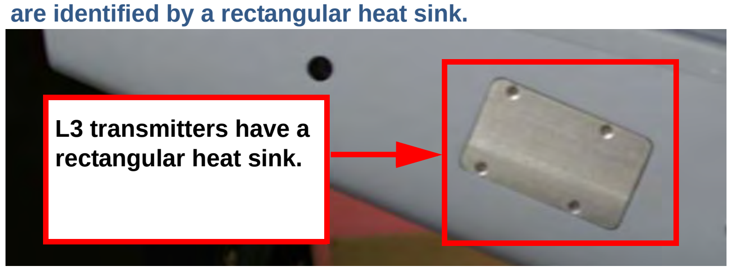
Single dual aircraft ground station	
OPS 1	Left 3, Right 6
OPS 2	Left 8, Right 9

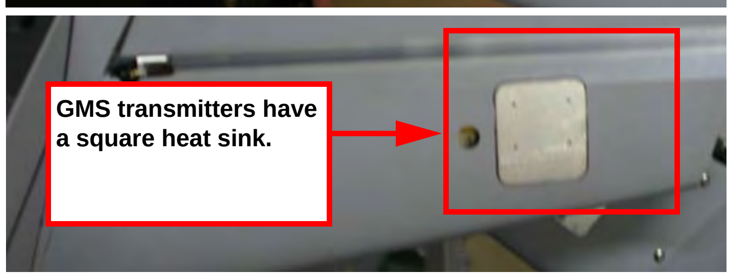
Two dual aircraft ground stations in close proximity	
OPS 1	Left 3, Right 6
OPS 2	Left 8, Right 9
OPS 3	Left 1, Right 7
OPS 4	Left 2, Right 4

- Whenever possible, avoid use of channel 1 on winglets with GMS transmitters due to GPS jamming potential from intermodulation effects with other systems. This may not always be possible, as shown here in the recommendations provided for two dual aircraft ground stations in close proximity.

Note: "Close proximity" is when one aircraft is flying in an area where its video signal could be picked up by another ground station.

Note: Some right winglets are made with L3 transmitters, which allow channel 1 to be used – on that wing only – without concern for GPS interference. Identify the wing model by the shape of the heat sink: GMS transmitters are identified by a square heat sink; L3 transmitters are identified by a rectangular heat sink.





- In the event of GPS loss, try to secure one transmitter at a time (if using 1.4 avionics) or both transmitters for a short time. This may stop some possible degradation due to intermodulation or a failed transmitter.
- Loss of video from a winglet, accompanied by reduction in current on the 13V bus, may indicate a blown fuse. Some winglets may be more prone to shorts than others. Troubleshoot blown fuses per the *Maintenance Handbook*.

Note: L3 transmitter power-up is significantly longer than GMS transmitter.

Ground Control Station Hardware

Video channel settings (cont.)

Guidelines

- Maintain at least one channel between the channels used for aircraft in the same airspace.
- When possible, 10 to 12 MHz separation between channels is optimal.
- If channels are changed, re-coordinate Forward Eyes units to the new channels.
- Keep track of the assigned frequency band. Channel 9 is slightly higher than 2400 MHz and may be unacceptable (due to frequency allocation in theatre), but is attractive for use due to frequency separation from other channels.

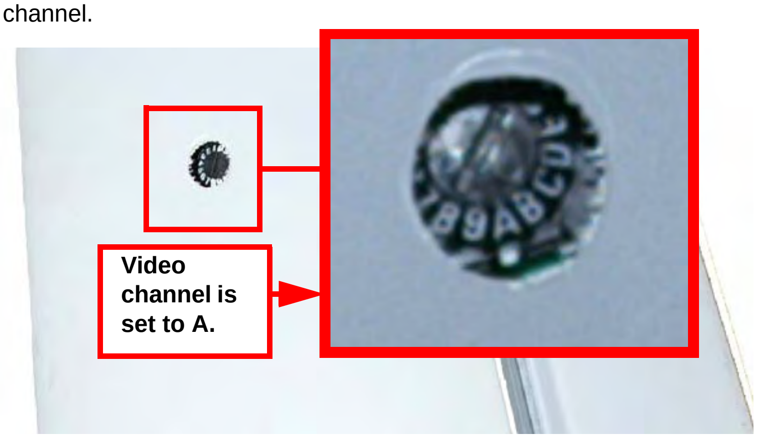
Frequencies

For frequency management considerations, the GMS video system channel frequencies (in MHz) are provided.

Note: Due to frequency allocation, use of frequencies greater than 2400 MHz may not be allowed. Know what frequencies are available for use prior to GCS setup.

Video Channel Frequencies – MHz			
1	2312.5	9	2411.0
2	2347.5	A	2434.0
3	2352.5	B	2453.0
4	2357.5	C	2463.0
5	2364.5	D	2473.0
6	2370.5	E	2486.0
7	2382.5	F	2490.0
8	2387.5	0	2495.0

To select the video channel on the winglet, align the mark with the desired channel.



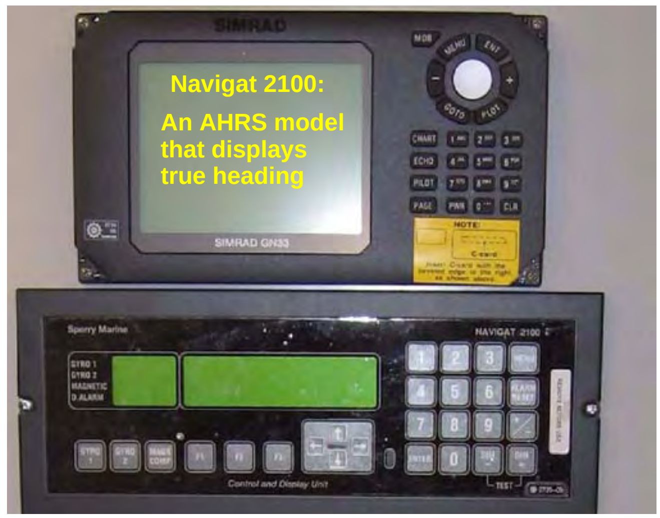
Ground Control Station Hardware	
ROVER Avionics (L-band video transmitter)	
Setup	1 The L-band transmitter has 64 available channels. Set the channel by rotating the channel selection dials (visible aft of the heat sink on the bottom of the avionics bay). Coordinate channel selection with ROVER-compatible aircraft in simultaneous operation and ROVER ground receiver users. 2 Apply fuselage seal tape over the channel selection dials before flight. 3 Attach receiver to power supply (12V), antenna, and display monitor. 4 Position antenna within line of sight of aircraft, away from building obstructions.
Test	1 Toggle on L-band video using the **L-Band** button on the I-MUSE Camera/Turret Settings panel. Wait 20 seconds. Confirm that video appears on the display monitor attached to the L-band receiver. 2 Toggle off L-band video using the **L-Band** button on the I-MUSE Camera/Turret Settings panel. Confirm that video disappears on the L-band display.
Notes	▪ Range of L-band video transmission is 10 km (6 miles). ▪ L-band video is unstabilized. ▪ In case of GPS dropouts with L-band video on, turn off L-band video.

2.5 ## Additional System Components – Hardware

In this section:

- AHRS
- Clear-to-land switch
- Desktop configuration
- Generator
- HiL (Hardware-in-the-Loop)
- Weather station

AHRS



For ship-based operations, AHRS (Attitude Heading and Reference System) is used to determine the heading, pitch, and roll information of the Insitu Ground Control Stations. The AHRS is needed for proper directional antenna pointing. By using GPS data from the aircraft, naval unit, and a fiber optic gyro, the system is able to determine the 3-axial movement of the naval craft and properly compensate the pointing direction of the directional antenna so that communication is maintained even as both the ship and aircraft are moving. Without this compensation the directional antenna would not be able to track the aircraft as the vessel pitched or rolled in waves and moved to differing headings.

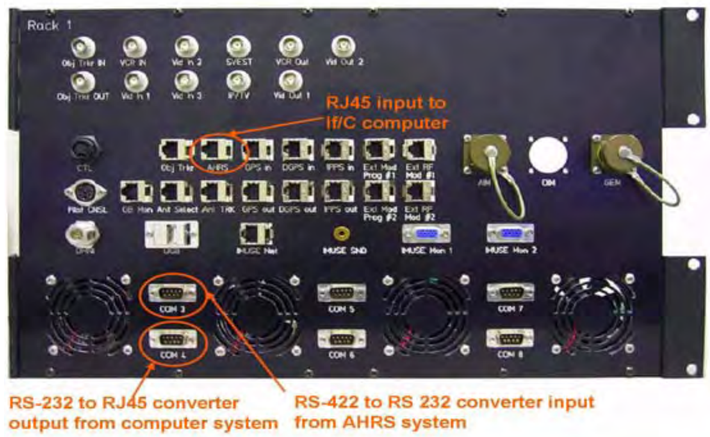
Some ground stations utilize a feed from the ship, which has to be fed through a translator program to correct the format so that the If/C can read it. There are various programs supplied with an installation of I-MUSE. In this case, no installation or calibration is needed. The most common translator used is the NMEA translator, "NMEA_AHRS.exe." The program takes AHRS information input on a serial stream, and outputs on another serial port in the correct format. The output is sent to the If/C. The translator normally runs on a separate computer, or any computer with two spare serial ports.

Additional System Components – Hardware

AHRS – Initial setup instructions

Step 1 – Hardware setup

1. Connect power cable to GCS UPS power and RS422 to RS232 converter to GCS Rack 1 COMM 3.



2. Connect RJ45 cable to Rack 1 AHRS port and other end to RJ45 to DB9 serial adapter connected to Rack 1 COM 4.

Note: **IMPORTANT! The DB9 serial to RJ45 converter must be configured for null modem operation.**

3. The Navigat 2100 will sound an alarm when it is initially powered up.

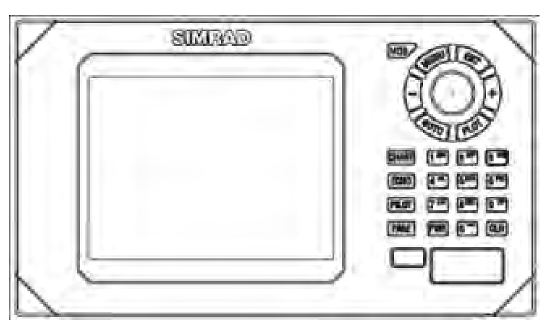
Fog sensor setup

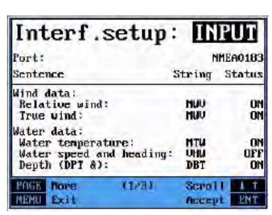
Setting up the FOG sensor requires that it be made level from the vessel. A rough level will be achieved with the following steps and then fine leveling adjustments can be done with software in a following section.

4. Obtain the vessel's offset from level by determining its steady state roll and pitch readings, which are often available from bridge or control center of the vessel.
5. Using a digital level and the rubber washers in the AHRS FOG mounting kit, attempt to level the FOG to offset the recorded roll and pitch readings of the vessel to within a degree.

Step 2 – Simrad GN33 configuration setup

1. Press the **Menu** key and then the **7** key for Setup.
2. Press **2** to select NEMA interface. A screen will appear that says **Interf.setup: INPUT**.





Additional System Components – Hardware

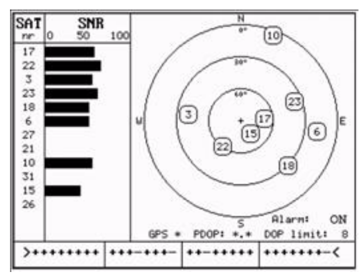
AHRS – Initial setup instructions (cont.)

Step 2 – Simrad GN33 configuration setup (cont.)

3 Press the **+** key to enter the **Interf.setup: OUTPUT** screen.

4 While in the **Interf.setup: OUTPU**T screen use the silver select key to scroll through the screens/pages and make these changes and selections:

a.	Port:	NMEA0183	
b.	GPS fixdata:	GGA	ON
c.	GNSS fixdata:	GNS	OFF
d.	Geographic pos, Lat/Lon:	GLL	OFF
e.	Recom. min. GPS data:	RMC	OFF
f.	Track made good & SOG:	VTG	ON
g.	Time and date:	ZDA	ON
h.	GNSS Sat. Fault Detection:	GBS	OFF
i.	Autopilot sentence ‘B’:	APB	OFF
j.	Bearing & distance + WP:	BWR	OFF
k.	Recom. min. nav. info:	RMB	OFF
l.	Routes:	RNN	OFF
m.	Routes:	RTE	OFF
n.	Cross-track error:	XTE	OFF
o.	Waypoint location:	WPL	OFF
p.	UTC & time to dest. WP:	ZTG	OFF



a. Press the **Menu** key and then the **2** key for Position.

b. Press the **5** key for Satellites. This brings up a list of GPS satellites within receiving range. Once the unit has located at least five satellites, continue on to the next step. This may take up to 30 minutes.

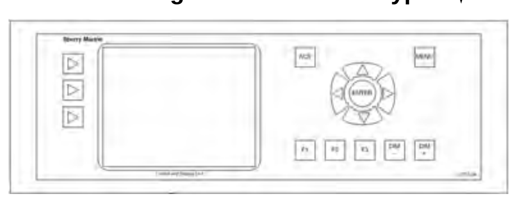
c. After five or more satellites have been located, press the **Menu** key and then the **2** key for Position followed by the **1** key for Position data. This will display the current latitude and longitude coordinates.

Step 3 – Navigat 2100 configuration setup

Note: There are two possible user interface modules for the Navigat 2100 system: one with a keypad (pictured); and one without a keypad (not pictured). Menus for both models are the same. However, for the latter model, selections are made with the arrow pad. Additional instructions for that model are provided as notes.

Navigat 2100 with keypad ↑

Navigat 2100 without keypad ↓



2

Setup

Additional System Components – Hardware

AHRS – Initial setup instructions (cont.)

Step 3 – Navigat 2100 configuration setup (cont.)

1 Press the **Menu** key until you are brought the Main Menu screen that gives SETUP MENU as an F3 option.

2 Press the **F3** key and a screen should now appear that gives two options. Press the **F2** key for service setup.

3 A screen will now appear asking for a setup code; enter the code **600** and then press the **Enter** key.

Note: For models without keypad, use the ↑↓ arrow keys to increment the number column.

4 The Service Setup 1 screen appears. Press the **F1** key to enter the Interface I/O Data settings selections.

5 Set the selections as shown here. Use the ↑↓ arrow key to scroll up and down through options and the **Enter** key to switch columns.

6 Press the **Menu** key to exit.

7 Press the **Menu** key until you are brought the Main Menu screen that gives SETUP MENU as an F3 option.

a.	Gyro 1 Input ↓	Fog Sensor
b.	Gyro 2 Input ↓	Off
c.	Mag. HDG INP. ↓	Off
d.	Speed 1 Input ↓	NMEA
e.	Speed 2 Input ↓	NMEA ONLY
f.	POS. 1 Input ↓	NMEA-GGA
g.	POS. 2 Input ↓	NMEA-GGA
h.	SENS.D.M. Output↓	NMEA-HCHDM
i.	S/Fast M. Output ↓	NMEA-HCHDM
j.	MAGN. VAR. ↓	NEMA-RMC
k.	NMEA SUP.Fast ↓	38400 BAUD
l.	TxD NMEA Fast↓	NMEA

8 Press the F3 key and a screen should now appear that gives two options. Press the F1 key for user setup.

9 Press the F1 key for Date and time.

10 10.Use the ↑↓ Arrow key to scroll up and down through options and set the Mode column to **Auto**.

Additional System Components – Hardware

AHRS – Initial setup instructions (cont.)

Step 3 – Navigat 2100 configuration setup (cont.)

11 Press the **Menu** key until you are brought the Main Menu screen that gives SETUP MENU as an F3 option.

12 Press the **F3** key and a screen should now appear that gives two options. Press the **F2** key for service setup.

13 A screen will now appear asking for a setup code; enter the code **610** and then press the **Enter** key.

14 The Service Setup 3 screen appears. Press the **F3** key (Reset FIU). This will restart the unit with the new settings.

15 Press the **F1** key to accept.

16 Press the **Menu** key until you are brought the Main Menu screen that gives SETUP MENU as an F3 option.

17 Press the **F1** key to enter Display Data menu.

18 Press the **F2** (Position) key. To display data from the FOG and GPS. This should match the LAT and LON on the Simrad GN33 display.

Step 4 – Navigat 2100 FOG sensor configuration setup

1 Press the **Menu** key until you are brought the Main Menu screen that gives SETUP MENU as an F3 option.

2 Press the **F3** key and a screen appears that gives two options. Press the **F2** key for service setup.

3 A screen appears asking for a setup code; enter the code **600** and then press the **Enter** key.

Note: For models without keypad, use the ↑↓ arrow keys to increment the number column.

Setup 2

Additional System Components – Hardware

AHRS – Initial setup instructions (cont.)

Step 4 – Navigat 2100 FOG sensor configuration setup (cont.)

4 Scroll through the screens until reaching the one that displays **analog output settings** as an option. This is normally selected with the **F2** key.

5 Select **correction values** from the next list of scrollable screens. This is normally selected with the **F2** key.

6 Input the appropriate corrections values for roll and pitch based on the amount of leveling still required after shimming to offset the ship's steady state roll and pitch from level.

7 Input the heading error in degrees from noted heading direction indicated on the FOG Sensor from ship's center line taking into consideration the fore ship direction.

Note: For models without keypad, use the up/down arrow keys to increment/decrement the number, and press the right/left arrow keys to move to the next column.

Press the **Enter** key once desired values have been entered.

8 When entering the heading value, the system will say that the max error correction is +/- 3 degrees and the unit will begin beeping. If your Navigat is not aligned with the ship's heading (say 90 degree offset) go ahead and confirm your change anyway.

Step 5 – GCS configuration setup

1 On the GCS computer, create a desktop shortcut with the following link: C:\Program Files\Insitu Group 4.23\Groundbase\NMEA_AHRS.exe.

2 If not already displayed, change the icon to the  symbol, found in program.exe.

3 Right-click on the short cut in the target window. Under the shortcut tab, after the -.exe suffix, add to the file name **-b38400 -r4 -i3**. Note that a space is required before each dash.

4 Copy the short cut to the Windows Start Up Menu by navigating to **Start** -> **All Programs** -> **Startup**, and pasting into this folder.

5 Verify the AHRS is functioning properly by:

a. Opening I-MUSE.

b. Selecting: **Tables**.

c. Selecting: **Groundbase**.

d. Selecting: **Main Page**.

e. Selecting: **If/C Status**.

A table should now appear.

6 In the bottom three rows of column two, ensure the values for Roll, Pitch, and Yaw are valid.

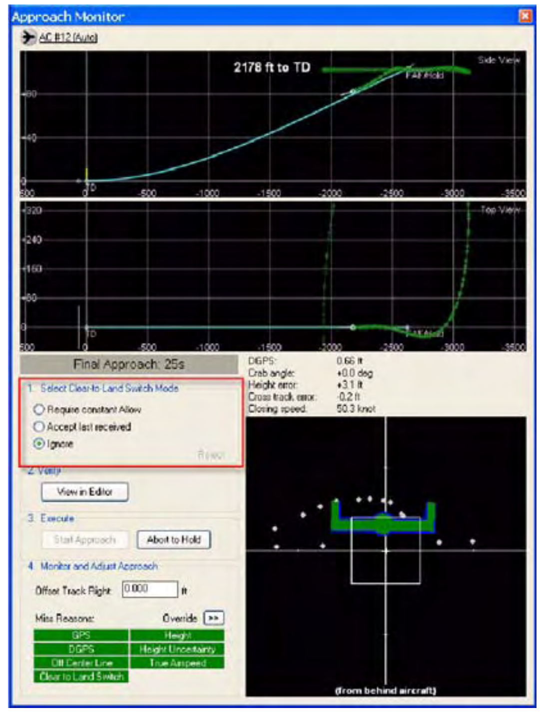
This completes all initial setup features for the AHRS system.

Additional System Components – Hardware

Clear-to-land switch

The Clear-to-land switch (CTL) is a safety device used in retrieval. Typically, the aircraft makes autonomous decisions about the safety of its approach, and will wave-off if appropriate. The CTL allows a ground observer to call a missed approach if the situation is unsatisfactory or unsafe.

There are two options for CTL use. The default is the slider on the right-hand side of the pilot's console; upon approach initiation, this is used. The other option is the dedicated CTL trigger; this is a rugged pistol-style trigger that provides the safety pulse. It plugs into the outside of the GCS.



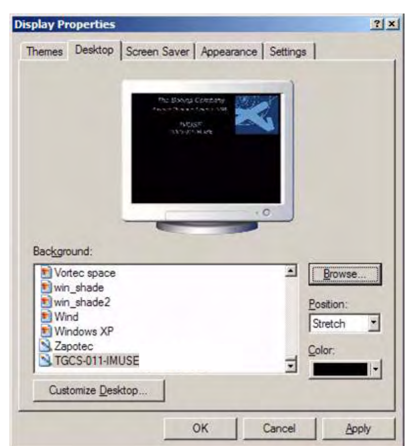
To access Clear-to-land in I-MUSE, select **Approach Monitor** from **Panel** menu on I-MUSE tool bar. There are three Clear-to-Land control options in I-MUSE:

- Require constant allow - Signal from CTL must indicate Proceed at all times. Loss of communication with CTL will cause a miss to be executed.
- Accept last received - Last signal from CTL must indicate Proceed. Loss of communication with CTL will **not** cause a miss (only a reject signal will cause a miss to executed).
- Ignore - Ignore signal from CTL and proceed with the approach.

Desktop configuration

Appearance

1. Obtain a copy of the desktop file from an Insitu representative.
2. Copy the desktop file to the system Windows
directory located at C:\WINDOWS\system.
3. Right-click on the desktop and select **Properties** from the menu that appears.
4. Select the **Desktop** tab option. Scroll down to the desktop file that was added to the system
Windows directory. Change background **Color** option to black.



Additional System Components – Hardware

Desktop configuration (cont.)

Appearance (cont.)

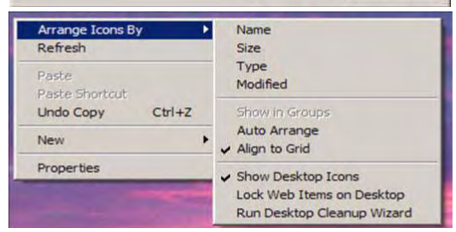
5 Click on **Customize Desktop**.

6 Select check boxes **My Computer**, **My Documents**, and **My Network Places**.

7 Disable (uncheck) check box **Desktop cleanup**.

8 Click **OK** on both this screen and the next screen.

9 Ensure that **Auto Arrange** is not checked by right-clicking on the desktop.



Icon layout

1 Drag the **Recycle Bin** icon to the bottom right corner of the desktop, just above the system tray.

2 Rename the **My Computer** icon to display the name of the machine.

Note: **Machine names vary. Contact an Insitu representative if the machine name is not known.**

3 Rename the **My Networks** icon to the workgroup name.

Note: **Workgroup names vary. Contact an Insitu representative if the workgroup name is not known.**

Additional System Components – Hardware

Desktop configuration (cont.)

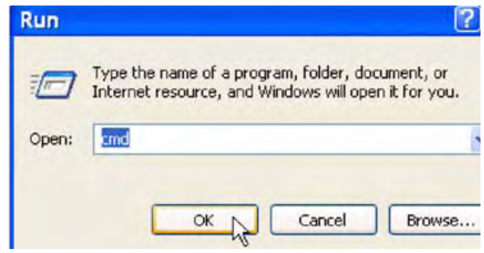
IP address

Find IP address

1 Left-click **Start** to open the primary Windows menu.

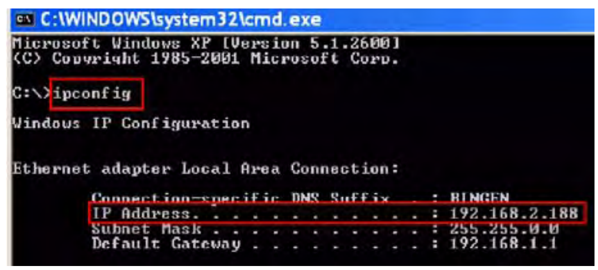
2 Select **Run**.

3 Enter **cmd** in **Open** field, click **OK**.



4 Type **ipconfig** into the command line and press the **Enter** key.

5 The line titled **IP Address** contains the IP Address for that computer.



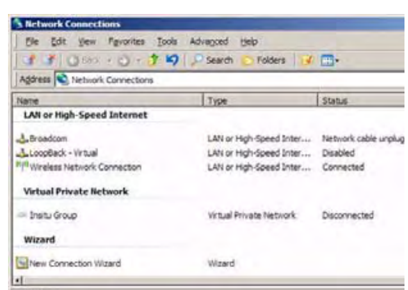
Note: **If the only output is Windows IP Configuration, the machine may not be connected to a network.**

For more information, see *Aircraft Network* in *I-MUSE online* reference documentation.

Assign alternate IP address

1 Right-click on the network workgroup icon that is renamed in this procedure under *Desktop Icon Layout* later in this section, and select **Properties.**

A list of installed network adapters appears.



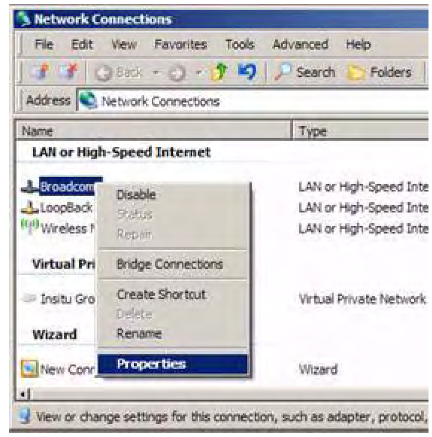
Setup 2

Additional System Components – Hardware

Desktop configuration (cont.)

IP address (cont.)

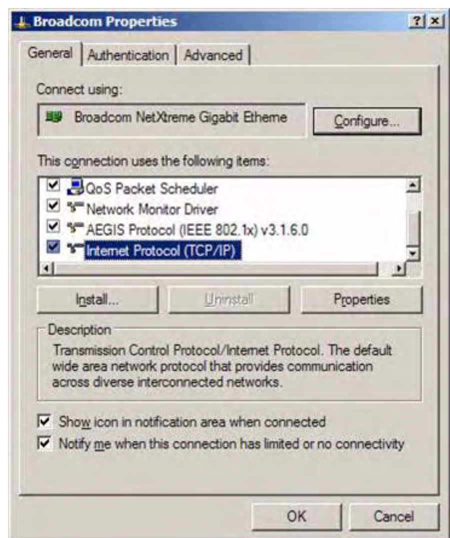
2 Right-click on the primary LAN network interface **Local Area Connection** and select **Properties**.

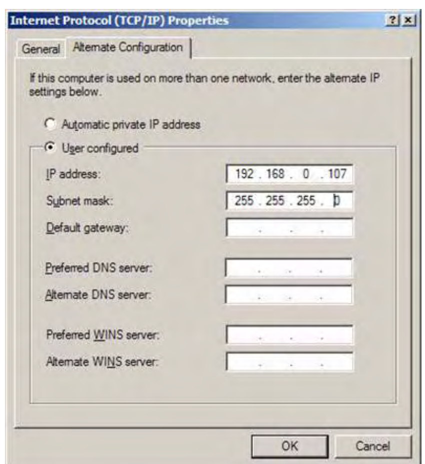


3 Ensure that the Internet Protocol (TCP/IP) is highlighted. Then, click on **Properties**.

The Internet Protocol (TCP/IP) Properties menu will appear.

4 Select **Alternate Configuration** tab. Enter alternate IP address and subnet mask.





Note: If alternate IP address and subnet mask are not known, contact an Insitu representative.

Click **OK** to return to the Network Connections screen, and then close it.

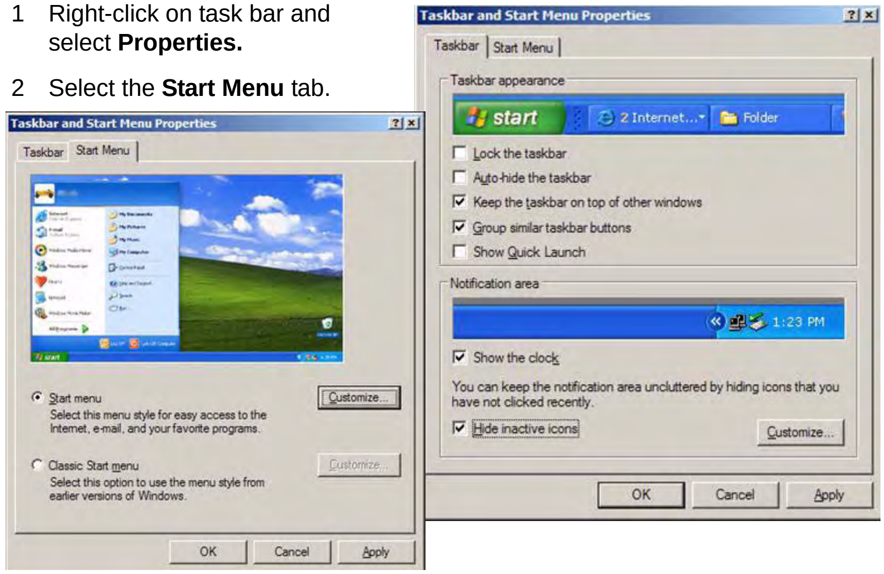
Additional System Components – Hardware

Desktop configuration (cont.)

Start menu configuration

1 Right-click on task bar and select **Properties.**

2 Select the **Start Menu** tab.



3 Click **Customize**. The Customize Start Menu page appears.

4 On the Customize Start Menu page:

- Select **Small icons.**
- Set the number of programs on the start menu to zero.
- Disable (uncheck) the Show on Start menu check boxes: **Internet** and **E-mail.**

5 Set the Start Menu items as follows:

- Control Panel - **Display as menu**
- My Computer - **Display as link**
- My Documents - **Don't Display**
- My Music - **Don't Display**
- Checkbox for **My Network Places** - Checked
- My Pictures - **Don't Display**
- Network Connections - **Display as Connect to menu**
- Printers and Faxes - **Checked**
- Run Command - **Checked**
- Scroll Programs - **Unchecked**
- Search - **Checked**
- Set Program Access and Defaults - **Unchecked**

6 Click **OK**.

- System Administrative Tools - Display on the All Programs Menu and the Start Menu.

Additional System Components – Hardware

Desktop configuration (cont.)

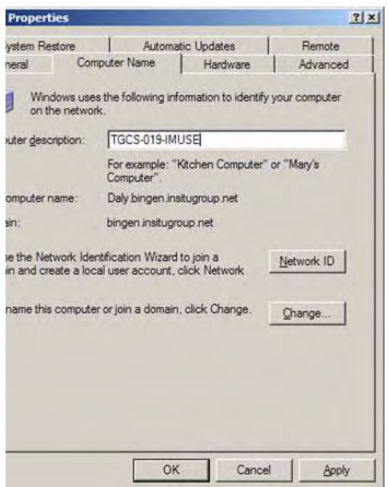
Start menu configuration (cont.)

7 Select the **Advanced** tab.

8 Disable (uncheck) the **Highlight newly installed programs** and **List my most recently opened documents** check boxes.

9 To back out to the desktop, select **OK** for all choices with this option.

10 Right click on the **machine name** icon on the Desktop and select **Properties**. Select the **Computer name** tab.



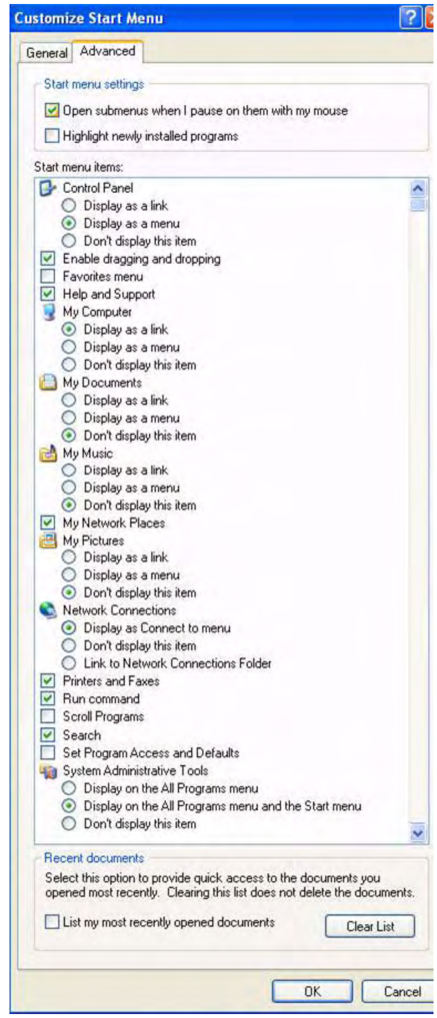
11 Select the **Change** button.

12 Enter the Insitu machine name into the **Computer name** field.

13 Change the name in the **Workgroup** field.

Note: These are the same machine and workgroup names that were changed earlier in this procedure under *Desktop Icon Layout*.

14 To allow changes to take effect, restart the system after changing either the machine name or the workgroup name.



Additional System Components – Hardware	
Generator	
	Refer to the manufacturer manual for requirements and exhaust/battery warnings.
HiL (Hardware-in-the-Loop) Simulator	
	Test onboard and ground elements prior to flight, using Insitu's hardware-in-the-loop (HiL) simulator. HiL simulators can be connected to any GCS, creating an interface identical to a GCS. Simulated features include airframe, aerodynamics, atmosphere, launcher, and SkyHook. Operators can fly, monitor, and control a virtual aircraft from I-MUSE, as if in actual flight. HiL simulators allow for the training of operators and the testing of parameter files and hardware, without the risks associated with actual flight. Tasks can be completed in as little as ten minutes or as much as several hours, depending on the breadth of the tasks.
Weather station	
	The optional weather station provides users with information on local conditions. The standard system provides data on wind speed, wind direction, temperature, pressure, and humidity. This is useful for takeoff and retrieval consideration. The anemometer must be aligned to north to provide accurate wind direction. The pressure data provided may not be accurate enough for an accurate reference for altimeter setting; a handheld is normally provided for this.

2.6 Aircraft

In this section:

- Step 1 – Unpacking
- Step 2 – Assembly
- Step 3 – Engine preflight
- Step 4 – Fuselage preflight
- Step 5 – Changing configurations
- Step 6 – Interference check
- Step 7 – Systems Check

Note: As a prerequisite for understanding and using this material, you must have successfully completed Insitu's authorized training for aircraft setup and preflight inspection.

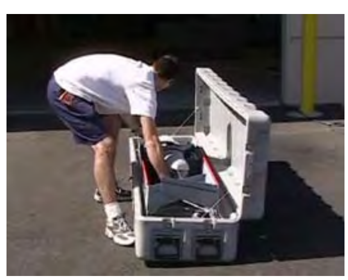
This section provides general guidelines and graphics to be used only in combination with the Aircraft Preflight/Postflight Inspection Checklist.

❑ **Use the latest approved *Aircraft Preflight/Postflight Inspection Checklist* to set up the aircraft for flight. The checklist is found in the *Pocket Handbook* and on Insitu's Extranet.**

Aircraft

Step 1 – Unpacking

- There are two types of storage cases: one with hinges and one without.
  - Hinged Case: Open all latches, and lift the lid.
  - Non-hinged Case: Lift the lid off vertically, until it has cleared the aircraft wings, and then set it aside. This is easiest to do with two people.
- Engage the locking mechanism located on underside of the bar marked by red arrow below, grasp the stand (as shown) and lift up, until the stand locks into a stable position. The stand raises only if the locking mechanism is engaged.



Aircraft

Step 2 – Assembly

Note: Use the latest approved *Aircraft Preflight/Postflight Inspection Checklist* for complete and accurate steps. The checklist is found:

- On Insitu's Extranet.
- In the *Pocket Handbook.*

1 **Aircraft Stand**

Raise to working height.

Wings are stored alongside the aircraft.

Remove any clips or foam plugs securing the flex strip to the wings for shipping and transport.

2 **Wing Servos:**

Ensure that servos are secure by pulling outward. Also ensure that all screws are in place.

3 **Control Horns**

Gently wiggle the control horn (in a clockwise/ counter-clockwise movement) to ensure that it is secure. If it is loose, it needs to be repaired before flight.

4 **Winglet Screws**

Check security.

5 **Gap Tape**

Ensure that all tape is down, and that nothing will flap in the wind.

6 **Wings**

Use a flat-head screwdriver to remove fuselage hatch cover.

Remove wing pins in fuselage wingbox.

To install each wing, grip the wing with one hand, towards the winglet end (as shown). Use the other hand to grip the wing and the flex strip, towards the open end of the wing (as shown).

CAUTION: Don't handle the wing by the control surfaces since this could damage the servos.

Carefully lift the wing up and out of the stand.

CAUTION: Maintain tension on the flex by holding it securely against wing while moving.

Aircraft

Step 2 – Assembly (cont.)

Align the wing with the fuselage wing root on the plane. If the flex strip is not already connected in the fuselage hatch, connect it.

CAUTION: Ensure that wing flex does not become bound or crimped when inserting.

Depress the flex tension lever to maintain tension on the flex while inserting the wing into the aircraft. Insert wing roughly perpendicular to the fuselage. (Wing tends to stick if not aligned properly.)

Note: It may be necessary to gently rock the wing fore and aft while applying enough force to fully seat the wing in the fuselage wing root.

Once installed into the fuselage, visually check alignment of the wing in the wingbox by looking into the wing pin hole.

Adjust alignment as needed, then insert the wing pin. Install the second wing as described in previous steps. Replace fuselage hatch cover.

7 **Orange Elevon Protection Strips**

Remove from wings before use!

CAUTION: Before powering up the aircraft, remove the orange elevon protection strips.

The orange elevon protection strips protect the gears and servos from being damaged during shipping and unloading, however they must be removed prior to use. Failure to do so will damage the gears and servos.

8 **Optional Payloads**

If operating the optional L-band video transmitter for use with ROVER Avionics, set the channel by rotating the channel selection dials (visible aft of the heat sink on the bottom of the avionics bay). Apply fuselage seal tape over the channel selection dials before flight.

Step 3 – Engine preflight

Use the latest approved *Aircraft Preflight/Postflight Inspection Checklist* for complete and accurate steps. The checklist is found:

- On Insitu’s Extranet.
- In the *Pocket Handbook.*

Step 4 – Fuselage preflight

Use the latest approved *Aircraft Preflight/Postflight Inspection Checklist* for complete and accurate steps. The checklist is found:

- On Insitu’s Extranet.
- In the *Pocket Handbook.*

Aircraft

Step 5 – Changing configurations

Whenever a module is changed in the field, the aircraft's parameter file must be updated.

These field modifications include:

- Changing weight and balance
- Changing engine and generator type
- Changing configuration type (such as, changing from an IR aircraft to an EO aircraft)

For information about making changes to the parameter file, refer to Chapter 3, *Preflight.*

Note: For simplicity, this procedure targets the change from IR to EO configuration.

Aircraft: IR to EO

1 To change aircraft configuration from IR to EO, exchange modules, change configuration as detailed and look at all the other EO aircraft to see typical ballast.

Note: Remove ballast from engine mount and add ballast to EO dome per EO aircraft parameter file specification. (See notes in weight and balance page.) Add ballast to the bulkhead at the aft of the nose module. (The farther the ballast is placed from the CG, the less weight is required.) After verifying that ballast is correct, take the weight and balance data from the EO aircraft, and use it to set the new aircraft ballast.

2 Move the battery. In IR configuration, the battery is in front of the fuel tank. In EO configuration, the battery is in front of the avionics. Wire length change may be required.

The aircraft should balance by hand 5-10 mm in front of the aft wing root fillets where the grippers push.

Aircraft: EO to IR

1 To change configuration of an aircraft from EO to IR, switch the modules, move the battery back, check the average ballast requirements, and change the parameter file as specified.

2 Check empty weight to ensure the ballasting has been done as required. If drastically different, then make corrections after checking component weights.

3 Keep master copies of the parameter files somewhere safe, and use the latest version of params when making exchanges.

Aircraft

Step 5 – Changing configurations (cont.)

Alticam 600-6000 Turret Installation

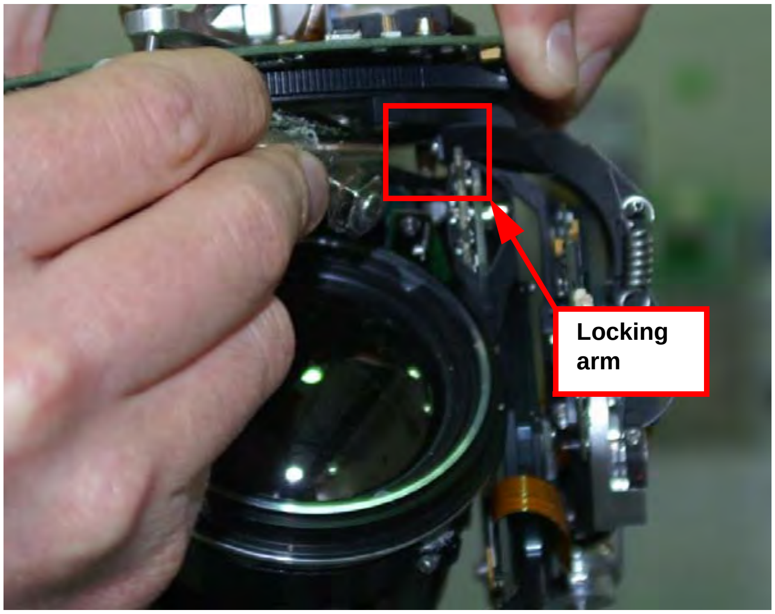
CAUTION: The camera turret and its circuit boards can be damaged by static electricity. Grounding static wrist straps should be worn before handling the camera turret assembly.

❑ **About locking and unlocking**

The locking arm is the small aluminum piece pointing down and back.

Lock the camera:

- After installation.
- Before launch.
- When not in use.



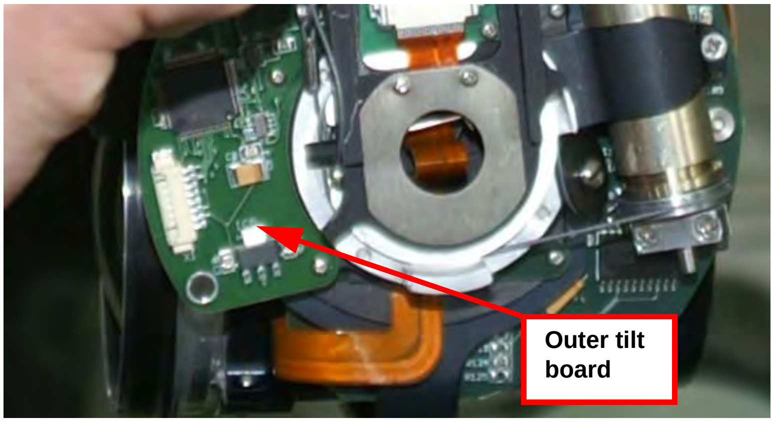
❑ **Unlock the camera**

- Before installation.
- From I-MUSE during flight.
- As directed in the *Maintenance Handbook*.

❑ **Unlock**

Grasp the outer tilt board and rotate it forward.

Note: **Outer tilt board is a half-circle board. Forward rotation releases the locking mechanism, allowing free movement of inner stage that holds camera.**



Aircraft

Step 5 – Changing configurations (cont.)

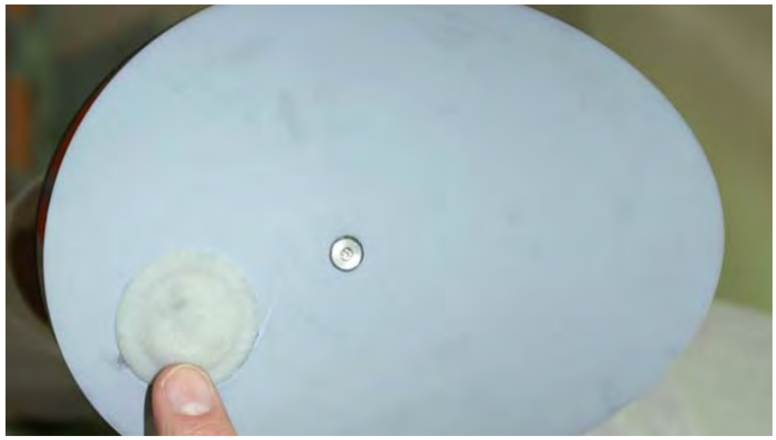
❑ **Lock**

Holding the camera/turret with the lens facing you, move the inner stage (which holds the camera) right and up, then rotate the outer tilt stage up. The camera can move approximately 1/8-inch when in the locked position.

❑ **Install**

1 Using a 3/32-inch balldriver, remove the hatch lid.

Note: The modified lid for IR mid-bay aircraft has a nylon hat on top that allows the 600-6000 camera/turret to fit in the IR mid-bay aircraft.



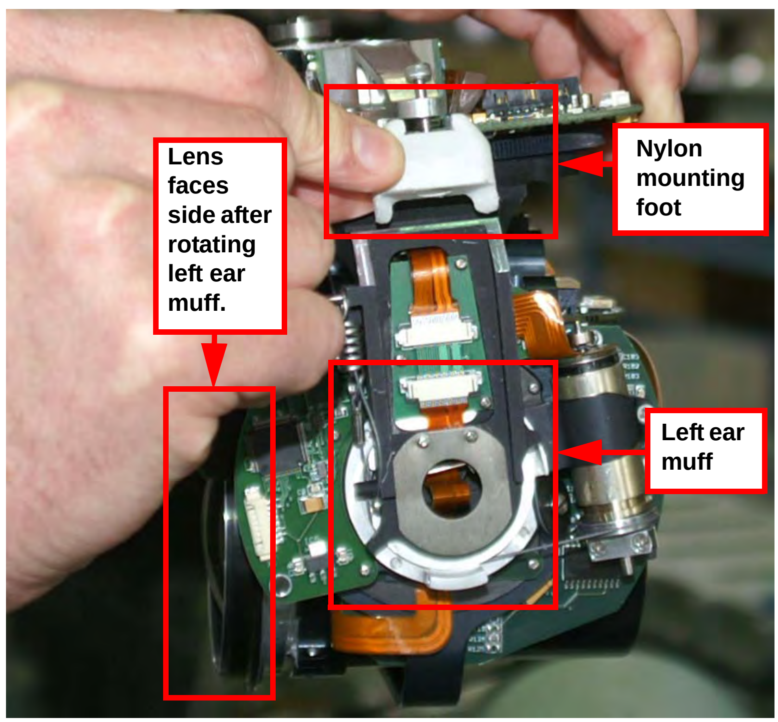
Note: The IR-mid-bay lid now screws directly into the turret instead of a mounting fixture. Lid removal and installation is unchanged.

2 Unlock the camera.

3 Orient the camera so it is level and facing forward.

4 Rotate the left ear muff to the front.

Note: The front is identified by the nylon mounting foot.



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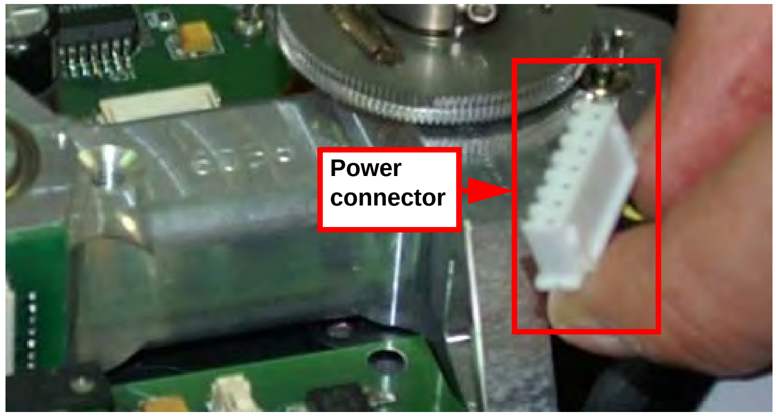
Aircraft

Step 5 – Changing configurations (cont.)

5 After camera is oriented properly, carefully place the camera in the hatch, holding the power connector out of the way.



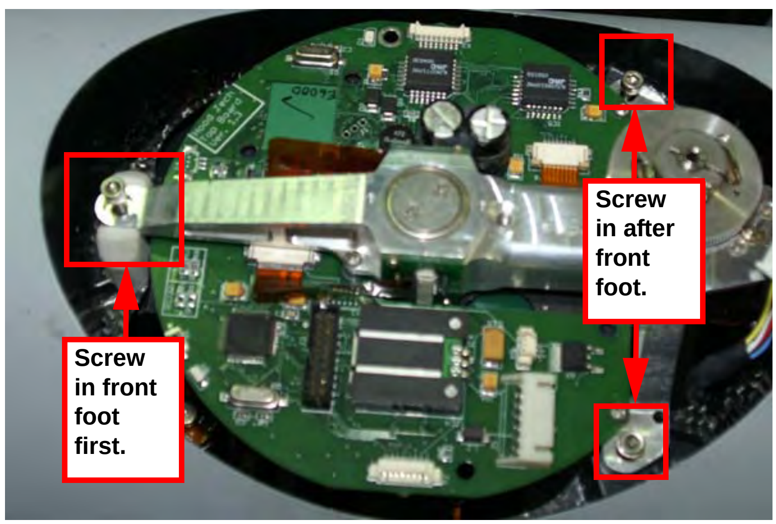
Note: The power connector is zip-tied on the left side of the aircraft, just behind the mounting flange.

If difficulty is experienced placing camera and turret through hatch, carefully wiggle the camera within the turret until the assembly slides through.

6 Using a 7/64-inch Allen wrench or balldriver, secure the camera/turret assembly:

a. Secure the front foot first – the nylon foot aligns the turret to the aircraft.

b. Secure the back two feet after the front foot is secure.



Aircraft		
Step 5 – Changing configurations		**(cont.)**
7 Connect the power. 8 Using the turret panel in I-MUSE, lock the turret. The **lock** button is treated like any other mode in I-MUSE. **CAUTION: Always lock the turret before moving the aircraft.**		

Aircraft
Step 6 – Interference check

Once the site has been set up, and the aircraft are programmed with the new mission files (see Chapter 3, *Software: Programming & Simulation)*, there are a number of checks that are best completed before flight. These checks are mainly to determine any local radio frequency (RF) interference with the UAV radio signals. If possible, it is best to coordinate with the users of the new site to conduct the interference check. This requires selectively turning on various emitters, while the operator checks for issues with the following:

1 **Video:** Look for noise in the picture (horizontal lines, snow or black dots). Look at the output of the receivers with the video off. Normally, the screen displays pure white noise. If any signal is present in the video frequency range, it is possible that some black bars or a totally black screen is displayed, or that an image is seen from another video system.

2 **Communication:** Check for gaps in downlink telemetry, uplink problems, or autopilot going to **SAFE a** on the ground. Look for high dropout rates and DGPS problems.

3 **GPS:** Look for drops in signal strength, satellite number and lock times. Look at the uncertainty values for both aircraft and SkyHook.

4 **Aircraft:** Check for un-commanded surface movement.

5 **Avionics:** Check for spikes on fast ADC channels (TAS, altitude, and gyros).

Note: Additional sections of this chapter provide detailed instructions for components related to these checks.

Step 7 –Systems Check

A Systems Check is performed by a qualified operator whenever an operator wants to check the operational readiness of equipment. Use the latest Systems Check Checklist found in I-MUSE to set up the aircraft for flight.

To view the Systems Check checklist in I-MUSE:

1 Select **Checklists** and Procedures from the **Panel** menu on the I-MUSE toolbar.

2 Select **Start New** from the toolbar.

3 Select **Systems Check** and left-click **Start** button.

The Systems Check varies depending on the aircraft configuration and the ground equipment.

A Systems Check typically consists of the following tasks:

- Setup
- Aircraft Power On
- GPS Check
- Video System Check
- Autopilot Check
- Flightplan Check
- Briefing
- Engine Start
- Autopilot Launch
- Ground Run

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3

Programming

Each aircraft has a unique configuration, and each mission has unique requirements. To help operators manage these differences, the aircraft avionics store much of the basic configuration data in non-volatile memory. This data is organized into four types of parameter files: aircraft parameters, mission parameters, reporting parameters, and communication parameters. Modem parameter settings are also stored separately, on the winglet modem. This chapter describes how to use and manage these files.

3.1 Aircraft Parameter Files

Each aircraft has its own set of calibration data and unique parameters. These are stored in Excel spreadsheets. These spreadsheets are labeled either **Seascan*XX*ACparams.xls** or **X200 Aircraft XXXX.040.xls**, depending on the version of the spreadsheet that shipped with the aircraft. The spreadsheet consists of many pages of calibration information. These pages are filled in during the calibration process at Insitu, and most do not require changes in the field.

All calibration data are linked to one page, the **ACparam** sheet. This sheet also contains autopilot settings, avionics information, and aerodynamic characteristics. This sheet generates the file that gets loaded onto the aircraft; it gives the aircraft all the information required for safe autopilot flight.

Once in the field, the aircraft parameter spreadsheet needs to be modified when a module change is made. This process is relatively simple, but care must be taken, and strict control over versions maintained. This chapter describes those procedures and the best practices when managing aircraft parameter files in general.

3.1.1 Spreadsheet versions and update methods

The method that you will use to update the aircraft parameter file are determined by the version of the spreadsheet. New aircraft ship with versions of the spreadsheet that provide simpler methods for updates. Newer versions of the spreadsheets are indicated by the "X200" prefix at the beginning of the file name, e.g., **X200 Aircraft 00002.040.xls**. Older versions must be updated manually.

- **Aircraft parameter files that were produced by Insitu with the “X200” prefix can be updated automatically using Programmer. Refer to the following sections for instructions on how to update the aircraft parameter file:**

  - ❑ "Update an aircraft parameter file using Programmer" on page 3-12
  - ❑ "Programming the Aircraft and If/C" on page 3-42

- **Older aircraft parameter files that do not have the X200 prefix must be updated manually. Refer to the following sections for instructions on how to update the aircraft parameter file manually:**

  - ❑ "Update an aircraft parameter file manually" on page 3-3
  - ❑ "Transfer parameters within Excel manually" on page 3-5
  - ❑ "Enter weight and balance manually" on page 3-7
  - ❑ "Change the engine and generator type manually" on page 3-8
  - ❑ "Change the aircraft configuration manually" on page 3-9
  - ❑ "Configure the simulator file manually" on page 3-10

❑"Verify parameter file changes" on page 3-11

3.1.2 Update an aircraft parameter file manually

Note: This section applies to older aircraft parameter spreadsheets that do not have the X200 prefix.

Keeping track of calibration data is very important. The following are best practices managing older aircraft parameter files manually.

✓ Keep all the spreadsheets organized and create backups periodically.

✓ Create a folder for each aircraft. Each time the parameter file is changed and version incremented, create a new folder.

✓ Keep a log of changes made to each spreadsheet so change history is available.

✓ Keep track of serial numbers in module changes; write them in this log.

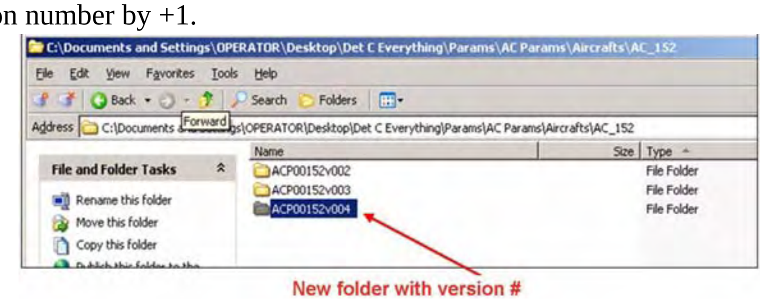
✓ Each time a spare module is shipped, it ships with its own CD with calibration data. These CDs should be kept together in a safe place, so any time they are needed, they can be found easily.

3.1.2.1 Create a new version of the aircraft parameter file

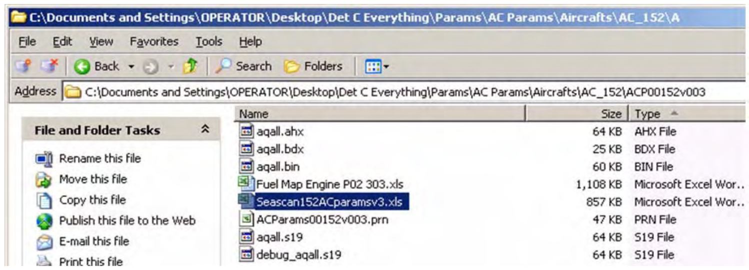
Note: This procedure applies to older aircraft parameter spreadsheets that do not have the X200 prefix.

1. Load the CD or file with new module parameters into computer.
2. Open the appropriate file containing aircraft parameter files (e.g. C:\aircraft\Params\AC Params).
3. Place the new file from CD into the correct folder (e.g. Engine, Avionics, Wings, etc.) and name it.
4. Browse to the aircraft files for the aircraft being changed (e.g. C:\aircraft\Params\AC Params\Aircraft).
5. Open AC folder (e.g. AC_152).

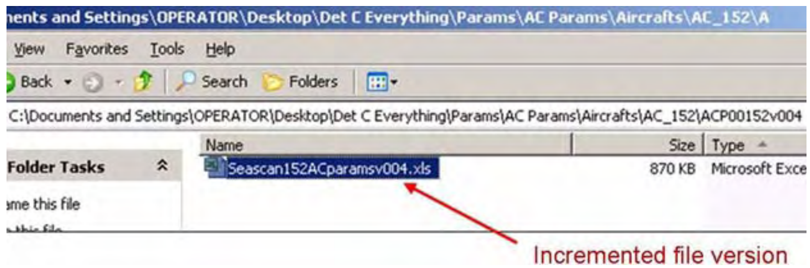
   a) Create a new folder and name it following previous conventions, incrementing the version number by +1.



b) Open the previous version folder (e.g. ACP00152v003) and copy the previous aircraft Excel file (e.g. Seascan152ACParamsv3.xls).

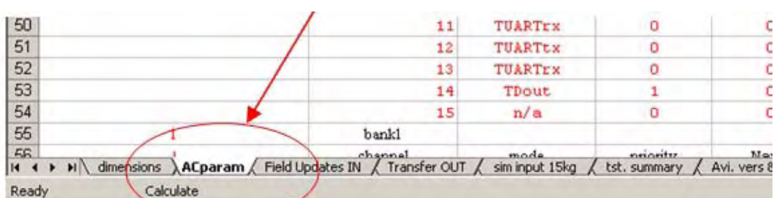


c) Paste this file into the new folder created earlier in this step; increment the version number of the file by +1.

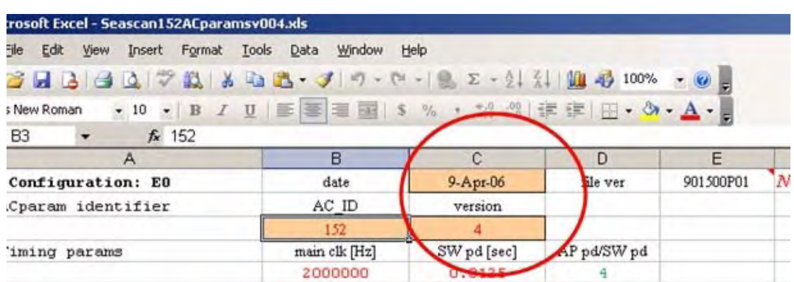


6 Insert by copying and pasting the new module parameter file into the folder created in the previous step (e.g. Fuel Map Engine P02-322.xls).

7 Open both Excel files: 1) the aircraft parameter file; and 2) the new module parameter file.



8 Go to the aircraft Excel file. Select the **ACparam** tab at the bottom of the Excel page. At the top of this page, increment the **Version #** and update the **date**.

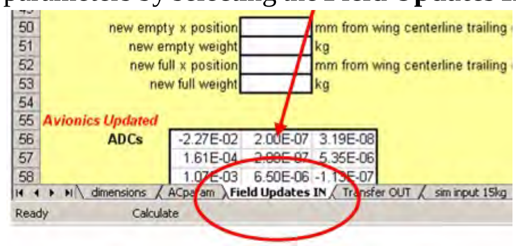


3.1.2.2 Transfer parameters within Excel manually

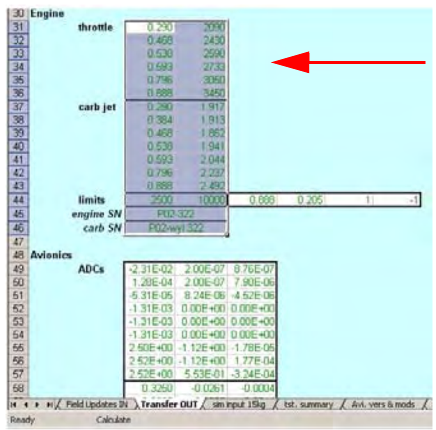
Note: This procedure applies to older aircraft parameter spreadsheets that do not have the X200 prefix.

Calibration data for the new component must be entered on the **Field Updates IN** tab. This tab contains sections to input all the calibration data. You must copy calibration data from the spreadsheet that shipped with the new module or source aircraft to your aircraft's parameter file.

1. Prepare to get the new parameters by selecting the **Field Updates In** tab of the Aircraft File.



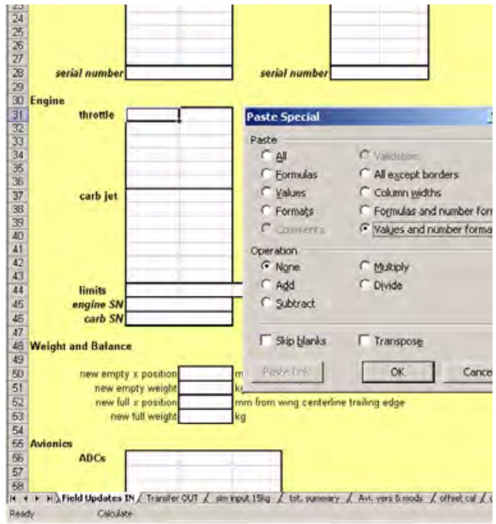
2. Switch to the new Module Parameter Excel file (e.g. Fuel Map Engine 322.xls). Go to the **Transfer OUT** tab. Copy the correct parameters (e.g. Engine Parameters).



Engine Parameter are high-lighted and copied.

3. Switch back to the Aircraft File and the **Field Updates IN** tab (e.g. Seascan152ACparamsv004.xls).

4 Right-click in the upper left of the parameters to be updated. Select **Paste Special** from the **Edit** drop-down menu. Select the values and number formats, then select **OK**.

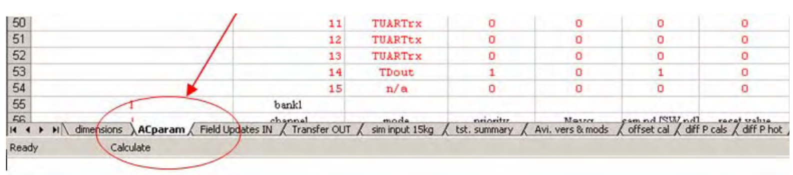


5 Repeat the previous step if all parameters were not pasted during the initial iteration.

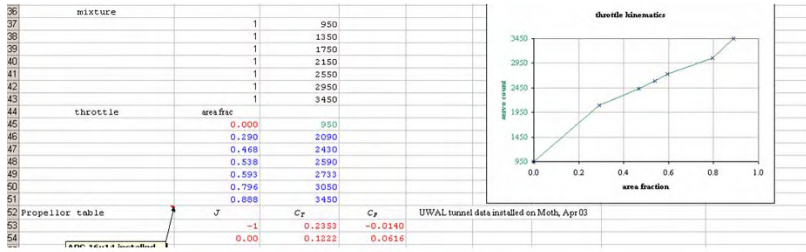
6 Once all module parameters are pasted into the aircraft file, the **Aircraft File Field Updates IN** tab indicates "***Engine Updated***."

7 Verify correct, expected parameters are listed by checking **SN** and values between spreadsheets.

8 Select the **ACparam** tab in the Aircraft File.

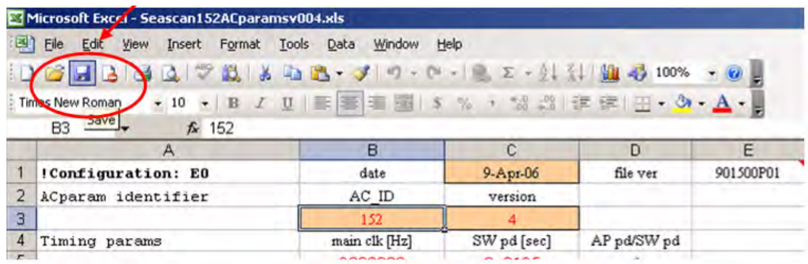


9 Scroll down to the Throttle section.



Verify that parameters have been updated and match parameters of transferred module parameter file (i.e. check that these numbers match numbers in Engine File, for this example).

10 If parameters are correct, save the Aircraft File by clicking on the **Save** button.



3.1.2.3 Enter weight and balance manually

Note: This procedure applies to older aircraft parameter spreadsheets that do not have the X200 prefix.

Weight and balance must be updated if any of the swapped components are different weights. If they are not the same, then the aircraft center of gravity will change, and the recorded aircraft weight will not be correct. This is not desirable from an aircraft dynamics perspective. To correct it, and update the information, use the following method:

1 Complete the aircraft hardware modifications.

2 Drain fuel.

3 Attach CG measurement jig.

4 Set desired CG position (in region of -70mm). Try to use the same location as the aircraft had before changes were made.

5 Check level.

6 If not level, balance with ballast at ends of fuselage, in a location that ballast can be affixed.

7 Enter new CG position in **Field Updates IN** page.

8 Check empty weight with jig removed.

9 Enter new empty weight on **Field Updates IN** page.

Note: If the aircraft spreadsheet is version 901500P03 or later, stop here. If the aircraft spreadsheet is earlier than version 901500P03, complete the following additional steps:

10 Fill with fuel.

11 Attach CG jig.

12 Check CG (find location where aircraft becomes level; do not add further ballast).

13 Enter CG location in update page.

14 Check gross weight with jig removed, enter in update page.

15 Click the **Save** button.

Note: This method assumes that the vertical CG does not change. Check the value is within limits.

3.1.2.4 Change the engine and generator type manually

Note: This procedure applies to older aircraft parameter spreadsheets that do not have the X200 prefix.

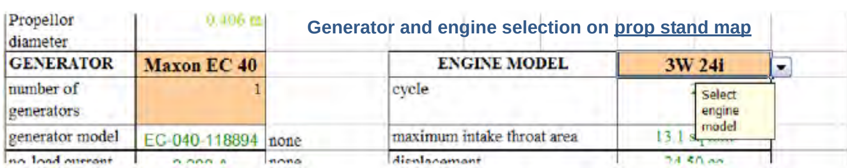
When putting a new engine type onto an airframe, the calibration data must be updated on the **Field Updates IN** tab.

1 Change engine and generator type as appropriate on the **prop stand map** tab. Select from the following engines:

- 3W 24i
- 3W 28i

2 To change generator type, choose between the following (or others currently available):

- Maxon EC 40
- Kollmorgen 1150 B



3 Remember to increment date and version number on the **ACparam** tab after changes have been made.

4 Click the **Save** button.

Note: Fuel burn estimates will not be correct unless the correct engine and generator type is selected on the prop stand map page.

3.1.2.5 Change the aircraft configuration manually

Note: This procedure applies to older aircraft parameter spreadsheets that do not have the X200 prefix.

Changing modules does not require any changes to the fuselage parameters. However, when changing configurations (e.g. IR to EO), certain steps are needed to update aerodynamic and inertial properties. This procedure outlines the changes needed:

1. Complete hardware changes.
2. Update weight and balance data as necessary.
3. Open the **dimensions** tab.
4. At the top (cell C1), select type as appropriate. Fuselage type is selected by choosing a number. When the appropriate selection is chosen, the choice will be highlighted (e.g. A-20 EO).

Note: Configuration will also appear at the top of the ACparam page, cell A1.

CONFIGURATION		A-20 EO	A-20 IR	A-20 DB	A-20 GR	A-15 EO	A-15 IR	A-15 DB	A-15 GR	B-20 EO	B-20 IR
1		1	2	3	4	5	6	7	8	9	10

Fuselage selection is highlighted in salmon-colored cell.

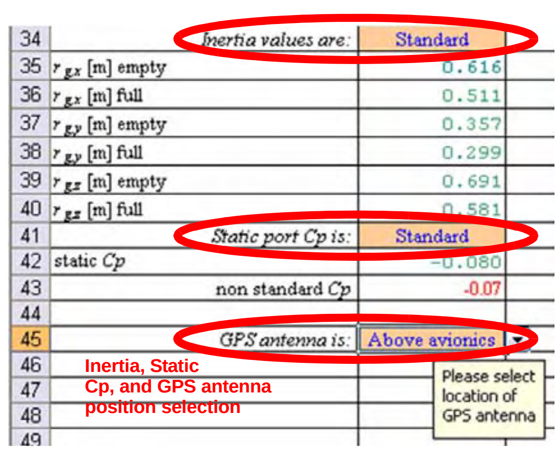
Note: If part is a spare module, choose the appropriate selection on the dimensions page, then hide non-relevant data on Transfer OUT page.

Configuration Key:	
A-15	Model A fuselage, model A wings
A-20	Model B fuselage (dome tabs), model A wings
B-20	Model B fuselage (dome tabs), model B wings (tooled servo tray)
EO	Standard EO
IR	Standard IR
DB	Dual Bay
GR	GeoRanger
SPARE	This parameter spreadsheet is for a single module only!

5. Check Inertia values are "Standard" (cell B34 of the Excel spreadsheet) or use "Calibration" if non-standard.

   Check static C_P (coefficient of pressure) value is "Standard" (cell B41 of the Excel spreadsheet) or use "Non Standard" value if appropriate:

   - -0.03 for long pitot/static boom
   - -0.13 for kalatel EO dome with side ports



6. Check GPS antenna position selection.
7. Set date and increment version on ACparam.
8. Click the **Save** button.

3.1.2.6 Configure the simulator file manually

Note: This procedure applies to older aircraft parameter spreadsheets that do not have the X200 prefix.

No changes to the simulator tab are needed if switching between EO and IR configurations. With spreadsheet version P03 or later, the simulator file is updated automatically based on configuration selection. If using an older file, the simulator file needs to be updated if any extra aerodynamic surfaces are added to the aircraft. For example, a GeoRanger or Dual Bay has a centerline fin that lies above the engine cowling. In this case, a new aero-panel needs to be created. The aero-panels are coordinates of corners that specify the wire frame model as displayed in FlightSim. The coordinate system used is the aircraft body axes, x forward, y right, and z down. The aircraft datum is a point on fuselage centerline, forward of the front bulkhead by 118 mm (for the old fuselage) or 93 mm (for the new fuselage).

GeoRanger Centerline Fin Simulator Panel

!centreline fin									
!call for even spacing in y		N_{panel}							
!panel		6							
!call for even spacing in q		N_{panel}	θ_{root}	θ_{tip}					
panelT		6	3.142	0.000					
!$x_{root,LE}$	$y_{root,LE}$	$z_{root,LE}$	$x_{root,TE}$	$y_{root,TE}$	$z_{root,TE}$	root cf/c	stall δC_l	section properties file	in (fwd, right, down) body axes
-1.042	0.000	-0.092	-1.206	0.000	-0.084	0.244	2.001	na001426.lut	0.000
!$x_{tip,LE}$	$y_{tip,LE}$	$z_{tip,LE}$	$x_{tip,TE}$	$y_{tip,TE}$	$z_{tip,TE}$	tip cf/c		0	in (fwd, right, down) body axes
-1.164	0.000	-0.397	-1.267	0.000	-0.397	0.238	2.001	na001426.lut	0.000
n/a									

This figure shows the addition needed for the GeoRanger or Dual Bay. The panel needs to be added after row 105 on the **sim 15kg** simulator tab (before end panels). Name the panel n/a in the bottom left hand side of the section. The area in green points FlightSim to use a look up table for the aerodynamic characteristics for that particular panel. In this case, it uses the same as the winglets – a symmetrical airfoil, found in **na001426.lut.** FlightSim needs this file in the folder where it is running.

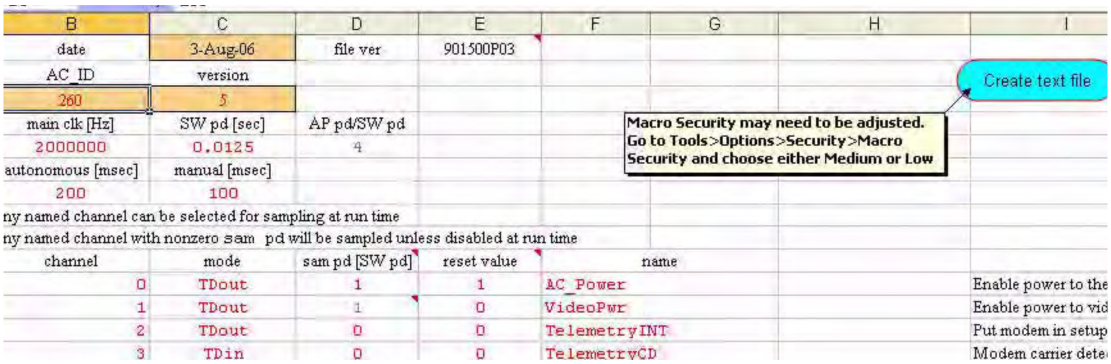
Once changes have been made, it is important to check the model in simulation. Before starting the simulation, check the surface is in the right place by looking at the wire frame (**Alt-F3**).

If any fins are added to the fuselage in front of the CG, be especially careful with control checks in simulation (turn reversals, etc.), as this tends to reduce the lateral stability and is not recommended.

3.1.2.7 Create a text file (.prn) from the aircraft parameter file manually

Note: This procedure applies to older aircraft parameter spreadsheets that do not have the X200 prefix.

Newer parameter files include a **Create text file** button on top of the ACParam sheet in the Excel spreadsheet.



This method of creating a .prn file saves the .prn file in the specified InsituGroup folder. For example, with 5.0 software, .prn files are found in:
C:\Program Files\InsituGroup 5\Groundbase\Parameters\ParamsBuilding.

1. With the aircraft parameter file open and the **ACParam** tab showing, select **File**, then **Save As**.
2. Select **Save as type: Formatted Text (Space delimited) (*.prn)**.
3. Name the file with the convention: 5-digit AC #, 3-digit version # (e.g. ACparams00152v004).
4. Click **Save**.
5. Click **OK** to save only the active sheet.
6. Click **Yes** to save format without all features.
7. Close the Excel aircraft file and the other parameter files.
8. When asked if you want to save changes click **No**.

3.1.2.8 Verify parameter file changes

Note: This procedure applies to older aircraft parameter spreadsheets that do not have the X200 prefix.

Any time a change has been made to a parameter file, it should be compared with previous versions. This safeguards against making unintentional changes. The first step is to save the **ACparam** page as a space delimited text file.

A text comparison program such as Beyond Compare should be used to compare the new parameter .prn file to either an earlier version of the parameter .prn file or to the parameter file for a similar aircraft.

The .prn extracted directly from Excel will occasionally have different spacing that causes Beyond Compare to mark differences that do not really exist. To avoid this problem, the .prn extracted from Excel can be read into MakeFlightParams and then written out as .prn files. These .prn files output by MakeFlightParams will have identical spacing.

For modifications to an existing aircraft parameter file:

1. Compare the new .prn file to the .prn file for the previous aircraft version.
   - ❑ Verify that only the date, version, and sections related to the desired modification have changed.
2. If a part/module was installed and a parameter file previously existed for that part/module (part/module was a spare with a parameter file, or the part/module was transferred from another aircraft):
   - ❑ Compare the new .prn file to the .prn file (or Excel file) that contains the parameters for the new part/module.
   - ❑ Verify that the sections of the aircraft parameter file having to do with the new module match the same sections in the file that contains the parameters for the new part/module.

For a new aircraft parameter file:

1. Compare the new .prn file against a .prn file for an aircraft in a similar configuration.
2. Verify that only the expected sections differ (date, AC_ID, version, avionics calibration, throttle calibration, servo calibration, carb jet calibration, masses & c.g.s, etc. as appropriate).

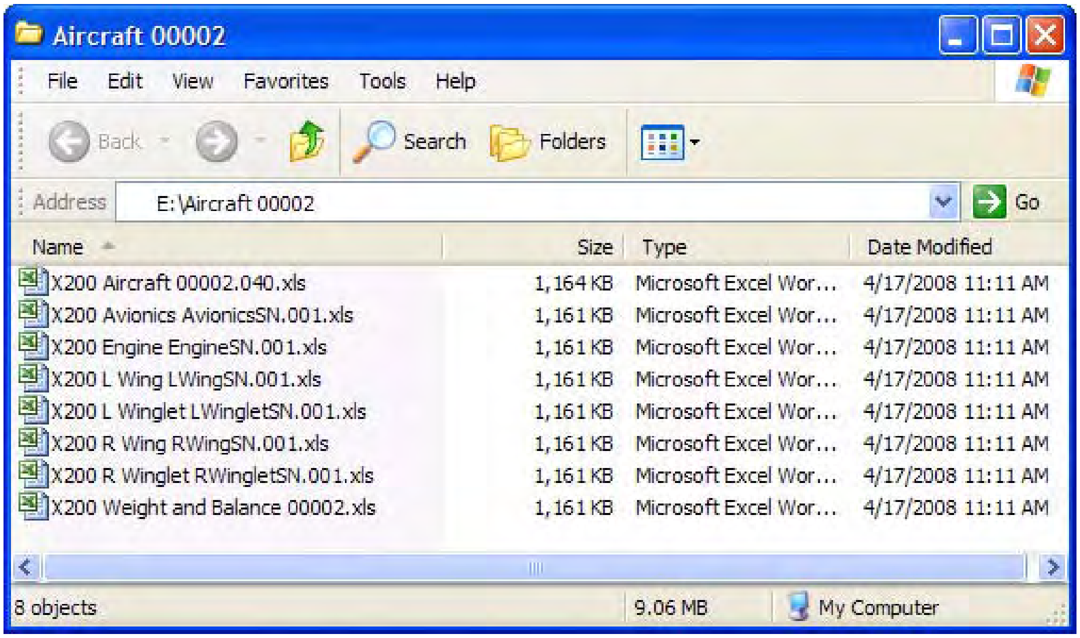
3.1.3 Update an aircraft parameter file using Programmer

Note: This procedure applies to aircraft parameter spreadsheets that have the X200 prefix, and requires I-MUSE version 5.3.x or later.

If you are running I-MUSE 5.3.x or later and your aircraft parameter file is version 020-030002R02 or later, then you can use Programmer to update your aircraft parameter files. This occurs as part of the process of uploading the parameter files to the aircraft and/or If/C. This process greatly reduces the chances of making unintended changes to the spreadsheet while copying and pasting information.

How it works

Newer aircraft ship with a USB drive that contains the aircraft parameter spreadsheet and supplemental spreadsheets for the aircraft components, weight and balance entry, and the engine parameters. These files are grouped in a folder labeled with the aircraft name, e.g. Aircraft 00002.



When you install a new component on the aircraft, you copy the new component's spreadsheet into this folder. Then, when you upload the aircraft parameter file to the aircraft using Programmer, Programmer looks to see if there are differences between the current aircraft parameter file and the supplemental spreadsheets. If there are differences, several things happen:

- Programmer will ask you if it should import the supplemental spreadsheets' configuration data into the aircraft parameter file.
- The program saves a copy of the old aircraft parameter file to the **Old** folder, within the aircraft folder.
- It copies the new data from the supplemental spreadsheets into the aircraft parameter file.
- It increments the spreadsheet version number and the current date fields within the file.
- It saves the updated aircraft parameter file with a new filename.
- It generates several files, including the aircraft parameter .prn file.
- It uploads the new .prn file to the aircraft.

Best practices for managing aircraft parameter files using Programmer

Keeping track of calibration data is very important. The following are best practices when updating parameter files using Programmer.

✓ Make the aircraft's USB storage device the primary location of the aircraft parameter file.

✓ Create backups of the storage devices periodically.

✓ Each time a spare module is shipped, it ships with its own CD with calibration data. These CDs should be kept together in a safe place, so any time they are needed, they can be found easily.

Prepare the aircraft parameter files for automatic update

Note: This procedure applies to aircraft and component parameter spreadsheets that have the X200 prefix, and requires I-MUSE version 5.3.x or later. If you are using a component with an older spreadsheet, see "Update an aircraft parameter file manually" on page 3-3.

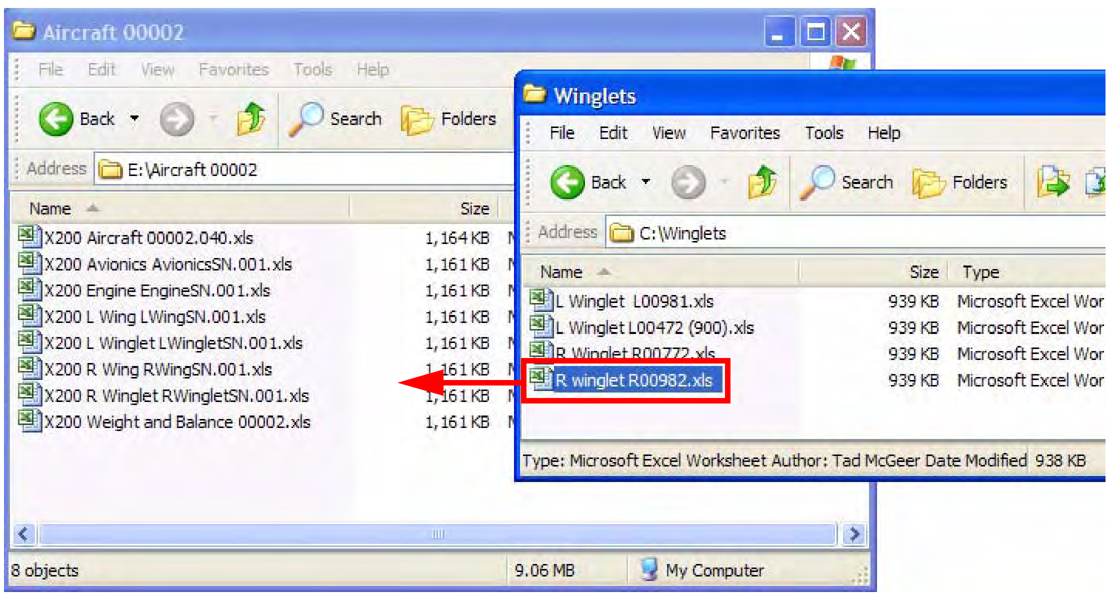
1 Complete the aircraft hardware modifications.

2 Note the new weight and CG measurements if applicable, as described in "Enter weight and balance manually" on page 3-7.

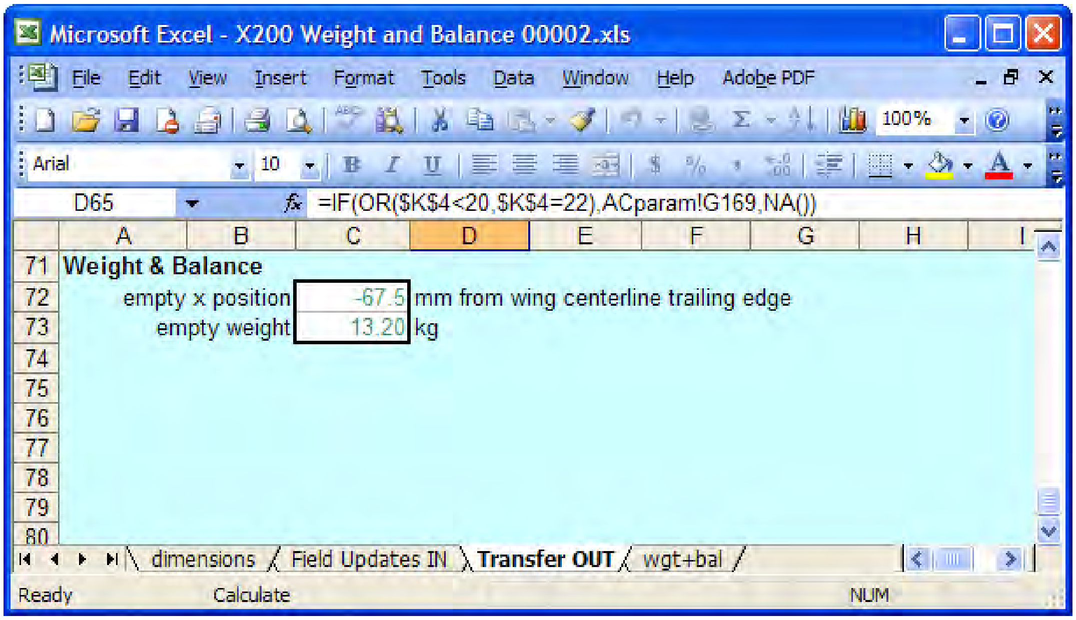
3 Insert the USB drive containing the aircraft parameter folder into the I-MUSE computer.

4 Load the CD or file containing the new component's spreadsheet into the computer.

5 Copy the new component spreadsheet into the aircraft parameter folder on the USB drive (e.g. X200 R winglet R00982.xls).



6 Open the Weight and Balance spreadsheet and enter the new data, if applicable.



7 Save and close the Weight and Balance spreadsheet.

8 To complete the update of the aircraft parameter file, go to "Programming the Aircraft and If/C" on page 3-42 and follow the instructions.

When you run Programmer to upload the aircraft parameter file, as described in "Programming the Aircraft and If/C" on page 3-42, Programmer will pull the new data from the new component and Weight and Balance spreadsheets into the aircraft parameter file.

3.1.4 Standalone simulation flight checks

Once the aircraft parameter file has been updated, it is important to check the model in simulation. A standalone simulation flight of the new aircraft parameter file should be performed with I-MUSE. This section outlines steps to create the files needed for simulation.

Before starting the simulation, check the surface is in the right place by looking at the wire frame (**Alt-F3**). If any fins are added to the fuselage in front of the CG, be especially careful with control checks in simulation (turn reversals, etc.), as this tends to reduce the lateral stability and is not recommended.

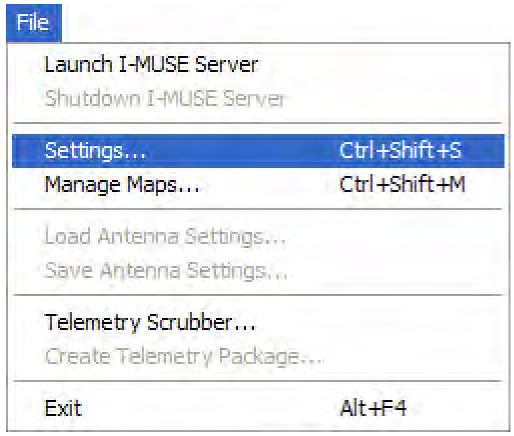
Generate the simulator parameter file in I-MUSE 5.3 and later

In earlier versions of I-MUSE, you had to generate a simulator parameter file from the aircraft parameter file in order to be able to simulate the new configuration. (See "Generate the simulator parameter file in I-MUSE 5.2 and earlier" on page 3-17 for instructions.) In I-MUSE 5.3 and later, you no longer have to generate a separate file.

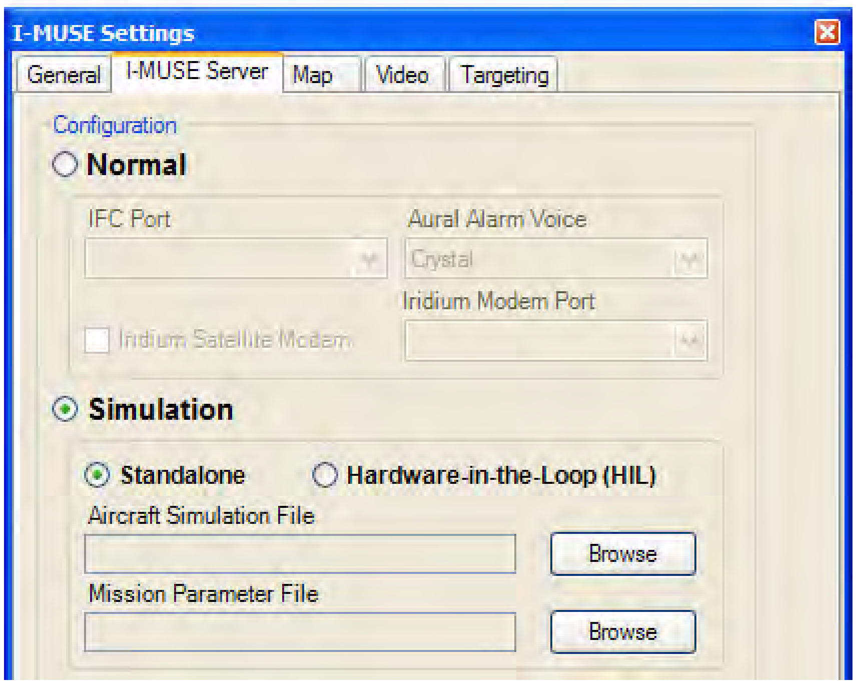
1 Insert the USB drive with the latest aircraft parameter file into the I-MUSE computer.

2 Start I-MUSE.

3 Click **File**, then **Settings...**



4 In the Settings dialog box, click the **I-MUSE Server** tab and then **Simulation**.

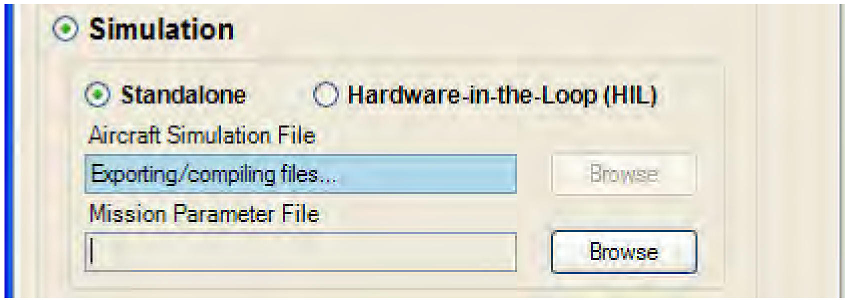


5 Make sure **Standalone** is selected.

6 Click **Browse** next to **Aircraft Simulation File**, and browse to the aircraft parameter .xls file on the USB key.

7 Select the aircraft parameter file and click **Open**.

I-MUSE will open the parameter file and export the simulator parameter file to the Groundbase folder on your computer.



8 Once the aircraft simulation file export is complete, click **Browse**, next to **Mission Parameter** file, and locate the correct mission parameter file.

> **Note: You can leave this field blank if you want to use the Arlington mission parameter file for simulation.**

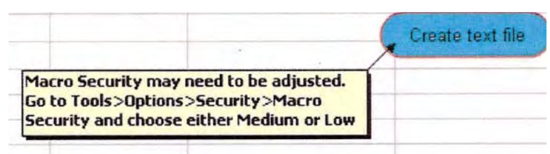
9 Select the file and click **Open**.

10 When the mission file has finished exporting, click **OK** at the bottom of the Settings dialog box. You can now execute the simulator flight check in I-MUSE.

Generate the simulator parameter file in I-MUSE 5.2 and earlier

Some newer aircraft parameter files have a button that will automatically create a .prn file and will start simulating the aircraft in I-MUSE. The newer parameter files include a **Create text file** button on top of the ACParam sheet in the Excel spreadsheet. This method of .prn file creation outputs the .prn file in the specified InsituGroup folder. For example, with 5.0 software, .prn files are found at C:\Program Files\InsituGroup 5\Groundbase\Parameters\ParamsBuilding.

Note: If using a newer aircraft parameter file that has the *Create text file* button, click the button and proceed to "Conduct the simulator flight check in FlightSim" below.



How to adjust macro security

Note: A warning message alerts you that macro security may need to be adjusted. Warning message includes adjustment instructions.

1 Extract the aircraft parameter file .prn from the **ACparam** page, and the sim15 file from the **sim input 15 kg** page of the Excel workbook. Save the ACparam file to the ParamsBuilding folder, and the sim file to the Groundbase folder.

2 Create a binary version of the aircraft parameter file using MakeFlightParams. Check for errors reported by MakeFlightParams.

- Open the command prompt in the ParamsBuilding folder and type **MakeFlightParams.exe –aACparamXXXXXvXXX.prn** (The numbers vary for each aircraft. For example, version 15 of aircraft 100 would be aACparam00100v015.prn.)

- Press **A** to select ACparam
- Press **S** to write to binary file
- Press **Q** twice to quit

3 Transfer the binary aircraft parameter file to the Groundbase folder of the software release that will be used to fly the aircraft.

Conduct the simulator flight check in FlightSim

1 Start FlightSim:

- FlightSim –g –t –rRPfile.NNN –asim15_acpNNNNNvNNN.prn

2 Check simulator model for appropriate aerodynamic surfaces, e.g. presence or absence of centerline fin.

- **ALT-F1** to switch to FlightSim pages.
- **ALT-F3** to display graphical aircraft model.
- **ALT-F3** again to display graphs again.

3 Set **fuel** mass to 2.0 kg (4.4 lbs).

- First FlightSim page, upper-right table, towards bottom of first column.

4 Set catapult pressure for launch.

a) **CTL-F11** (from FlightSim pages) for airfoil and launch/retrieve I/O page

b) Set **init res pr** in first table, third item.

- **5.6e5** for 14 kg (30.86 lbs) aircraft
- **6.2e5** for 16 kg (35.27 lbs) aircraft
- Or **6e5** for most aircraft

5 Upload surface wind

- **Esc** back to first Groundbase page
- Upload zero **rwy wind** at bottom of second Groundbase page

6 Turn **in flight status** off

7 Command **catapult takeoff**

- Verify commanded airspeed is appropriate for altitude and gross weight

Programming 3

8 Throughout rest of check, monitor aircraft for control anomalies, tracking, stability, etc.

9 Launch aircraft and verify appropriate climb-out and hold

- Verify max throttle commanded (with an appropriate corresponding RPM)

10 Track box at least once at maximum speed

11 Track box at least once at minimum speed

12 Perform max-rate turn reversals at minimum speed.

13 Upload and execute a standard 800 m (~2,600 ft) SkyHook approach

- Verify that the aircraft commands min throttle (with an appropriate corresponding RPM) during descent in procedure turn (when given deadman clearance, set to ignore).
- It may be necessary to lower min throttle setting to achieve desired min RPM.
- Verify that TAS at touchdown is close to commanded TAS.

3.1.5 Logging verification of parameter file

Following successful completion of these checks, a maintenance item should be opened in the aircraft logbook stating that parameter file version N has been verified and needs to be programmed into the aircraft before flight. This ensures that the aircraft is programmed with the correct parameter file prior to flight and also provides a record in the logbook that the aircraft parameter file has been verified. Optionally, in addition to the above step, the appropriate communications, mission, and reporting parameter files can be chosen and programmed into the aircraft along with the verified aircraft parameter file (the maintenance item can then be closed).

3.1.6 Warnings – Aircraft parameter file spreadsheet

Check area fraction	Automated min throttle selection is not within 0.1 to 0.4. Check by making the engine mapping unusual at low throttle.
High Fuel Burn!	Fuel burn curve is too high; it is greater than 5% above equivalence ratio limit on average
Low Fuel Burn!	Fuel burn curve is too low; it is less than 75% of the limit on average.
Mapping not in correct order!	This check ensures that the **nominal area fractions** increase appropriately.
Need to Map Lower	It is necessary to map engines at all operating points. This warning indicates that mapping is not done to a low enough RPM.

Note: **IMPORTANT! Some warnings in the aircraft parameter file spreadsheet are specific to newer versions of the spreadsheet. If you think you are not operating with all safety warnings listed here, contact Insitu's operations support group to get the most recent aircraft parameter file spreadsheet.**

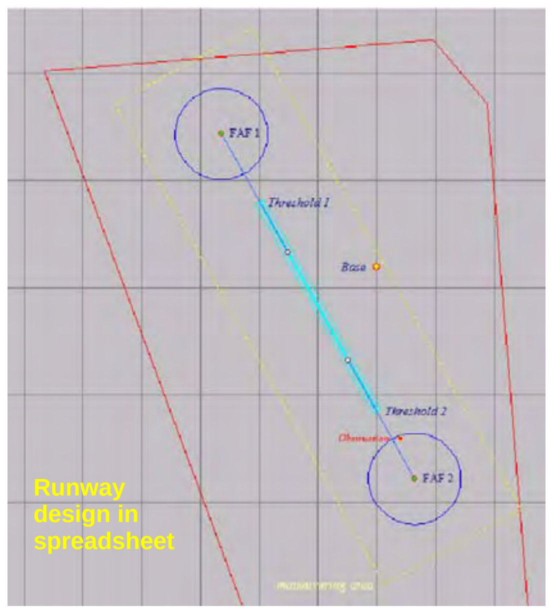
- **Operational Support (inside the US): 866-637-4691**
- **Operational Support (outside the US): 509-637-4691**

3.2 Mission Files

Mission files determine the aircraft's default route, its lost comm runways, its standard approach, and the behavior in a lost communication situation. Each site needs its own mission file, and the parameters for each are likely to vary significantly. Laying out runways requires knowledge of the aircraft approach sequence; route and timeout settings require understanding of the principles and behavior of the aircraft, especially its actions in lost comm. Before the mission file is created, the site survey must be performed to identify runways, ground station location, typical operating altitudes, winds, etc. It is good practice to use the Mission Setup spreadsheet. This allows quick verification of changes in Excel without creating a file for use in I-MUSE. Final testing should always be done in I-MUSE.

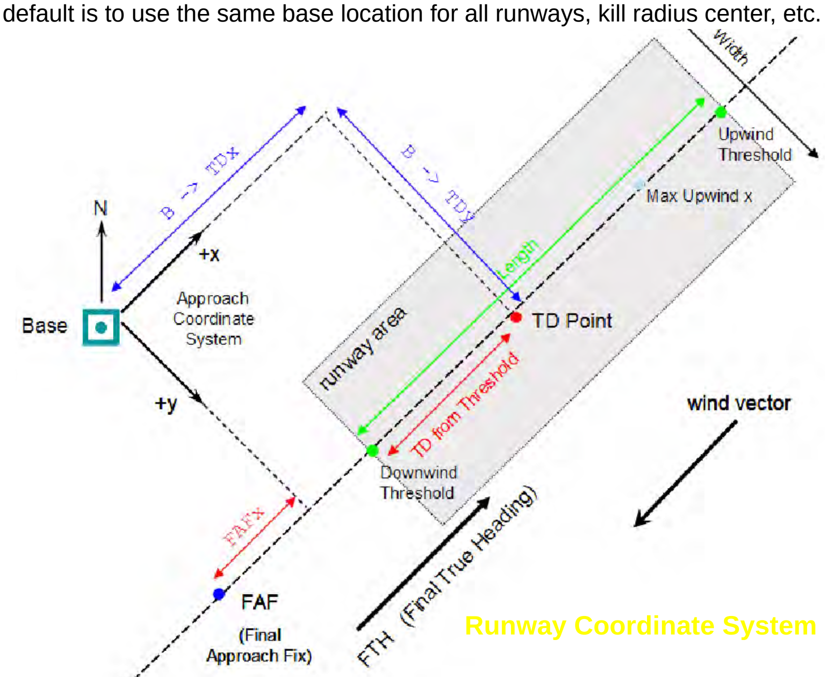
The Mission Setup spreadsheet, found in the C:\Program Files\InsituGroup 5\Groundbase\Parameters\ParamsBuilding folder, will calculate the required runway and approach parameters based on surveyed positions of the base and two thresholds. It sets up two approaches from opposing directions on the same runway. If two runways need to be set up with non-opposing directions, the max tailwind allowable must be increased from zero, otherwise the aircraft may not be able to land when wind is in the wrong direction during a lost comm, auto-land sequence.

In the spreadsheet, only the cells that allow input can be selected. This removes accidental changing of cell formulas. If a **Standard** selection is made, the parameter cell contents turn grey, and the cells are locked from editing. When a **Custom** selection is made, cell contents are black, and are free to edit. A potential input cell is white. On the MSparam sheet, all cells in blue are linked to another page, and formulas should not be broken without careful consideration. Red values should not need to be changed. Spreadsheet plots should be free to edit, although some rescaling of axes may be necessary. True perspective is gained when the orbits are shown as circles. The first page contains detailed instructions.



<table>
<tr><th colspan="2">File Management</th></tr>
<tr><th colspan="2">Mission files</th></tr>
<tr><td>Runway – layout</td><td>
The first section in the mission file contains the runways the aircraft will use in the event of lost communication. If desired, these can also be used to land the aircraft when in control. The standard is to have at least two in the file, and often these are two opposing approaches to the same runway area. Having at least two means the aircraft can select an approach direction that does not have a tailwind component.

Runways are defined in approach coordinates, relative to a base location. The default is to use the same base location for all runways, kill radius center, etc.



Base and runway altitudes

The mission file base location is defined under the TDMA stns @ row, which can be found near the top of a mission parameter file. The base location has an associated altitude as well as a latitude and longitude. This altitude should be set to 50 feet (15 m) AGL.

Within each runway set, there is another base location; this is normally set to the same as the TDMA station location and altitude. In each section, a touchdown height is defined relative to this base altitude (positive above). With a flat area, this touchdown height would be -50 feet (-15 m), but if the touchdown areas vary in height, then the value would change.

Runway width

This should be set to the safe runway area width.
</td></tr>
<tr><td>Runway – approach setup</td><td>
Decision height

The decision height is the height relative to the touchdown (AGL) at which the aircraft will decide to commit to the landing, or abort and try again (perhaps due to centerline or height errors). The standard value is 10 m (33 ft), but this could be changed.
</td></tr>
</table>

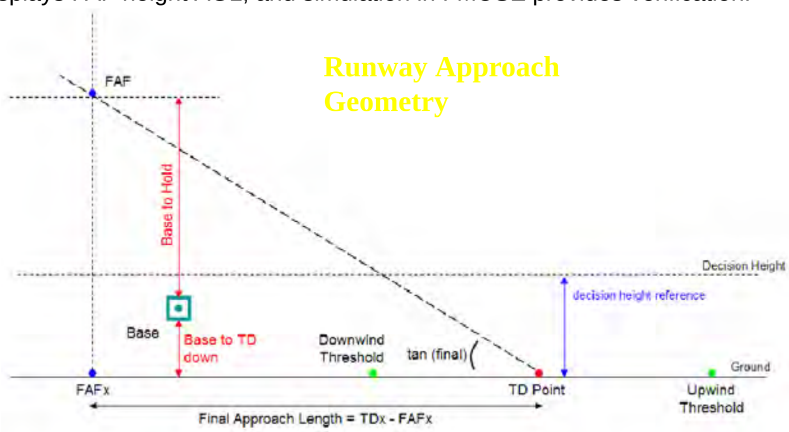
File Management

Mission files (cont.)

Runway – approach setup (cont.)

Final approach

Final approach parameters cover the length of final approach, the gradient, and subsequently the height of the FAF. Standard approach is 700 m (2,296 feet) at a gradient of 0.05. Changing either of these values changes the FAF height, and this needs to be considered when flying close to trees or other tall obstacles. FAF height needs to be high enough that the aircraft will converge on centerline well before it descends below obstacle height. The aircraft will often transition to final approach when off centerline, and possibly descend before getting to the safe area. Hence FAF should generally be set at least 10 m (33 feet) higher than the local obstacles. The Mission Setup spreadsheet displays FAF height AGL, and simulation in I-MUSE provides verification.



Hold type

Hold type can be either at FAF or relative to base. A hold at FAF will set the procedure turn orbit about the Final Approach Fix. A hold relative to base will allow a procedure turn that is offset from centerline, or moved towards the touchdown point. (Do not move the hold further away from the touchdown point than the FAF (when using code prior to version 4.22).

The standard hold type for a runway is FAF. Enter **FAF** in the **Hold** field.

For an offset hold, enter **rel_base**. If an offset hold is used, there must be a row to define its location. This is comprised of field with titles **hold @, x [m] and y [m].** These are in approach coordinates, so **x** is negative for a location near the FAF. The **y** is offset from centerline. If hold is not set to **rel_base** this row will not affect the hold position.

Miss type and miss parameter

The runway miss type can be either a "wave off" or a "go around". In a missed approach, a go around will trigger a full power, straight climb out, with an optional sidestep. A wave off will turn back to FAF and throttle up at the same time. Runways are generally set up to use a go around. In the mission file, set **go around** to **1** to do a go around, and **0** to do a wave off.

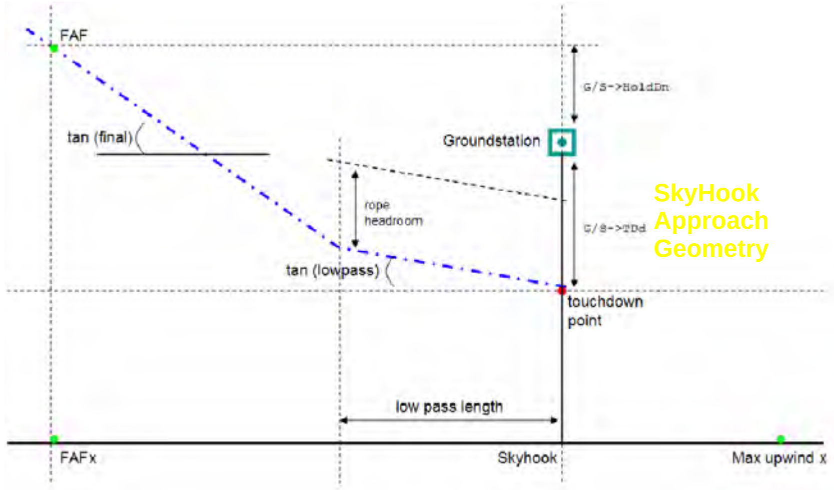
File Management	
Mission files	**(cont.)**
Runway – approach setup (cont.)	If a go around is specified, then go around parameters must be set. These are **max len [m]** and **sidestep y [m]**. Max length is the distance past the touchdown point that the aircraft will fly straight before turning back to FAF (unless it nears FAF altitude, in which case it will turn sooner). The sidestep value is the distance the aircraft will offset its climb-out path from the runway, in approach coordinates. Once the aircraft reaches the altitude to turn, it will turn either direction back to the FAF. Simulation can show the appropriate value to use for max length. Ideally this would be set so that the turn occurs at FAF height, or as appropriate. If a wave off is specified, then the lower fields **go around** and **sidestep y [m]** must be changed to **wave off** and **direction**. In this case, the max length is normally set to 20 m (~65 feet), and direction right/left as appropriate. **Runway priorities and allowable winds** Runway priority is set by the **priority** field. **0** is highest priority. The **max tail [m/s]** sets the allowable tailwind for the particular approach. Normally this is set to zero, so the aircraft will never do an approach with a tail wind. Approaches with a tail wind lead to a high ground speed and more damage possibilities. It is possible that approaches might only be possible in one direction, or the winds are such that there is no runway available without a tailwind. In this case, with lost comm, the aircraft would wait until its onboard wind finding algorithms indicated a favorable change. If this possibility exists in the mission file (perhaps only two runways that have headings that are not opposite), then setting some allowable tailwind may allow an approach to proceed, if the possibility of waiting is not acceptable. If the wind does not change in this situation, the aircraft will run out of fuel before it tries to land. The **max cross [m/s]** sets the allowable crosswind for approach. This is normally set to 100 m/s (328 ft/s), which effectively removes any restrictions. **Touchdown location** Currently, the touchdown point is specified relative to the threshold. It is good practice to set this to at least 200 m (656 feet). This allows for potential barometric altitude errors when landing in a lost comm situation. For example, if the aircraft is gliding at 20:1, then 10 m (33 feet) of altitude error corresponds to 200 m of error in the actual touchdown point on the ground. The touchdown point cannot be closer than 200 m from the upwind threshold (this provides margin for error at the far end of the runway).
Standard approach template **Note: Use the relocatable appr template to define the settings that are default when a SkyHook approach is chosen.**	**Final approach** SkyHook final approach is similar to the runway, but split into two sections: the low pass and the final approach. Final approach gradient is normally higher than the low pass, in which the aircraft starts to decide whether it has hit the rope. FAF height is determined from the combination of the two gradients, the low pass length, and the final length. In I-MUSE, the parameter for final length is not clearly seen, as the sum of the two appears as **Approach Length.** As in a runway approach, the final approach gradient is limited from 0.031 (3.1%) to about 0.07 (7.0%) or so. Above this, the aircraft has trouble descending fast enough, which means it will probably speed up and hit the rope violently if set too high. Simulation will show what gradients work, obviously this point changes with aircraft weight, and will vary with local winds (lift areas, etc.).

File Management

Mission files (cont.)

Standard approach template (cont.)

For operation in a tight area, or an approach over some obstacle, the gradient can be increased, final length can be reduced, but a distance from SkyHook to FAF of less than 500 m (1,640 feet) is not advised.



Hold type

Hold type definition is the same as for a runway. It can be either FAF or rel_base. When rel_base is used, the aircraft reads the rows for hold position **x [m]** and **y [m]**.

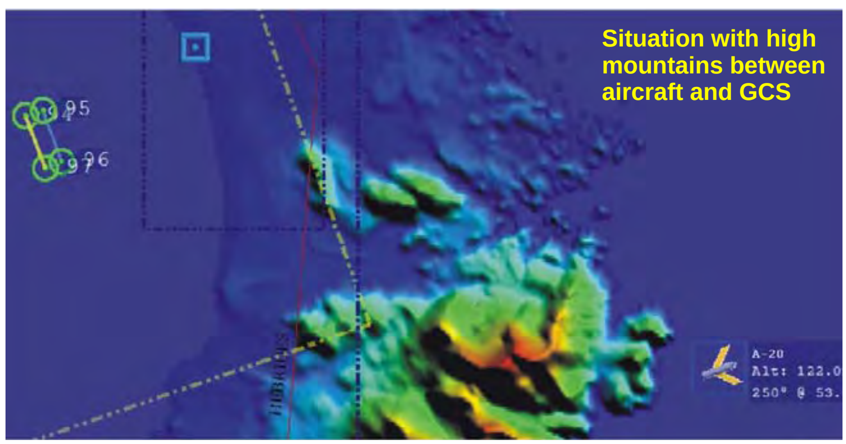
Miss type

Miss type definition is the same as for a runway, with corresponding title manipulation needed in the mission file. Wave offs are the standard miss type for a SkyHook, with max upwind **x** (miss point past TD) set to 20 m or so (~65 ft). For a situation where approach and climb-out has to be restricted to a certain corridor, go around must be used to prevent the aircraft flying back to the FAF (and perhaps hitting trees at low altitude). In this case, max upwind **x** must be set high, to allow the aircraft to climb before turning, but a wave off must be triggered manually if the rope is missed (otherwise the aircraft will stay at retrieval height for this length).

Retrieval location

This is the retrieval (TD) point in approach coordinates. The standard for **x** is **0** (at the rope), **y** is **0** (an offset can be added when setting up for flight; setting to 0 removes possibility of forgetting to change an incorrect offset in the event of variable approach directions). The position **abv base [m]** is the height above the GPS antenna, which is normally -5.5 for a standard SkyHook, but may be different for a shipboard installation, depending on the installation. Note that this definition is opposite to that used in the approach editor (where we specify **TD below SkyHook GPS**, down being positive). The setting **top of ret zone [m]** is the rope headroom, or height above approach path that the aircraft is allowed to be within during **low pass**. It is a safety factor for proximity to the boom above. Normal setting is 3.5 or 4 m (~11.5-13 feet).

File Management	
Mission files	**(cont.)**
Auto-kill behavior	The kill perimeter is the radius that defines the safe location in the event of lost comm or other comm problems. The radius size is also the size of the perimeter that extends around the aircraft's current track. If enabled, auto kill logic will cut the engine if the aircraft loses comm for more than the link timeout value (normal 10 seconds) only if either of the following happens: ▪ The aircraft is outside the current kill perimeter (perhaps due to inability to track, strong wind etc.). ▪ The aircraft has been without GPS for the GPS timeout period (set in Comm parameter file, not the mission file). The aircraft kill radius is centered by default to the general mission file base location, but could be put anywhere that is appropriate. The maximum size of this is limited to about 32,000 m (about 20 miles). Note the field for GPS timeout period in the mission file **if no GPS for [sec]** does not currently affect this behavior.
Timeout principles and lost comm	When the aircraft has lost communication with the GCS, it attempts to come home and land autonomously. The return home procedure uses four comm limit timers from the mission file: ▪ start climb @ ▪ climb for < ▪ then home @ ▪ wait @ home The following comm failure sequence initiates when the link timeout period expires (i.e. the aircraft has lost comm with the If/C for the period set in the Comm parameter file; normally 10 seconds): 1 The aircraft selects SAFE autopilot settings and starts a modem reset cycle. During the **start climb** @ period, aircraft that are flying a route will continue the route; aircraft that are flying an orbit will fly directly toward the nearest waypoint. This brings the aircraft within the kill perimeter, removing the possibility of an auto-kill due to being outside the kill radius. For more information about kill perimeter, see the *Auto Kill Behavior* section earlier in this chapter. 2 Upon expiration of the **start climb** @ period, the aircraft calculates the altitude required for line of sight to the GCS from which it lost comm. The aircraft climbs to the higher of two possibilities: line of sight altitude; or the "safe" altitude. However, the aircraft will not climb above the commanded max altitude. The climb continues for the **climb for <** period, unless it reaches the calculated altitude before this timer expires. If no climb was calculated, the aircraft proceeds to the next comm limit timer. 3 After the climb, the aircraft continues to fly the pre-abort route for the **then home** @ period. If there were no routes near the area where comm was lost, the aircraft may already be on its way home.

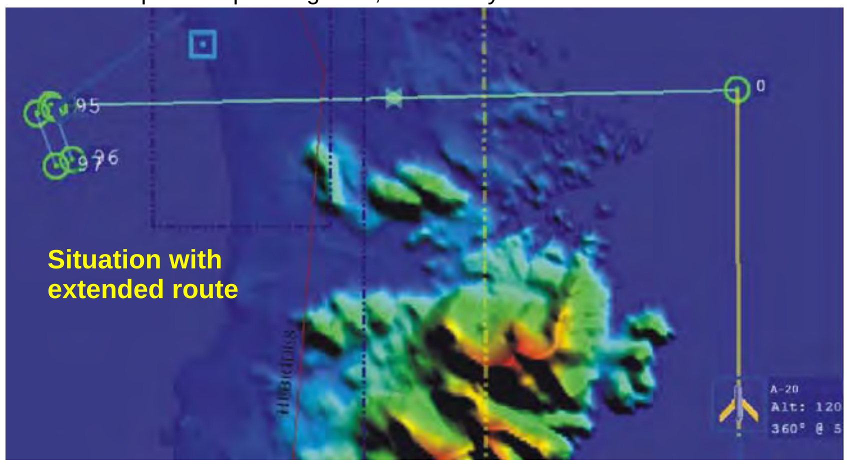
File Management	
Mission files	**(cont.)**
Timeout principles and lost comm (cont.)	4 When the aircraft begins its return to base, it notes the waypoint defined in the **abort via seg,** and traces the route forward from this waypoint to find the terminal circuit – the point where the path starts to loop. The aircraft finds the distance from its current location to the highest numbered waypoint in the terminal circuit; it also finds the distance from the abort waypoint to the terminal circuit. If abort waypoint distance is greater, the aircraft checks subsequent waypoints in the sequence and goes directly to the waypoint that is closest to home. Therefore, the aircraft does not fly to abort waypoints that are not in the direction of home. Also, the aircraft ignores waypoints in the same route with lower numbers than the abort segment. The aircraft then follows the route until reaching the terminal circuit, where it waits in the pattern for the **wait @ home** period. 5 Once the last comm limit timer has expired, the aircraft starts the auto approach sequence. In runway priority order, it checks all runways within 3 km (~1.9 miles) of the closest for wind limits. It selects the most favorable and attempts to land. The maximum number of passes is defined in the **max miss appr** field. When this number is exceeded, the aircraft commits to landing, regardless.
Designing for appropriate lost comm behavior	Each mission file has a field **abort via seg**. This defines the waypoint that the aircraft looks at when it first returns home when the **then home @** timer expires. With this knowledge of lost comm behavior, the route must be designed so that the potential location for the aircraft is always safe. 

File Management

Mission files (cont.)

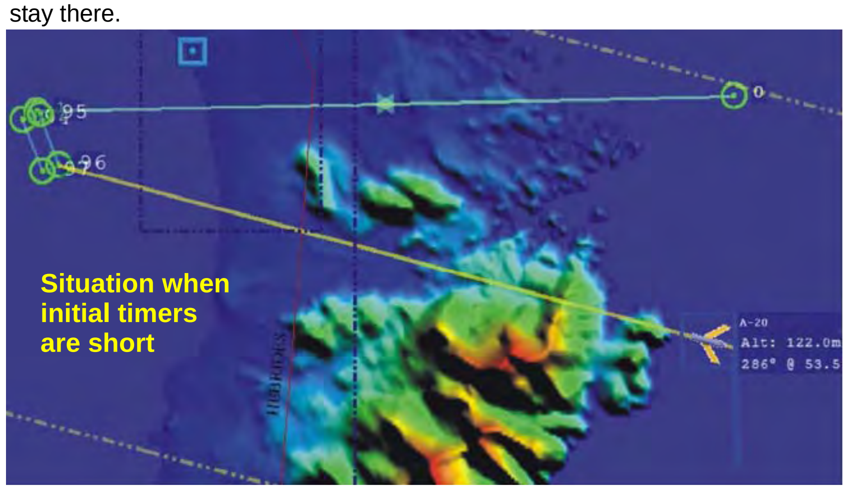
Designing for appropriate lost comm behavior (cont.)

If the aircraft is orbiting and loses comm in its current location, which is likely due to the mountains, it will fly directly to the nearest waypoint, 96 in this case. This is dangerous and may lead to a crash. If there was a route that extended out to the expected operating area, it would fly direct towards this route.



In this case, the aircraft goes direct to waypoint 0, which takes it around the mountains. If waypoint 0 is not the abort waypoint however, there still may be problems. The length of the timers up to and including **then home** @ could expire before the aircraft is safely north of the mountains. In this case, if the abort waypoint is set in the racetrack, it is going to go direct to that point, or whatever waypoint is closer in that terminal circuit, see below

The mission file should be set up so that the abort waypoint is 0, and the timers should allow the aircraft to get to a safe location before it goes home. Note if the aircraft is closer to the highest numbered waypoint in the terminal circuit than the abort waypoint is, it will decide to go straight there rather than fly towards 0 when it goes home. In this case, there could be a similar situation to that above. Hence the timeout for **then home** @ should be set long enough so that the aircraft can return to a safe location before starting home. The minimum time needed can be found in simulation, by putting the aircraft at the extremes of the operating area, and adding in unfavorable winds. In the case above, if the aircraft is out to the west of the terminal circuit, it will go there and stay there.



<table>
<tr><th colspan="2">File Management</th></tr>
<tr><th>Mission files</th><th>(cont.)</th></tr>
<tr><td>Mission limits</td><td>The mission limits section defines the defaults for minimum altitude (min alt), safe altitude (safe alt) and maximum altitude (max alt). These limits can be changed while in flight, however in the event of a reset the changes will be lost.

Minimum altitude is generally set to approx.100 m (300 feet) AGL, however each location has different restrictions for operations, so this could vary.

Safe altitude is the minimum altitude the aircraft will be during a lost uplink situation. It should be set higher than all obstacles in the area, and be might be similar to the expected operating altitude.

Maximum altitude is the height the aircraft will not fly above in a lost uplink period. If operating below a certain altitude (for example, if there are other airspace users above), this limit should provide some cushion between the two airspaces. This cushion should be 500 feet (about 150 m) or so if possible.</td></tr>
<tr><td>Planning mission file with spreadsheet</td><td>Approach – runway

User can select from Standard or Custom. The standard approach option sets all parameters to accepted standard values, and locks cells. Custom allows parameters to be modified, and the chart will display the changes. Note cell value ranges and check Safety Checks section for warnings

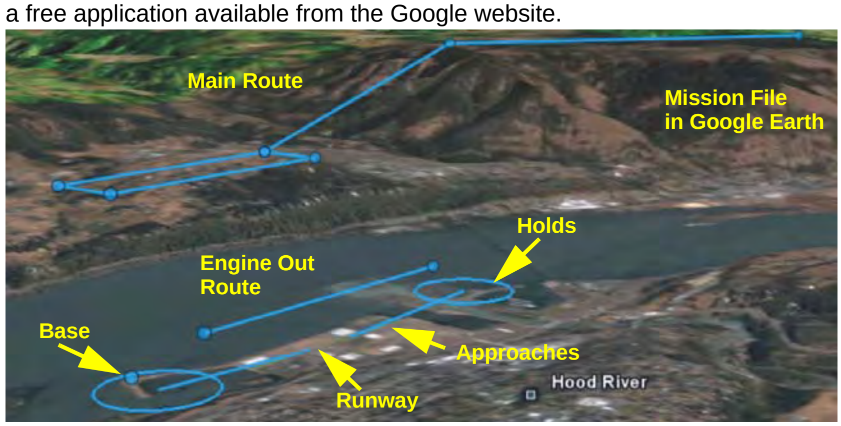
Approach – Standard

User can select from Standard or Custom. The standard approach option sets all parameters to accepted standard values, and locks cells. Custom allows parameters to be modified, but the chart will not display the approach. Use the SkyHook Test page to adjust parameters and check clearance, then fill in this section with appropriate values. Note cell value ranges and check Safety Checks section for warnings.

Boundaries

Boundaries and landmarks can be input in the boundaries section. This allows visualization of potential obstructions.

Google Earth

The View in Google Earth button, found under the Google Earth page of the Mission Setup spreadsheet, allows viewing of the mission file in Google Earth, a free application available from the Google website.

</td></tr>
</table>

File Management

Mission file (cont.)

Planning mission file with spreadsheet (cont.)

Google Earth **(cont.)**

For Google Earth to work correctly the following must be in place:

- Google Earth installed into the default location (C:\Program Files\Google\Google Earth)
- A connection to the Internet (or cached data for your location)
- The **Terrain** layer must be enabled

In addition to these requirements, there are the following limitations:

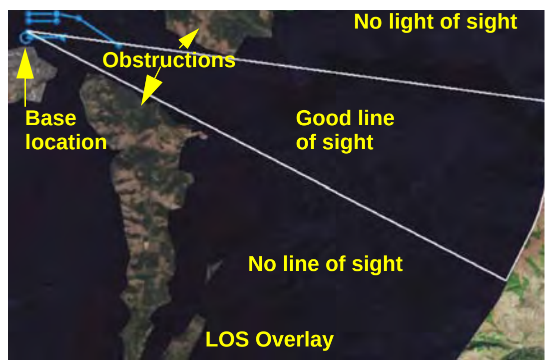
- Up to three routes (in addition to the Engine Out route) display best. If more than three are put in the route section, they will be linked (correct display will always be gained in I-MUSE).
- Some display problems may be found in Google Earth when using more than 20 additional waypoints (remember there is a limit of 100 in Helmsman).

The altitude overlay gets less accurate the further from base it is viewed. The safe area is always more conservative than the truth however.

This figure shows the altitude overlay feature. The green areas are safe to fly at the altitude specified, but this does not take line of sight (LOS) into account.

Note: Instructions for using the overlay tool are found in the Mission Setup spreadsheet under the <u>Instructions</u> tab.

This figure shows an overlay between the specified antenna height at the base (or a user-specified location), and a ring at the altitude and range specified. As shown in the example, only areas that have no obstructions between the base and the outside of the circle have actual line of sight. Areas closer to base will have better line of site than shown with a long range.



Note: This overlay does not take account for excess attenuation of RF signals having paths close to the ground. Actual performance is likely to be less than shown. Use margin in altitude to be safe. See discussion on line of sight in the *Maritime Operations* section of Chapter 6, *Flight*.

A second line of sight overlay can also be shown (in red). This helps in identifying areas that are suitable for handoffs between a hub and a spoke.

File Management	
Mission files	**(cont.)**
Planning mission file with spreadsheet (cont.)	**Landmarks** The landmarks page allows creation of a landmark file for Groundbase, it does not affect the mission file. For further information about landmark files, see the *Groundbase Handbook.* **Layout** The user can select from either a maritime layout or a custom layout. Normal layouts on land will use a custom layout. The maritime option sets thresholds and altitudes appropriate for the base location at sea (some random location at sea level). All the user has to do in this situation is to enter the new base location, and choose approach behavior. The custom layout allows two inputs for thresholds. These mark the ends of the acceptable landing area (but not the touchdown point). Ground level altitudes for each point can also be input, along with runway width. **Note: Spreadsheet will set base altitude to 15 m (about 50 feet) above the defined base ground altitude – a normal SkyHook height.** **Limits** The limits page allows the lost comm timeouts, kill radius, and mission altitudes to be selected. It warns if the altitudes are set incorrectly, and limits kill radius to that set in flight software. Also displayed are lookup tables for altitude conversion. Heights AGL are all referenced to the **base** altitude on the **Approach Setup** page. **MSparam** The **MSparam** sheet is the master page for mission file creation. Name, date and version number must be changed for each file made. Keep the name length to five characters. Note that the sheet is designed for a housekeeping route to be added as appropriate, below the engine out route. Initially the **abort via seg** is linked to the engine out route. Once a housekeeping route is designed and added, the user should change this waypoint reference as appropriate. The **abort via seg** waypoint can be changed to any waypoint, but it must be listed in the routes section. Mission file creation tends to have a certain amount of iteration as changes are made, but this spreadsheet should allow quick layout and visualization of changes. Once the mission file is ready to test, the user can choose the **Save and output to text file** button. This saves the changes, then saves the mission file page as a space delimited text file to the Groundbase Params Building folder, of the software version specified at the prompt, with a name and version number as specified in the sheet. **Obstruction** The obstruction section allows the user to input a location and height of an obstacle in the runway area. The user must select whether they want clearance checked for approach 1 or 2. Clearance and warnings are displayed in **Safety Checks** section. Multiple obstructions can be checked for clearance one by one with the appropriate parameters and approach number selected.

File Management	
Mission files	**(cont.)**
Planning mission file with spreadsheet (cont.)	**Route** The Route page allows creation of a two segment route above the designated runway. This is the **Engine-Out Route**. The user can select from **Above Runway** or **Custom**. Above Runway will fill in the correct location and lock the cells. Custom allows a different position to be entered. Route length and altitude need to be entered, and warnings considered. If it is desired to enter Routes in degrees lat/lon (rather than radians on the MSparam page), it can be done in the **Additional Routes** section. Press the **Add to MSparam** button to overwrite the Routes in the MSparam section with what is here. Note that changes made and displayed in the Route plot are only transferred to the mission file once the **Add to MSparam** button is pressed. **Safety checks** The **Safety Checks** section gives warnings when problems exist with the runway parameters chosen. Runway obstruction clearance is displayed, and warns if too low. It also displays FAF altitudes above ground level and warns if too low. SkyHook miss parameters are also checked to make sure that **miss point past TD** is set appropriately in a go around situation. **SkyHook test** Also included in the spreadsheet are the **SkyHook Test** and Range & Bearing pages. These do not affect the mission file, but are of some use in setting up a new site, including SkyHook obstruction clearance checks. **Route layout** 1 Waypoint number (0-99). The aircraft will go from this waypoint to the one on the following line. To create a closed route, put in a previously defined waypoint number without any other data fields below the last waypoint (see 94 in this example). 2 Waypoint position, latitude in radians. 3 Waypoint position, longitude in radians. 4 Minimum height (meters, MSL). The aircraft cycles between min and max altitude. To hold fixed altitude, set min and max the same (normal procedure). 5 Maximum height (meters, MSL). See above. 6 Wind finding flag; the maximum distance (hectometers; 100 meters equals 1 hectometer) between wind-finding maneuvers. If the aircraft has gone this far and not computed a wind finding solution, a maneuver will be commanded. Set to zero to disable.

File Management

Mission files (cont.)

Planning mission file with spreadsheet (cont.)

Route layout **(cont.)**

7 Shuttle climb flag. If set, the aircraft will do a shuttle climb to the maximum altitude on the start of this route leg.

8 Shuttle descent flag. Set to descend to the minimum altitude on this leg.

9 Speed to fly flag. This will auto-set the speed (within safe lift coefficient limits) to that which gives the maximum distance at level flight.

10 Minimum time flag. Aircraft will fly this leg with minimum time.

Normal procedure is to have two routes in the mission file. The first is a two-point route over a designated landing area, (e.g. directly over runway specified earlier). This route is for use in an engine failure. With an engine failure, the track to this route, so it is in a safe location for landing. For good centerline position, make this route at least 1.5 km long (a little less than one mile). This allows aircraft time to converge onto center before flying into designated area. This also prevents unwanted turns due to proximity to the next waypoint, and a corresponding 180° (3.14 rad) heading change. Make the route at least 500 m (1,640 feet) longer than each end of the runway area.

The second route is the homecoming route, and contains the abort waypoint and the terminal circuit. Normal procedure is to place this close to the base, for housekeeping purposes after takeoff and prior to retrieval. This is normally a racetrack pattern 1 or 2 km (~0.6-1.25 miles) long, often with a two or three segment tail that joins at one corner. These tail waypoints head the aircraft into the terminal circuit, and are often moved to change the route the aircraft takes back from the operating area. This is useful for airspace deconfliction, especially when given a corridor through which to fly, or to avoid over-flight of ascertain zone. Each additional route in the mission file can be added to the next free rows below the last waypoint, i.e. there is no space needed.

The number of routes is not limited in the software, only the number of waypoints. It is good to add in routes that are anticipated for regular use, such as a transition section between areas. Try not to overload the display with routes, as this causes confusion and can lead to mistakes.

Mission Route Layout

Route definition in the mission file falls under these parameters:

Flight plan

1	2	3	4	5	6	7	8	9	10
92	0.52934580	-1.567411196	460	460	0	0	0	0	0
93	0.529440022	-1.567411859	460	460	0	0	0	0	0
94	0.529553080	-1.567457769	460	460	0	0	0	0	0
95	0.529553080	-1.567537780	460	460	0	0	0	0	0
96	0.529663327	-1.567537780	460	460	0	0	0	0	0
97	0.529663327	-1.567457769	460	460	0	0	0	0	0
94									

<table>
<tr><th colspan="2">File Management</th></tr>
<tr><th colspan="2">Mission files (cont.)</th></tr>
<tr><td>Planning mission file with spreadsheet (cont.)</td><td>Route layout (cont.)
Modification and quick layout

Standard procedure when flying somewhere new might be to create a test mission file for the area, perhaps with just a two point route, or a route with points created in Excel. Assuming imagery is available for the area, a simulation could be run with I-MUSE. I-MUSE can be used to modify/create the routes in the local area (taking account of local airspace boundaries etc.). These routes can then be written to a text file through I-MUSE using the plan out field in the file settings. Using Excel, open this file (look for all files) using the fixed width option for formatting. This should be in the same format as the mission file spreadsheet, and can be copied to the route section. If you are modifying an existing route, copy over what is there. Check waypoint numbers do not conflict with what might be there already.</td></tr>
<tr><td>Mission file verification</td><td>1 Modify fields in mission parameter file Excel worksheet; save changes.
▪ Use I-MUSE as tool for approach design:
    ▪ Use Approach Table
    ▪ Use Plan In/Out to capture route data
▪ Be sure to use a unique name and version number for each change to the file. Keep name length to five characters

2 Save sheet as a .prn file (space-delimited text file).

3 Use MakeFlightParams to create a binary file.
▪ Run command line inside ParamsBuilding folder with command:
  ▪ makeflightparams -mMymissionfile.prn
    ▪ Inside MakeFlightParams:
    ▪ M to select mission parameter file
    ▪ S to write to a binary file (creates binary file with mission name and version number, e.g. mstest.001)
    ▪ Exit Program

4 Use I-MUSE to verify mission parameter file.

▪ In I-MUSE: IMUSE Settings > IMUSE Server. Select Advanced, choose FlightSim, and modify arguments as follows: –rRPBlckD.002 –tCAT –g –mmstest.001
  ▪ Verify takeoff
    ▪ Appropriate climb-out and hold point
  ▪ Verify all approaches and runways
    ▪ Verify thresholds match for approaches to the same runway (e.g. from 90 and 270 degrees)
  ▪ Verify mission limits
  ▪ Verify engine kill radius and behavior
  ▪ Verify routes
  ▪ Verify appropriate behavior during uplink failure, including:
    ▪ Check abort-via waypoint
    ▪ Check flight-path is appropriate for area
    ▪ Check timeouts
    ▪ Check runway selection for various winds</td></tr>
</table>

<table>
<tr><th colspan="2">File Management</th></tr>
<tr><th colspan="2">Mission files (cont.)</th></tr>
<tr><td>Mission file verification (cont.)</td><td>
4 Use I-MUSE to verify mission parameter file. (cont.)

Verify clearance with obstacles and the ground:
Make sure the aircraft will comfortably clear obstacles such as trees, buildings, power lines, and towers in all of the following scenarios:

At minimum altitude (it may be acceptable not to clear all obstacles at minimum altitude, but this should be known)
At safe altitude
During takeoff sequence (including turn to hold or route)
During loiter at FAF altitude for all runway and SkyHook approaches
During all runway approaches
During a missed approach from any point along the runway approach – up to decision point (including turn and flight back to FAF or hold)
During all possible SkyHook approaches
During a missed approach from any point along the SkyHook approach including an upwind miss (including turn and flight back to FAF or hold)

Perform these checks for the heaviest aircraft that will be flown and for the minimum and maximum wind magnitudes and directions that will exist for a given maneuver. Consider effect of density altitude on TAS and climb-rate (i.e. simulate at altitude of mission location on a hot day). Consider possible altimeter errors and tracking errors. (e.g. What if altimeter is off by 10 m, or what if the aircraft is approaching 3 m too low?)

5 Correct any problems in the mission parameter file spreadsheet, increment the version, and try again
6 Program aircraft with Programmer.
</td></tr>
<tr><td>MapPacks</td><td>
MapPacks are a way of collecting and organizing maps into convenient packages with user-defined names and descriptions. They are an essential component to flight and mission planning. There are three categories of maps that are drawn in I-MUSE’s Map Control area:

Elevation: Topographical depictions
Raster: Aerial photographs of the terrain or CDRG charts
Vector: Line-based drawings of noteworthy features such as highways, lakes, and rivers

All three categories of maps can be displayed at the same time, and are always drawn in the order listed above (first elevation, then raster, then vector), so that later ones appear on top of earlier ones, over-writing them if necessary. Due to the processing power required to draw elevation maps, these maps are usually not rendered, but the underlying data is still available for flight planning.

The Show Vector Labels option is disabled by default when creating a new MapPack. However, Show Vector Labels is enabled in the MapPacks that are shipped with I-MUSE. To show or hide labels:

Select Manage Maps from the File menu on the I-MUSE toolbar.
Select the MapPacks tab.
Select the map(s) from the MapPacks List.
Press Edit to open the MapPack Editor.
Activate or deactivate the Show Vector Labels checkbox.

</td></tr>
</table>

File Management

Mission files (cont.)

MapPacks (cont.)

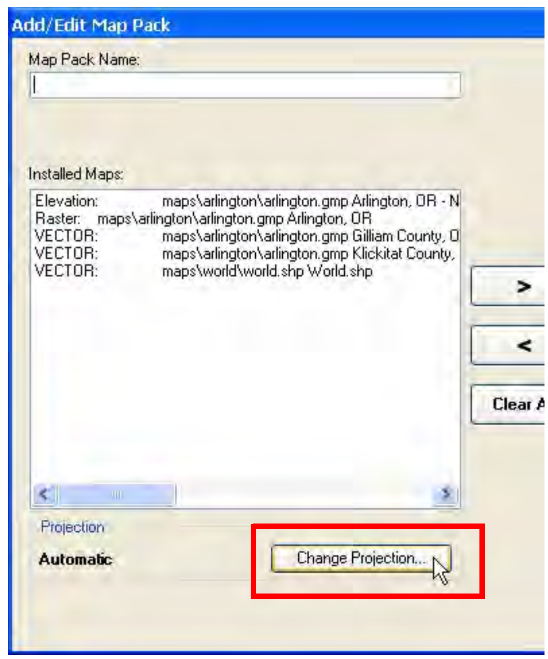
Map Projection

When operating in the vicinity of 180° longitude or polar regions, change map projections. This changes the projection of the map so the named region is centered on the screen. This is also necessary for aircraft navigation.

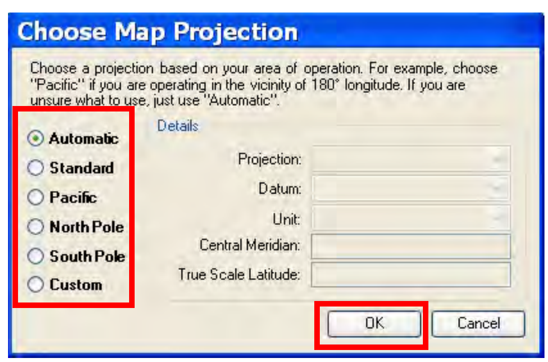
CAUTION: In I-MUSE 5.1.X and earlier, operating near the 180° longitude meridian (near the International Date Line) or near the North Pole or South Pole is not supported and can result in loss of aircraft.

To change map projection:

1. From the I-MUSE toolbar, navigate to Manage Maps: **File→ManageMaps** (Ctrl+Shift+M). This brings up the **Map Management** menu.
2. Click on **Add** or **Edit**. This brings up the **Add/Edit MapPack** menu.
3. Click on **Change Projection**. This brings up the **Choose Map Projection** menu.



4. Select the map projection that corresponds to the area of operation and click **OK**.



File Management

Mission files (cont.)

MapPacks (cont.)

Map Projection Options

Automatic: This is the default. I-MUSE examines the map data files in use and chooses the most commonly occurring projection (Map data is stored on a disk in a specific projection). Use this option when unsure which projection is best.

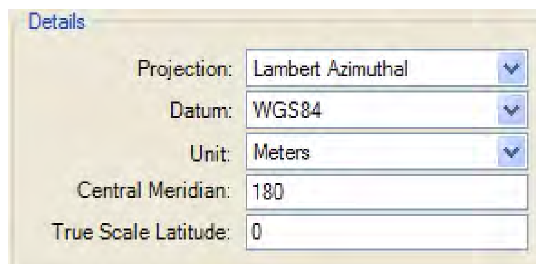
Standard: The central meridian is 0° longitude. This is a Mercator projection best suited for equatorial and mid-latitude views. Orbits will be circular in this projection

Pacific: The central meridian is 180° longitude. This is a Mercator projection best suited for equatorial and mid-latitude views with operations in the vicinity of 180° longitude.

North Pole and South Pole: Use when flying at latitudes above 70° north or south.

Note: While the polar stereographic projection includes the entire globe, the grid distorts as it extends from the polar regions, and is not recommended while flying at latitudes below 70° north or south.

Custom: Create a customized projection by selecting options from the **Details** pane of the **Choose Map Projection** dialog.



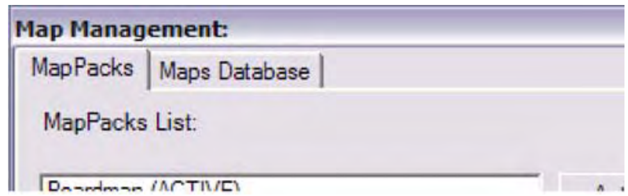
File Management

Mission Planning

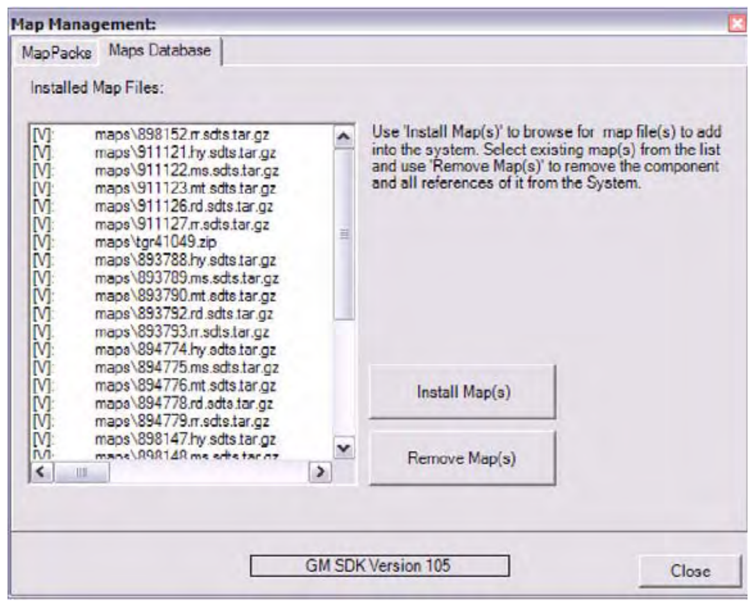
MapPacks – Adding maps to the maps database

After maps are added to the database, they can be grouped into **MapPacks**, and assigned names and descriptions.

1. To add maps to the database, click on the **Manage Maps** button in the toolbar.
2. In the **Map Management** window, click the **Maps Database** tab.



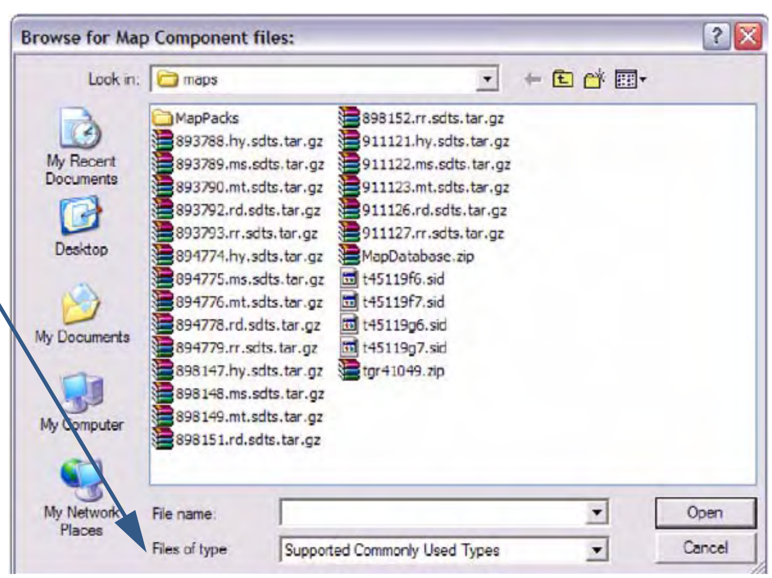
3. Click the **Install Map(s)** button to display the **Browse for Map Component Files** window.
4. After selecting the maps to be added, click the **Open** button. The **Map Management** window now displays the selected maps that have just been loaded.
5. To remove maps from the database, select them in the list, then clicking on **Remove Map(s)** button. Select more than one map at a time by using the **CTL** and **SHIFT** keys.



By default, the most commonly-supported file types are displayed.

Change the file types that are displayed by clicking the **Files of type** drop-down menu.

To select more than one map at a time, press **CTL** while clicking each map or, if selecting several maps in a row, click the first of the series and press **SHIFT** while clicking the last of the series.

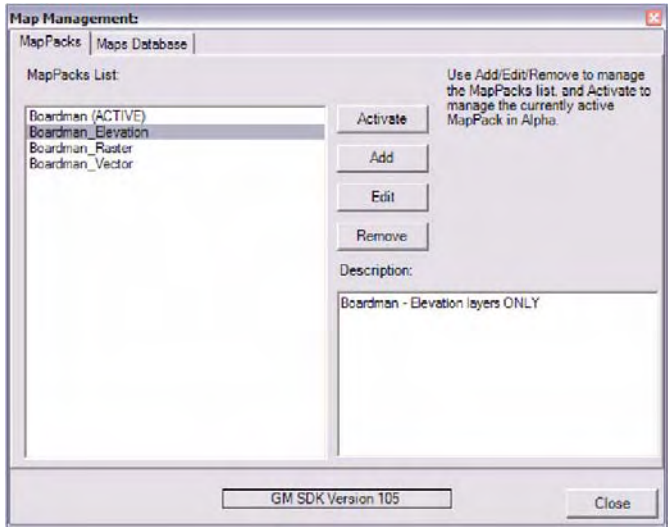


File Management

Mission Planning (cont.)

MapPacks – Maintaining MapPacks and MapPack lists (cont.)

1. To change the collection of maps in a MapPack, select the **MapPacks** tab in the **Map Management** window.
2. Select the map to edit, and click the **Edit** button. The **Add/Edit MapPack** window opens and displays the information for the MapPack selected.
3. Perform the same operations if adding a new MapPack: moving maps to or from the MapPack, changing the name or description, or setting the default behavior for displaying elevation maps.



Note: After saving changes to a MapPack, all maps in the I-MUSE main window are refreshed, which may take some time depending on your computer's capabilities.

The list of MapPacks under the **MapPacks** tab may be edited by using the **Add** or **Remove** buttons.

You can also set which MapPack is currently being displayed in the **Map Control** area by selecting the MapPack in the **MapPacks List,** and then clicking the **Activate** button. The **Map Control** area is then refreshed to reflect the selected MapPack.

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3.3 Programming Aircraft Software

About Programmer

Programmer (Programmer.exe, included with I-MUSE 5.2 and later) is used to program the aircraft and If/C. Programmer converts parameter files (in either .xls or .prn format) into .s19 files, and flashes the files to the aircraft and If/C. In I-MUSE 5.3 and later, Programmer can also be used to compile the aircraft parameter file, as described in "Update an aircraft parameter file using Programmer" on page 3-12.

Programmer can be run from the I-MUSE machine or from a laptop. When programming the aircraft, running Programmer from a laptop eliminates the need to run a long cable from the I-MUSE machine to the aircraft.

In I-MUSE 5.1.X and earlier:

Note: Programmer is only available with I-MUSE 5.2 and later. For software versions earlier than I-MUSE 5.2, use Planner (planner.exe). After creating the .prn text files, select a directory to which the .s19 file will be written once the file is created, and run Planner. Carefully inspect the Planner output to check for errors (particularly at the start when MakeFlightParams reads in the parameter files). Detailed programming instructions for software versions earlier than I-MUSE 5.2 are provided in *Appendix A.*

About Terminal

Before Programmer, all programming was conducted through a traditional terminal program. Now, Programmer flashes the necessary commands for each programming option to the aircraft or If/C, eliminating the need for direct operator input. Legacy programming screens are still active and available. For legacy programming screens, click **Show Terminal**.

In Terminal, operators can program aircraft and If/C as they did prior to I-MUSE 5.2. Detailed instructions for programming before I-MUSE 5.2 are provided in *Appendix A*. Files can be dragged and dropped into the Terminal window, just as with the legacy programming window.

While Programmer handles most programming needs, it does not conduct If/C port mapping, field pitot offset correction, or memory testing. For each of these tasks, click on **Show Terminal**, then program as directed later in this section.

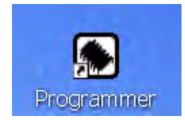
To leave Terminal, close the window. Shut down the aircraft or If/C, then bring it back up to return to normal mode.

Whenever an error is encountered, a report, identifiable by date and time, is logged in the Programmer Error Reports directory on the desktop. Send the contents of this directory back to Insitu if problems are encountered.

3.3.1 Programming the Aircraft and If/C

Note: This section includes detailed programming and file management instructions. Once familiarized with the processes described here, a simplified programming guide in the *Pocket Handbook* is available for quick reference

1 Open Programmer by clicking the Programmer desktop icon.



Note: If an error is encountered during programming, a report file, identified by time and date, is logged in the <u>Programmer Error Reports</u> directory on the desktop. Send error report contents to Insitu if problems arise.

2 Choose a COM port.

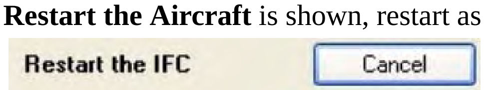
Typically, the I-MUSE machine in a GCS has two serial ports dedicated to programming – one for the If/C and one for the aircraft. Programmer automatically detects the number of COM ports, and all choices are displayed in the drop-down menu. Select the desired COM port.

Note: Programmer remembers COM port settings. COM ports are initially set by Insitu during GCS setup.

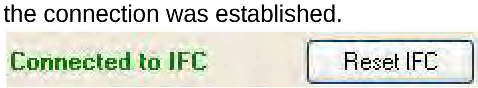
3 Click **Connect IFC** and/or **Connect AC**. It may be necessary to power off, then power on the aircraft or If/C.

Note: Programmer allows simultaneous programming of If/C and aircraft. You must connect to an aircraft to upload aircraft parameters. You must connect to the If/C to program the If/C modem settings.

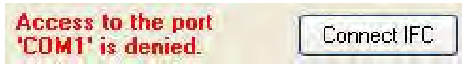
4 If **Restart the IFC** or **Restart the Aircraft** is shown, restart as instructed.

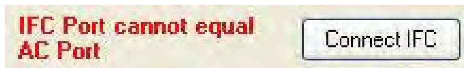


- Green text indicates the connection was established.



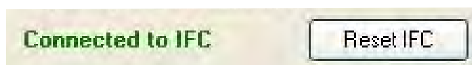
- Red text indicates an error was encountered. Troubleshoot errors as follows:
  - 

    Check COM port connections and try again.
  - 

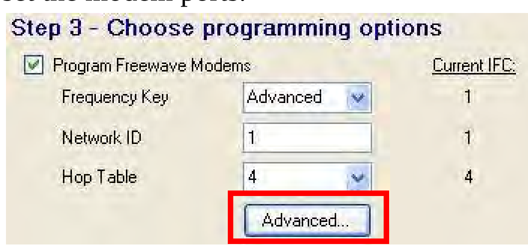
    Make sure that no other programs are attempting to access the COM port and try again. Closing all other applications is recommended.
  - 

    Check and change COM port settings. If/C and aircraft can not share a COM port – each requires a dedicated COM port.

Once a connection is established, termination of an active connection is accomplished through the use of either the **Power Off AC** or the **Reset IFC** button. The corresponding device is either powered off in the case of an aircraft, or power-cycled, in the case of an IFC to remove it from boot mode.



5 Click **Advanced** to set the modem ports.



Note: You must be connected to the If/C to program the modems.

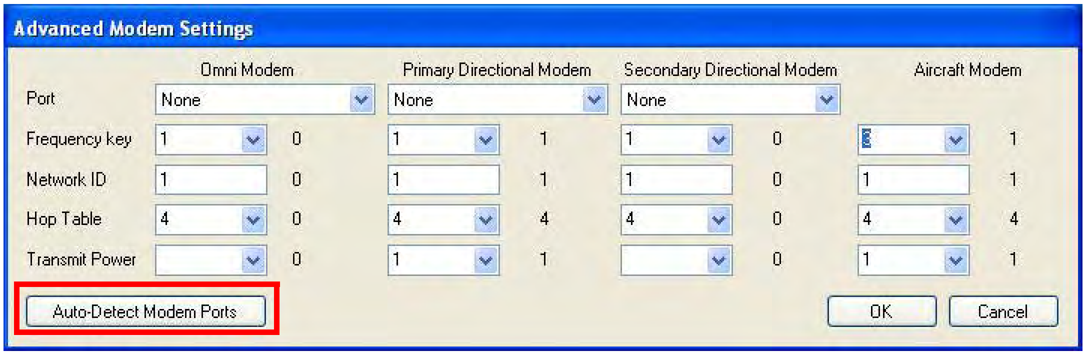
Use the **Advanced Modem Settings** dialog box to program multiple modems. There is one modem for each antenna. Typical antenna configurations include:

Simple GCS	Two modems: If/C and AIM
Complex GCS	Three or four modems: OIM, multiple AIMs, and If/C
Ship Installation	Three modems
HiL Simulator	One modem: AIM

Each modem is connected to the If/C through a different port. Port settings are initially programmed during the Insitu setup. Programmer remembers the most recent settings, and displays them in the drop-down menu. (However, when you install an updated version of Programmer, such as during a software upgrade, you will have to reset the modem settings.)

a) Select the desired value(s) from the **Port** drop-down menu(s), or

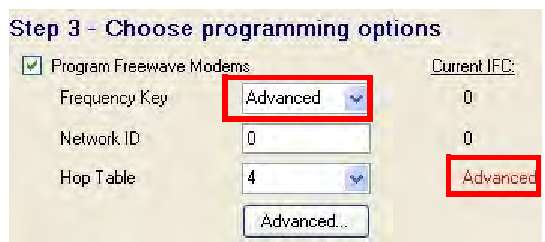
b) Click **Auto-Detect Modem Ports** to pull the modem port data from the If/C port map.



Note: Auto-Detect Modem Ports will return values for all of the antenna listed in the If/C port map, regardless of whether you actually have these antenna connected to the If/C. If you do not have a particular antenna connected to the If/C, change the modem port selection back to None.

c) Click **OK** when you are finished.

6 Update the **Frequency Key**, **Network ID**, and **Hop Table**.



When values are set in the Advanced Modem Settings menu, the value appears as Advanced in the primary Programmer menu.

Aircraft and antenna **Frequency Key**, **Network ID**, and **Hop Table** values must match to enable communication. When antenna is communicating to one aircraft, to switch antenna communication to another aircraft:

- Change GCS modem settings to match those desired for the given location.
- Set the aircraft to match GCS modem settings.

To change the aircraft to which an antenna is communicating, change the **Frequency Key**, **Network ID**, and **Hop Table** values to match those of the desired aircraft. Transmit power governs the strength of the signal. Typically, this is set to 10, which is the equivalent of 100%. However, For 1.3 GHz operations, when programming the AIM through the If/C, if the AIM has an amplifier, do not set transmit power of the modem for the AIM to a value greater than 6. Check for amplifier located on direct iridium antenna dish mount.

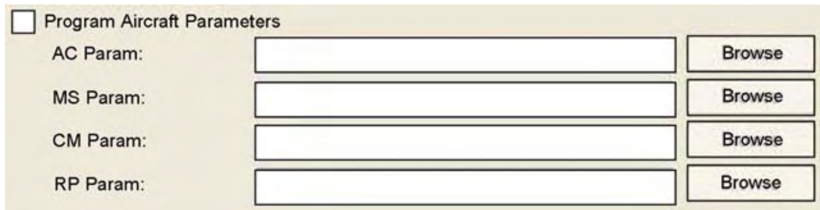
Note: For 900 MHz operations, set the transmit power of the modem for the AIM to 10.

CAUTION: With 1.3 GHz operations, setting the transmit power of the modem for the AIM to a value greater than 6 will result in damage to the amplifier.

7 Program the aircraft parameters.

Note: You must be connected to an aircraft to enable the Program Aircraft Parameters checkbox. The most recent parameter file settings are remembered. Programmer does not detect what parameter files are on the aircraft when it connects.

a) Click the **Program Aircraft Parameters** checkbox to enable parameter file inputs.



b) Browse to and open each parameter file.

If you are using I-MUSE 5.3 or later, browse to the Excel version of the aircraft parameter file. If you are using I-MUSE 5.2, browse to the extracted .prn files.

Parameter File	Sample Filename	Expected File Location
Aircraft parameter	X200 Aircraft 00002.040.xls ACparam000002v040.prn	Aircraft folder on the aircraft USB drive
Mission parameter	MSarltn_001.prn	C:\Program Files\InsituGroup 5\Groundbase\Parameters\ParamsBuilding
Communication parameter	CMelsnr_004.prn	C:\Program Files\InsituGroup 5\Groundbase\Parameters\ParamsBuilding
Reporting parameter	RPtrout_006.prn	C:\Program Files\InsituGroup 5\Groundbase\Parameters\ParamsBuilding

8 Select additional code and bootloader updates as needed.

CAUTION: Programming the bootloader is a dangerous operation because a programming failure will result in complete loss of functionality for the aircraft avionics or If/C. If programming fails, contact Insitu's operations support group immediately without disconnecting power or resetting any components.

Programmer knows what code the If/C and aircraft should be loaded with for the particular version of Programmer. If If/C and/or aircraft code are out of date, Programmer indicates **Update needed**. If they are current, Programmer indicates **Up-to-date**. If an update is needed, the checkbox is enabled. If no updates are needed, the checkbox is grayed out.

Before programming the bootloader, ensure that:

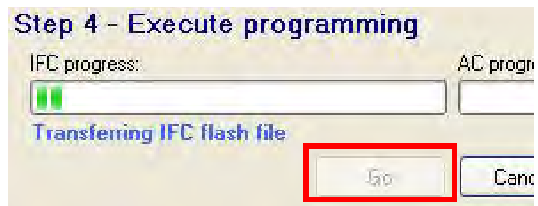
- A continuous power supply will be available for the next half hour.
- If programming the aircraft, the aircraft battery is connected and the belly plug is connected to shore power.
- If using a laptop, the power supply is plugged in and operational.
- All serial and power connections are secure.

If programming fails, contact Insitu's operations support group immediately without disconnecting power or resetting any components.

Note: For If/C port mapping, field pitot offset correction, and memory testing, see *Show Terminal* later in this section.

9 Execute all selected programming.

a) Click **Go**. A status bar displays the progress.



Note: To start over, except when programming the bootloader, close and reopen Programmer or use the Reset IFC and Power Off AC buttons in *Step 2* to reset or power off the corresponding device. Do not do this when programming the bootloader.

b) Close Programmer when complete.

3.3.2 If/C port mapping

Port mapping is needed to tell the If/C which devices are hooked up to which physical ports. To configure IO device port mapping – serial port to device:

1 Open Programmer and connect to the If/C as described in *Step 1* and *Step 2*.

2 Click **Show Terminal**.

3 Read the current configuration: **r**

Note: This shows current mapping saved in flash for all available devices.

```
Device                 Port on IfC
--------------------------------------
Primary Dir Antenna    Internal Modem 1
Secondary Dir Antenna  RJ45 J10,J11
Omni Antenna           Internal Modem 0
Skyhook GPS            RJ45 J7,3,12
Antenna Actuator       RJ45 J8
AHRS                   RJ45 J4
>>p
```

4 Go to program If/C port map menu: **p**

5 Map If/C ports to devices: 1

Note: **This allows programming of each device that was listed when the current port mapping was read.**

```
==================================
=========IFC Port Mapping=========
==================================
1)   Map IfC Ports to Devices
2)   View Port Mapping Help
3)   View Current Choices
4)   View Map Currently in Flash
5)   Save Port Mapping to Flash
99 to exit
Choose an option: 1
```

6 Select a port to map to:

7 Enter the desired port for each device.

Note: **Devices are programmed in the order they were listed when current port mapping was read. To skip one device and move on to the next, press Enter.**

```
==Map Primary Directional Modem==

00)                  Internal Modem 0
01)                  RJ45 J10,12
02)                  Fiber1 Ch1,2
03)                  Fiber2 Ch1,2
04)    *      *      Internal Modem 1
05)                  RJ45 J9,16
No Configuration
<ENTER> to skip
Select a port to map to:
```

CURRENTLY SELECTED IN FLASH

CURRENT SELECTION – UNSAVED

8 Once ports have been mapped to all devices, press **Enter** to continue.

This recalls the If/C port mapping menu.

```
Device                   Port on IfC
-------------------------------------
Primary Dir Antenna      Internal Modem 1
Secondary Dir Antenna    RJ45 J10,J11
Omni Antenna             Internal Modem 0
Skyhook GPS              RJ45 J7,3,12
Antenna Actuator         RJ45 J8
AHRS                     RJ45 J4

Press <Enter> to continue:
```

9 Save Port Mapping to Flash: **5**

```
----------------------------------
=========IFC Port Mapping=========
==================================
1)   Map IfC Ports to Devices
2)   View Port Mapping Help
3)   View Current Choices
4)   View Map Currently in Flash
5)   Save Port Mapping to Flash
99 to exit
Choose an option: 5
```

10 After current mapping choices are saved to flash, a message indicates if there were any omissions during mapping.

```
== You have chosen wisely ========
```

Port mapping was completed successfully

```
== You have chosen poorly ========
```

Incorrect mapping; repeat procedure.

11 Type **99** to exit.

CAUTION: Failure to exit properly results in failure to save port mapping changes.

Note: **When configuration is changed, the old values are set aside in internal flash memory. If a message states that there is no room for configuration, it is necessary to erase the parameter memory by typing k 1 2000. Internal flash memory will be full after 1,024 configuration changes. Since it can only be erased 100 times, only erase when there is no room for configuration.**

12 Close the Terminal window.

13 Power off the aircraft and/or If/C, then power on the aircraft and/or If/C

Note: Closing the Terminal window leaves the aircraft or If/C in bootloader mode. Rebooting the aircraft and/or If/C takes them out of the bootloader, returning to normal mode. Closing the Programmer application closes the serial port.

3.3.3 Field pitot offset correction

1 Set up aircraft programming cable.

2 Open Programmer and perform the procedure in *Step 1 – Choose a COM port*.

3 Click **Show Terminal**.

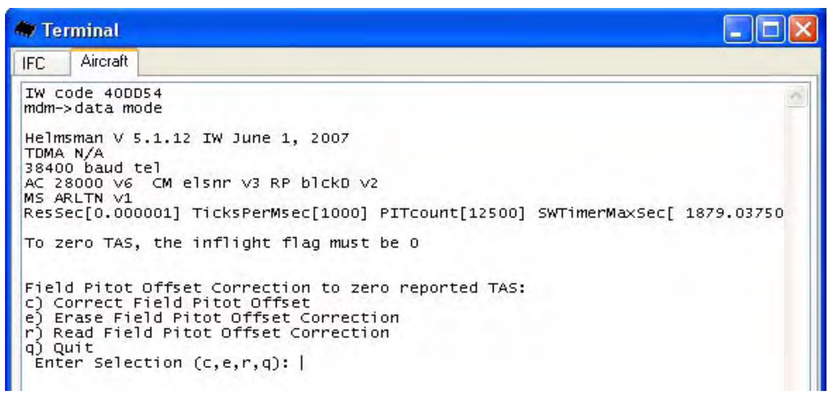
4 Click on the **Aircraft** tab.

5 Click in the Terminal window, then press **Enter** as instructed.

Note: Do not press b as when entering the bootloader.

6 Power on the aircraft.

7 Verify that the startup banner is displayed in the Terminal window.



8 In I-MUSE Engineering Tables, click the **Main** tab and set **in flight** to **0** (Advanced Autopilot Controls).

9 Wait 10 minutes for the aircraft temperature to stabilize.

10 Verify pitot and static systems are not being excited by winds or atmospheric pressure changes. To accomplish this, see Insitu's official procedures. Cup hands to act as a wind break, if necessary.

11 In the Terminal window, type **t** for TAS to enter calibration mode.

12 Read menu items presented.

13 Type **c** to run calibration.

14 Read warning message.

15 Press **Enter**.

16 Note the offset value. Enter it as appropriate in the aircraft maintenance log.

17 If an error is reported, follow the instructions in the error message.

18 Type **q** to quit.

19 In I-MUSE engineering tables, review TAS value. It should be approximately ±3 knots (±1.5 m/s).

20 If TAS is greater than ±10 knots (±5 m/s), retry procedure. If discrepancy persists, return for repair.

Note: This procedure can be performed while the aircraft is communicating with the ground system.

21 Close both the Terminal window and Programmer.

3.3.4 Memory testing

1 Power off the aircraft or If/C.

2 Open Programmer and perform the procedure in *Step 1 – Choose a COM port*.

3 Click **Show Terminal**.

4 Click on the tab that corresponds to the device to be tested: **IFC** or **Aircraft.**

5 Click in the Terminal window and press **Enter** to open the connection.

6 Press and hold **t** while powering on the aircraft or IFC. **Starting memory test** appears, followed by **Testing....**

7 When the tests are complete:

- If **FAILED!** appears for the aircraft, the aircraft cannot be flown using this avionics module. Contact Insitu's operations support group for avionics module replacement.
- If **FAILED!** appears for the If/C, the If/C cannot be used.
- If **PASSED!** appears, the memory test was passed.

8 Close both the Terminal window and Programmer.

9 Power off the aircraft and/or If/C, then power on the aircraft and/or If/C

Note: Closing the Terminal window leaves the aircraft or If/C in bootloader mode. Rebooting the aircraft and/or If/C takes them out of the bootloader, returning to normal mode.

3.3.5 Accelerometer offset correction

Occasionally, on-board accelerometers drift out of calibration. An aircraft parameter file update includes a feature to adjust the accelerometer output within a small range – up to +/- 0.3 G (2.9 m/s^2).

Note: Aircraft parameter files earlier than revision 020-030002R02 do not have this capability. To obtain a spreadsheet update for an aircraft with an earlier aircraft parameter file, contact Insitu's Operations Support Group.

If the aircraft is level and not moving, the accelerometers should ideally read:

- X axis: 0.00 G (0.0 m/s^2)
- Z axis: -1.00 G (-9.8 m/s^2)

The published allowable error limit for the accelerometers is:

- X axis: +/- 0.03 G (0.3 m/s^2)
- Z axis: +/- 0.05 G (0.5 m/s^2)

CAUTION: If a launch is attempted with an accelerometer reading outside this range, flight control problems are possible.

How to offset the accelerometer readings

1. Turn the aircraft on normally and wait until the avionics temperature stabilizes.
2. Ensure that the aircraft is level and not moving. Use a spirit level to ensure the pitch angle is close to zero.
3. Record the X and Z values. As an example, say X = 0.02 G (0.2 m/s^2) and Z = -0.77 G (-7.5 m/s^2). In this case, X is within the limits, but the Z accelerometer needs adjustment (as it is in error by +0.23 G or +2.3 m/s^2).
4. Open the aircraft parameter file spreadsheet, e.g. Seascan380ACparams.xls
5. Open the **Field Updates IN** page. Near the bottom of the page there is a new section entitled **Accelerometer Offsets**.
6. Enter the offset that is required to bring the accelerometers within limits. In our example, this means enter -0.23 G into the Z accelerometer field.
7. Increment the file version and save.
8. Reprogram the aircraft with the new parameter file.
9. Turn the aircraft on and verify that the accelerometers read expected values when level and at operating temperature.
10. Pitch the aircraft upwards vertically. The X accelerometer should read 1.0 G, and the Z should read 0.0 G. Use a spirit level to ensure the aircraft is within a few degrees of vertical.

Note: When an offset is entered into either of the Accelerometer Offsets fields, the correction applies to both the default calibration data and any updated avionics information entered into the Field Updates IN page.

If an offset is entered into the spreadsheet, the data available for Transfer OUT includes the correction automatically.

If an offset has been entered into the spreadsheet, and new avionics data is then entered into the updates page, the accelerometer offsets must be set to zero or new information will be adjusted. There is a macro that checks to see if the avionics update cells have changed (as happens when pasting in new data), and if either of the accelerometer offsets are not zero, it prompts to set them back to zero.

3.3.6 Futaba Pilot Console Emergency Reprogramming

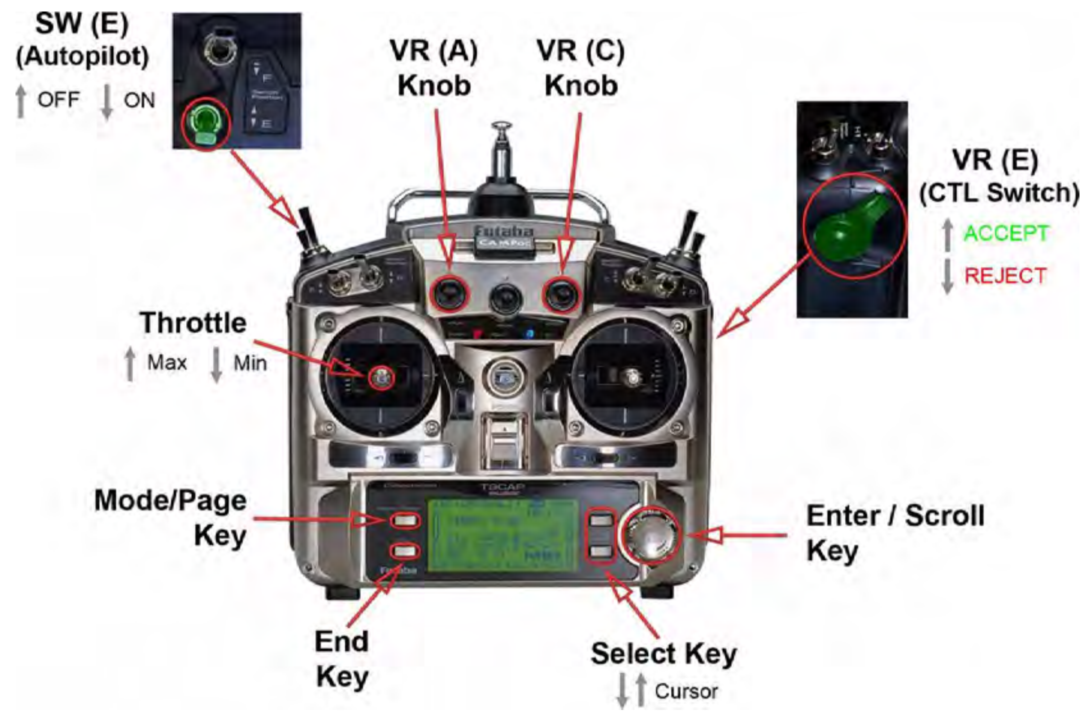
The Futaba Pilot Console emergency reprogramming procedure allows flight operators to reprogram the Futaba Pilot Console. Use this document only if the CAM Pac and internal flash memory lose programming or if an infield update is required. If internal flash memory has failed but the CAM Pac is intact (programmed), use the GCS shop program guide and programmed CAM Pac to re-flash internal memory (refer all keys to Futaba Pilot Console Switch Functions table).

Tools:

- Futaba Pilot Console
- GCS If/C (for power)
- Groundbase (for testing)

Parts / Materials:

- None

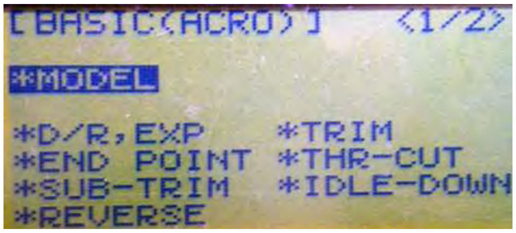


SW (E) Autopilot	Used to toggle the Autopilot on or off. The left and right sticks operate different functions based on whether the Autopilot is set as on or off	**VR (A) Knob**	Rotate this knob to set flaps. This is not used during flightly, only initial programming.	**Select (↑↓ Cursor) Key**	Used for programming. Press either key to move cursor up or down between selections.
VR (E) CTL Switch	The right lever is used to authorized the aircraft for landings. In the on position the aircraft can land. In the off position the aircraft will not land. Also known as CTL (Clear To Land).	**VR (C) Knob**	Rotate this knob clockwise or counterclockwise to toggle between fields.	**End Key**	Used for programming. Press to exit current mode or menu.
Throttle	Used to control the throttle (up on the stick increases the throttle, while down on the stick decreases the throttle) and the rudder (left on the stick turns left, right on the stick turns right) while the Autopilot is off. Used for control wheel tracking of the payload when the Autopilot is on.	**Mode/ Page Key**	Used for programming. Press and hold the key to move between modes and press to change pages.	**Enter/Scroll Key**	Used for programming. Rotate the key to highlight a selection and press to accept selection.

Futaba Pilot Console – Emergency Reprogramming Procedure

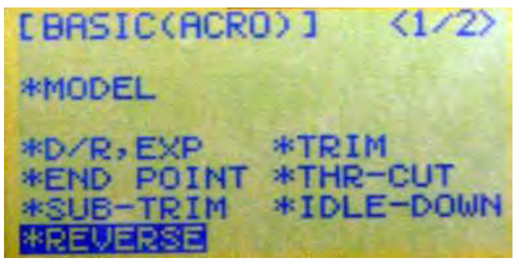
Setting the Auto Pilot Switch

1 Press and hold the **Mode/Page** key until page one of the **Basic (Acro)** menu appears.

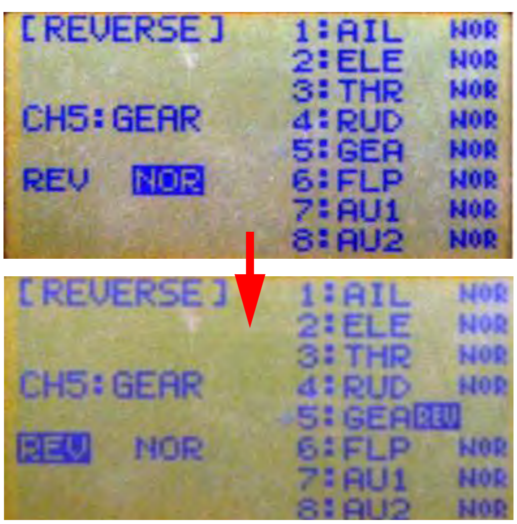


Note: **Verify that the Basic (Acro) menu appears. If the Advance (Acro) menu appears, press the Mode/Page key to switch back to the Basic (Acro) menu.**

2 Rotate the **Enter/Scroll** key clockwise until the cursor highlights the **REVERSE** field



3 Press the **Enter/Scroll** key to enter the **REVERSE** menu. Press the **Select (Cursor)** down key until **5:GEA** is selected. Rotate the **Enter/Scroll** key clockwise to change the value of **5:GEA** from **NOR** to **REV**.



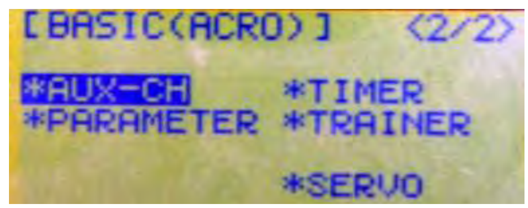
4 After setting the value of **5:GEA** to **REV**, press the **End** key twice to save the changes and exit.

Verifying Switch Configuration

1 Press and hold the **Mode/Page** key until page one of the **Basic (Acro)** menu appears.

Note: **Verify that the Basic (Acro) menu appears. If the Advance (Acro) menu appears, press the Mode/Page key to switch back to the Basic (Acro) menu.**

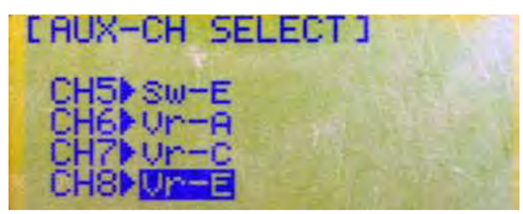
2 Rotate the **Enter/Scroll** key clockwise to scroll to the second page of the **Basic (Acro)** menu, until the cursor highlights the **AUX-CH** field.



3 Press the **Enter/Scroll** key to enter the **AUX-CH** menu. Verify the values listed in the **AUX-CH** menu match the following:

- **CH5 ⇨ Sw-E**
- **CH6 ⇨ Vr-A**
- **CH7 ⇨ Vr-C**
- **CH8 ⇨ Vr-E**

Note: **Setting CH8 to Vr-E moves the CTL Switch to the VR-E switch position.**



4 After verifying and changing the values in the **AUX-CH** menu, press the **End** key twice to save the changes and exit.

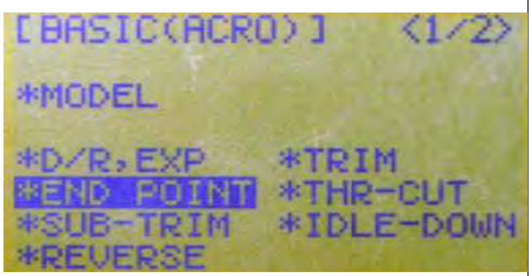
Futaba Pilot Console – Emergency Reprogramming Procedure (Continued)

Disabling Manual Flaps Control

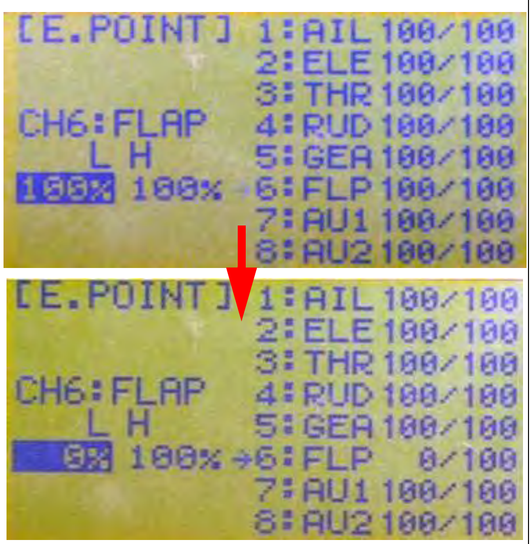
1. Press and hold the **Mode/Page** key until page one of the **Basic (Acro)** menu appears.

Note: **Verify that the Basic (Acro) menu appears. If the Advance (Acro) menu appears, press the Mode/Page key to switch back to the Basic (Acro) menu.**

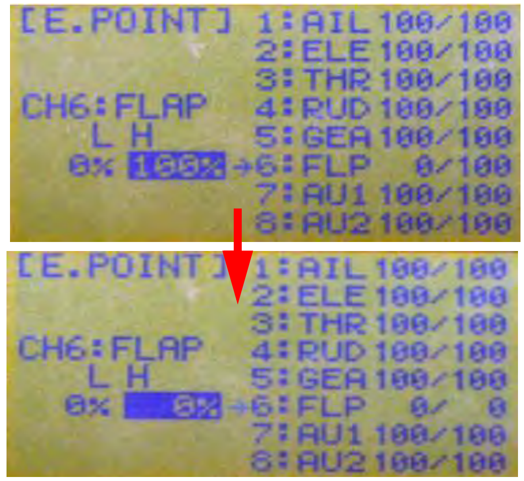
2. Rotate the **Enter/Scroll** key clockwise until the cursor highlights the **END POINT** field.



3. Press the **Enter/Scroll** key to enter the **END POINT** menu. Use the **Select (Cursor)** down key to select **6:FLP**. Change the first listed percentage value to **0%** by rotating the **Enter/Scroll** key counter clockwise.



4. Rotate the **VR (A)** knob clockwise to select the next listed percentage value for **6:FLP**. Change this value to **0%** by rotating the **Enter/Scroll** key counterclockwise.

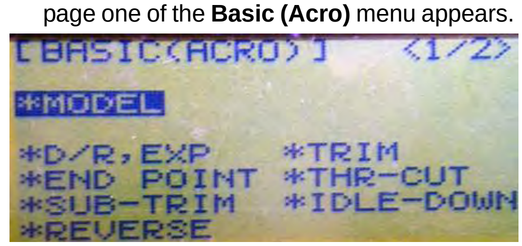


Note: **To move between 6:FLP fields, rotate the VR (A) knob clockwise or counterclockwise. Use this knob during programming only, not during flight.**

5. Press **End** key twice to save changes and exit.

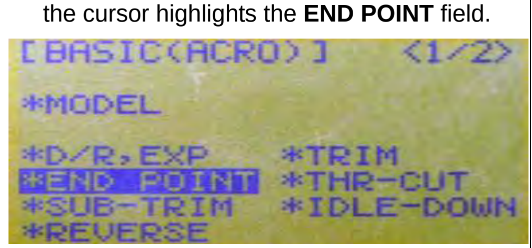
Disabling Manual Mixture Control

1. Press and hold the **Mode/Page** key until page one of the **Basic (Acro)** menu appears.



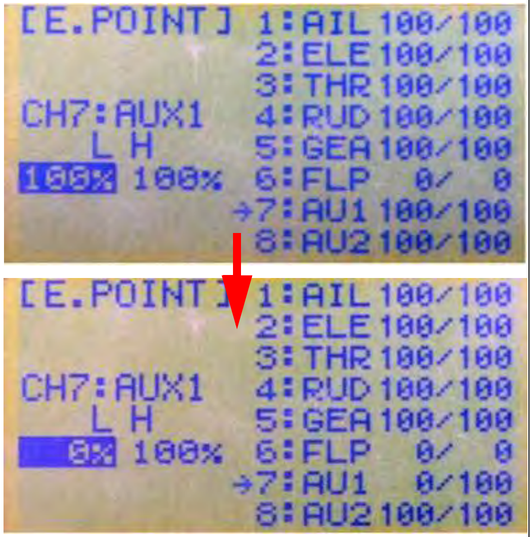
Note: **Verify that the Basic (Acro) menu appears. If the Advance (Acro) menu appears, press the Mode/Page key to switch back to the Basic (Acro) menu.**

2. Rotate the **Enter/Scroll** key clockwise until the cursor highlights the **END POINT** field.



Futaba Pilot Console – Emergency Reprogramming Procedure (Continued)

3 Press the **Enter/Scroll** key to enter the **END POINT** menu. Use the **Select (Cursor)** down key to select **7:AU1**. Change the first listed percentage value to **0%** by rotating the **Enter/Scroll** key counterclockwise.



4 Rotate the **VR (C)** knob clockwise to select the next listed percentage value for **7:AU1**. Change this value to **0%** by rotating the **Enter/Scroll** key counterclockwise.

Note: **To move between the two 7:AU1 fields, rotate the VR (C) knob clockwise or counterclockwise.**

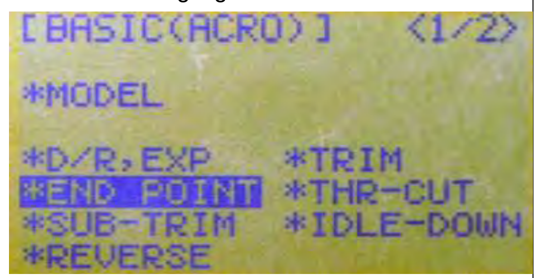
5 After setting the percentage values for **7:AU1**, press the **End** key twice to save the changes and exit.

Configuring Throttle Max and Throttle Min Settings

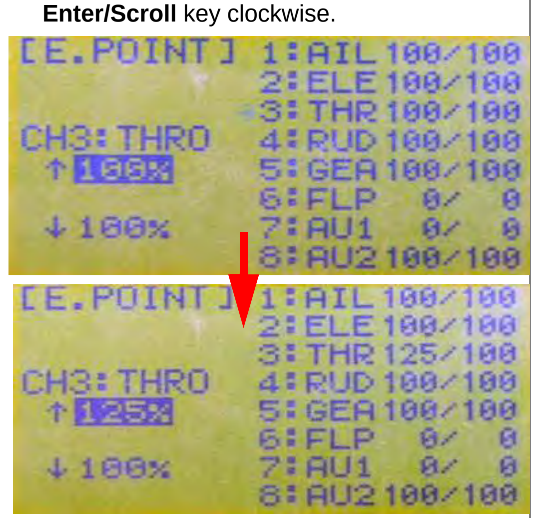
1 Press and hold the **Mode/Page** key until page one of the **Basic (Acro)** menu appears.

Note: **Verify that the Basic (Acro) menu appears. If the Advance (Acro) menu appears, press the Mode/Page key to switch back to the Basic (Acro) menu.**

2 Rotate the **Enter/Scroll** key clockwise until the cursor highlights the **END POINT** field.

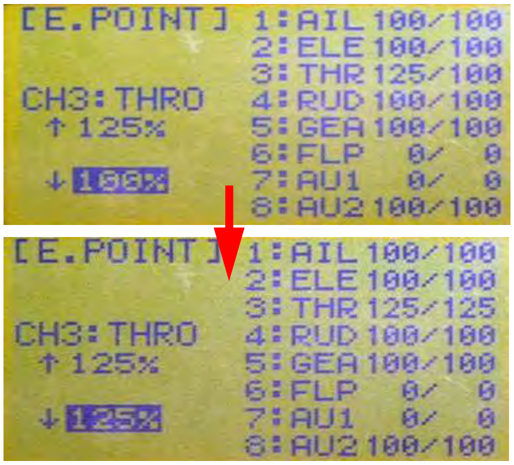


3 Press the **Enter/Scroll** key to enter the **END POINT** menu. Use the **Select (Cursor)** down key to select **3:THR**. Place the throttle stick in the up position to select the upper (max) percentage value. Change the upper (max) percentage value to **125%** by rotating the **Enter/Scroll** key clockwise.



Futaba Pilot Console – Emergency Reprogramming Procedure (Continued)

4 Place the throttle stick in the down position to select the lower (min) percentage value. Change the lower (min) percentage value to **125%** by rotating the **Enter/Scroll** key clockwise.

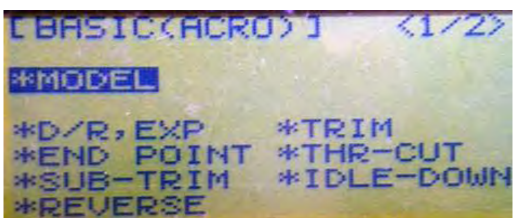


Note: **To move between the two 3:THR fields, move the throttle stick up or down.**

5 Press the **End** key twice to save the changes and exit.

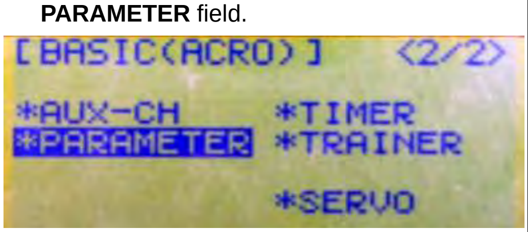
Verifying Factory Parameters

1 Press and hold the **Mode/Page** key until page one of the **Basic (Acro)** menu appears.



Note: **Verify that the Basic (Acro) menu appears. If the Advance (Acro) menu appears, press the Mode/Page key to switch back to the Basic (Acro) menu.**

2 Rotate the **Enter/Scroll** key clockwise to scroll to the second page of the **Basic (Acro)** menu, until the cursor highlights the **PARAMETER** field.

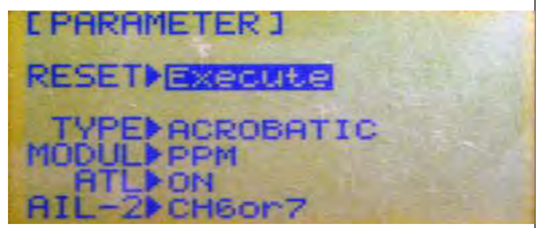


WARNING!

Do not make changes to the RESET field.

3 Press the **Enter/Scroll** key to enter the **PARAMETERS** menu. Verify that the values listed in the **PARAMETERS** menu match the following:

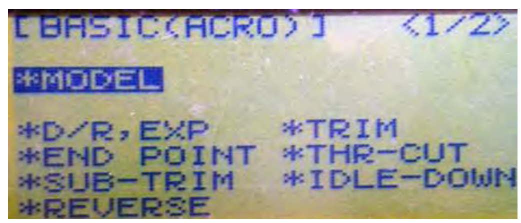
- TYPE: ACROBATIC
- MODUL: PPM
- ATL: ON
- AIL-2: CH6or7



4 Press the **End** key twice to exit.

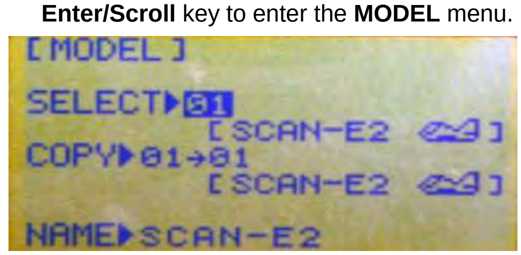
Changing the Revision of the Program Name

1 Press and hold the **Mode/Page** key until page one of the **Basic (Acro)** menu appears.



Note: **Verify that the Basic (Acro) menu appears. If the Advance (Acro) menu appears, press the Mode/Page key to switch back to the Basic (Acro) menu.**

2 If the **MODEL** field is not already selected, rotate the **Enter/Scroll** key until it is selected. Once the **MODEL** field is selected, press the **Enter/Scroll** key to enter the **MODEL** menu.

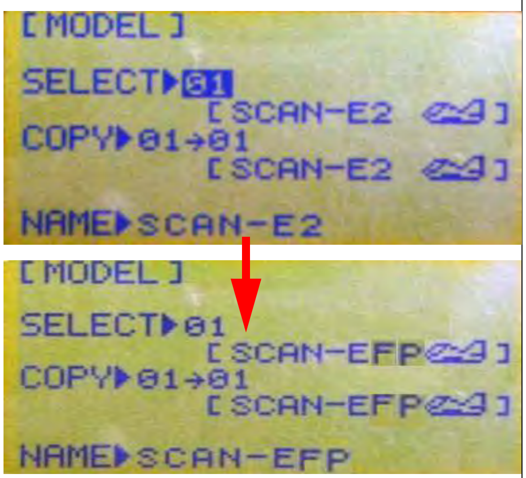


Programming 3

Futaba Pilot Console – Emergency Reprogramming Procedure (Continued)

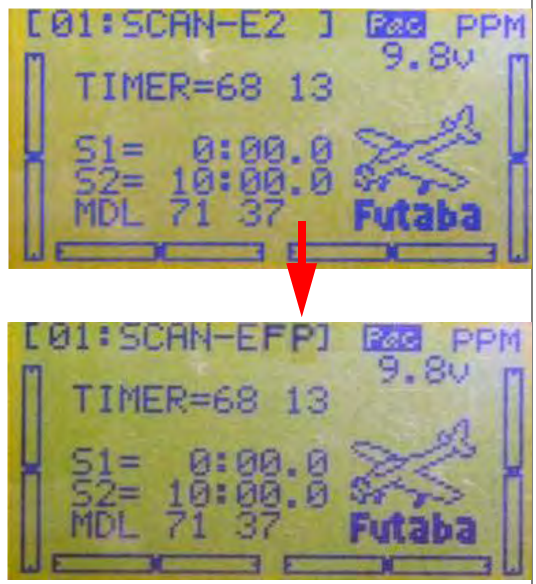
- Use the **Select (Cursor)** down key to scroll to the **NAME** field. The **Select (Cursor)** up and **Select (Cursor)** down keys can be used to move back and forth within the **NAME** field.
- The **Enter/Scroll** key is used to change the values in each text field. Rotate the key clockwise to increase the value, counterclockwise to decrease the value.

3 Using the **Select (Cursor)** keys and the **Enter/Scroll** key, change the value listed in the **NAME** field (most instances, this value is **SCAN-E2**) to **SCAN-EFP**.



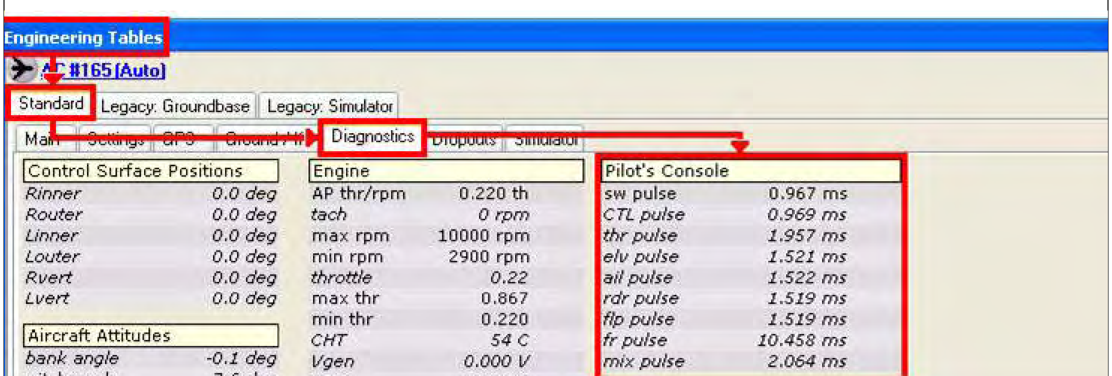
4 After changing the **NAME** field to **SCAN-EFP**, press the **End** key twice to save the changes and exit.

5 The changed name can now be seen on the main screen.



Verifying FPC Changes with I-MUSE

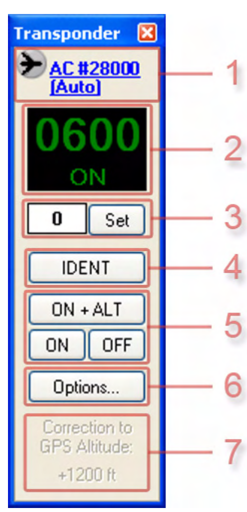
1 While on the ground, connect the newly programmed Futaba Pilot's Console to I-MUSE. Under the engineering tables, select **Standard > Diagnostics > Pilot's Console**. Verify that the proper fields respond to the Futaba Pilot's Console.

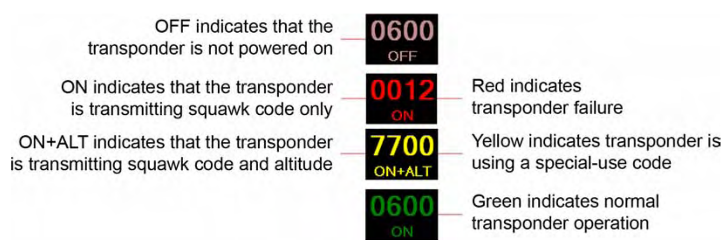


3.3.7 Transponder Quick Reference Card

Transponder - Quick Reference Card
Transponder Panel Operation and Air Traffic Controller Terminology

Transponder Panel	
Item	**Function**
Aircraft 1	Information in the Transponder Panel is for the aircraft listed in this field.
Transponder Display 2	Transponder Display shows the current four-digit squawk code, as well as the transponder's current mode of operation.
Squawk Code Entry 3	The Squawk Code Entry field allows operators to enter a four-digit identifying squawk code. Clicking the Squawk Code Entry **Set** button sets the current squawk code to the newly-entered squawk code. **Note:** Only change the squawk code when requested to do so by Air Traffic Control.
IDENT Button 4	Clicking the **IDENT** button commands the transponder to perform the Identify function. The Identify function causes the aircraft's radar return to appear brighter than normal for 20 seconds. **Note:** Only use the Identify function when requested to do so by Air Traffic Control.
Transponder Mode Setting Buttons 5	The Transponder Mode Setting buttons allow the operator to set the transponder's current mode of operation. They are: • **ON + ALT** - sets the transponder to transmit both squawk code and altitude • **OFF** - sets the transponder to the power off mode • **ON** - sets the transponder to transmit squawk code only
Options Button 6	Clicking the transponder **Options...** button opens the Transponder Options window. See the Transponder Options Window table on the next page for more information.
Correction to GPS Altitude Section 7	The Correction to GPS Altitude section displays the value entered as the GPS altitude correction for altitude reporting. See the Transponder Options Window table on the next page for more information. **Note:** This field is only applicable when the transponder is in ON+ALT mode.



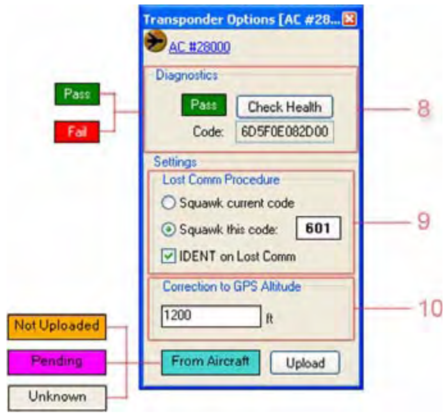


Note: Some squawk codes have established meanings in the Air Traffic Control system and should be used with care. The following special-use codes require confirmation before use:

7600 through 7677 - lost communications codes
7700 through 7777 - emergency codes
0000 - restricted code

Other codes may have established meanings within the operational environment, so users should take care to set the transponder squawk code in accordance with local Air Traffic Control policy.

026-010113 v1.2
Transponder v.5.1 rel. FEB07



Transponder Options Window	
Item	**Function**
Diagnostics Section 8	Allows operator to check general transponder health. The **Pass** indicator shows that the transponder is operating properly. The **Fail** indicator shows that the transponder has failed. The hexadecimal code listed in the **Code:** field can be used to help troubleshoot transponder failures.
Settings - Lost Comm Procedure Section 9	Allows the operator to set the response mode of the transponder in the event of a lost communication emergency. This procedure is executed if the aircraft loses communication link with a ground station. The operator selects either the **Squawk current code** (transponder continues to transmit currently-selected code) or **Squawk this code:** (transponder transmits user-entered code) to determine which code the transponder transmits upon a lost communication emergency. The **IDENT on Lost Comm** check box allows the user to select if the transponder will perform the IDENT function during a lost communication emergency.
Settings - Correction to GPS Altitude Section 10	Allows the operator to select either GPS altitude or pressure altitude by using a correction factor. Transponders typically report pressure altitude. This correction is applied to the GPS altitude when pressure altitude is desired. Use the **GPS-to-Pressure Altitude Spreadsheet** available through the I-MUSE checklist to compute the appropriate setting before each flight.
Settings - Upload Button	Click the **Upload** button to send any changes made to the Settings section to the aircraft. When the data in the Settings section matches the data uploaded and current on the aircraft, **From Aircraft** is displayed; when the data is changed and no longer matches the current data on the aircraft, **Not Uploaded** is displayed; when the operator clicks the **Upload** button and the data has not been accepted on the aircraft, **Pending** is displayed; when the state of the Settings data is unknown, **Unknown** is displayed.

Transponder Terminology	
Air Traffic Controllers may use the following commands to direct the operation of the transponder. Operators should comply with the request as quickly as possible and reply to the Air Traffic Controller by repeating the command.	
ATC Term	**Description**
SQUAWK (number)	Set transponder code to the indicated number
IDENT	Engage the transponder Identify feature (IDENT)
SQUAWK (number) and IDENT	Set transponder code to the indicated number, then engage the transponder Identify feature (IDENT)
STOP SQUAWK	Set transponder mode to off (OFF)
SQUAWK MAYDAY	Set transponder code to emergency (7700 is standard emergency code)
SQUAWK VFR	Set transponder code to default VFR (1200 is standard VFR code)
REPEAT LAST	If a command is not understood, operators should reply to the Air Traffic Controller with this command

3.4 Ground Control Station Software

In this section:

- If/C programming
- Modem
- I-MUSE
- ObjectTracker
- Acadia
- Antenna

Ground Control Station Software	
If/C programming	
With I-MUSE 5.2 and later: ▪ If/C programming can be conducted at the same time as aircraft programming, using the Programmer application. For Programmer instructions, refer to *Programming Aircraft Software,* earlier in this chapter.	With I-MUSE 5.1.X and earlier: ▪ Use Planner. Refer to *Appendix A*.
Modem settings	
With I-MUSE 5.2 and later: ▪ Modem programming can be conducted at the same time as aircraft programming, using the Programmer application. For Programmer instructions, refer to *Programming Aircraft Software,* earlier in this chapter.	With I-MUSE 5.1.X and earlier: ▪ Use Planner. Refer to *Appendix A*.

Ground Control Station Software

I-MUSE

Software

Setup consists of launching I-MUSE Client and connecting I-MUSE Client to I-MUSE servers.

Launch I-MUSE Client

1 Double-click I-MUSE Client desktop icon or select **All Programs > InsituGroup 5 > I-MUSE Client** from Windows **Start** menu.

I-MUSE Client connects to I-MUSE Servers through **Aircraft Network** panel, which is comprised of:

- a list of GCS Objects
- a list of Connections

Launch and connect to an I-MUSE Server on a local machine

1 Select **Launch I-MUSE Server** from the **File** menu on the I-MUSE toolbar.

Launch and connect to an I-MUSE Server on a network machine

1 Open the Aircraft Network Panel in I-MUSE by selecting Aircraft Network from the **Panel** menu on the I-MUSE toolbar.

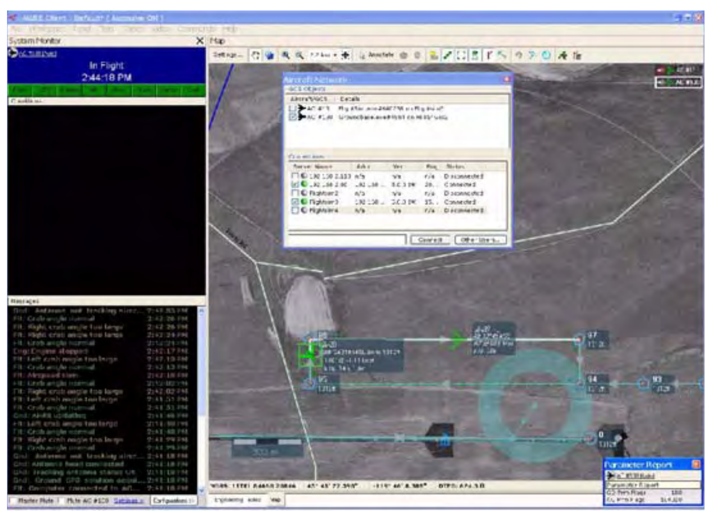
2 Enter name or IP address of the machine on which I-MUSE server is running in the text box at the bottom of the Aircraft Network panel. To find your IP address, see *IP Address* in Chapter 2, *Setup*.

3 Click the **Connect** button.

Note: Only networks with functional Domain Name Servers (DNS) can use machine names.

Connections

Aircraft



Once a connection with the server is made, I-MUSE queries the server for connected aircraft. If there are any, aircraft status and server connection are listed in the upper section of the window. (Extend Server Name column to see entire entry.) Aircraft routes, current settings, and current positions are also drawn upon the Map area.

If more than one aircraft is listed in the Aircraft/GCS column, the active aircraft (the focus of aircraft-specific commands) is designated by a checkmark in the box beside its ID. Change active aircraft by checking the box beside the aircraft.

Ground Control Station Software	
I-MUSE	**(cont.)**
Connections (cont.)	**Server** Manually disconnect and reconnect to servers by unchecking or checking the box beside the server name in the lower portion of the Aircraft Network panel. Once I-MUSE has disconnected from a server, the status light beside the server's name turns gray. Along with the server's name, the Aircraft Network panel also reports which version of Groundbase the server is running, the ping rates (the amount of time it takes for information to travel between I-MUSE Client and I-MUSE Server), and the status of the server in relation to I-MUSE (whether I-MUSE is currently in communication with the server or not). If there are several disconnected servers which you would like to remove from the list, right click in the list area and select the **Remove all disconnected servers from list** option.
ObjectTracker	
	After loading a new ACparam file, restart ObjectTracker as noted in the preflight Check. If ObjectTracker is not restarted, ObjectTracker will neither recognize the new aircraft configuration nor acquire the necessary ACparam file. As a result, target coordinates will not be displayed on ObjectTracker. If ObjectTracker was not restarted before the aircraft was powered on, to correct the problem during Video System Check: ▪ Restart ObjectTracker. ▪ Get a parameter report. ▪ Download the ACparam file from the aircraft (Standard ->Settings tab in I-MUSE; ALT-F5 page in Groundbase); or, transfer the binary ACparam file via network or USB drive from another computer or folder (e.g. from the I-MUSE computer) to the ObjectTracker folder on the ObjectTracker computer. ▪ Get a parameter report. ▪ Check alarm settings.
Nostromo N52	When installing the Nostromo N52 software, ensure that the device is unplugged during the entire installation. Failure to do so may result in incorrect installation or a spontaneous reboot.
Acadia	
Acadia Card	**Function** The **Function** drop-down menu provides the follow selections: ▪ **Raw Video Display** ▪ **Stabilization** ▪ **Mosaicking** Once the **View Video** checkbox is checked, use the **Function** drop-down menu to change how the video is displayed on the PC's screen. **Note: This field does not have any bearing on the configuration of the Acadia card. This field only correlates to the View Video checkbox located just above the Reset Display button. It is neither part of the Acadia Controls section, nor is it used to program the Acadia card.**

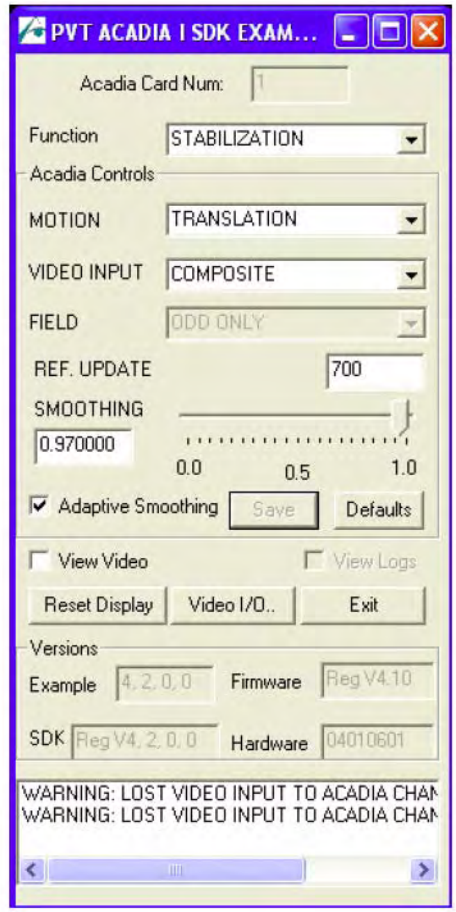
Ground Control Station Software

Acadia **(cont.)**

Acadia Card (cont.)

MOTION

For GCS applications, select the **TRANSLATION** motion model, which compensates for horizontal and vertical shifts in the imagery, but not for rotation or other motions. It is the simplest and also the most robust for poor scene content. This model is used primarily to stabilize simple hand-held camcorder video (not for mosaic construction), moving object detection, or other applications where all motion must be precisely modeled.



For S-VEST applications, select **PROGRESSIVE AFFINE**. This is the setting used by the Terasight Manager (and older VICE systems) primarily for building mosaics. The orientation of the camera/picture remains constant as pixels are added to that initial reference frame.

VIDEO INPUT

The **VIDEO INPUT** pull-down menu selects the type of video input provided to the Acadia I PCI board. Depending on the cabling, select **S-Video** or **Composite** cabling. **S-Video** is recommended for higher video quality.

REF. UPDATE

The **REF. UPDATE** threshold field defines (in pixels) the amount of motion allowed between the stabilization display reference image and the current image before the former is updated. On the analog stabilization output, this is seen as a reset of the display to the current image. The default value is 360 pixels. It is recommended that this value be kept between 300 and 700. For S-VEST applications, **REF. UPDATE** is typically set to 700.

SMOOTHING

Motion smoothing may be controlled either by the slider tool or by setting a value in the **SMOOTHING** box. Smoothing applies a low-pass filter to the motion used to warp the video for stabilized analog output. High-frequency jitter is removed, while systematic pans and zooms are retained in the output. This makes the output visually pleasing and seems more natural. The range of smoothing can be controlled between 0.0 and 1.0, although the most effective parameters lie between 0.9 and 1.0. A value of 1.0 makes the video most stable (no smoothing). A value of 0.0 indicates no stabilization whatsoever.

Ground Control Station Software

Antennas

Quickset Soft Stop Setup

1 Disconnect the quickset cable at the AIM and plug in the AIM test cable. One end goes to the AIM, the other end goes to the quickset cable. The third cable coming off the test cable goes to the serial port on your computer.

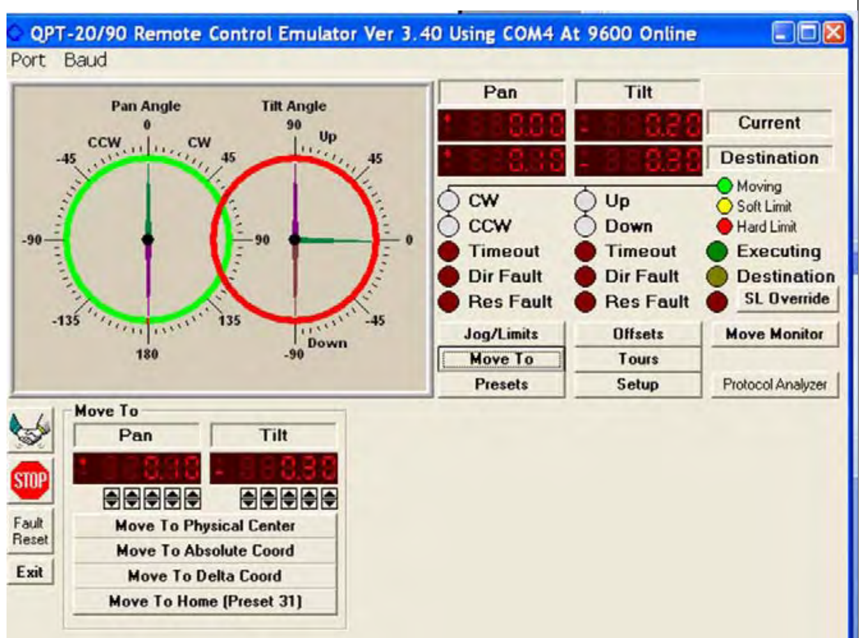
2 Power up the AIM.

3 Open the PRT-2090 Remote Emulator program.

4 Select the proper com port for your computer.

5 Click the **Start** button. It takes a few seconds to connect to the quickset.

6 The **Move To** window appears. Use this screen to move the quickset head to the desired coordinates.



7 To set the pan to 0, click the up and down arrows under **Pan**.

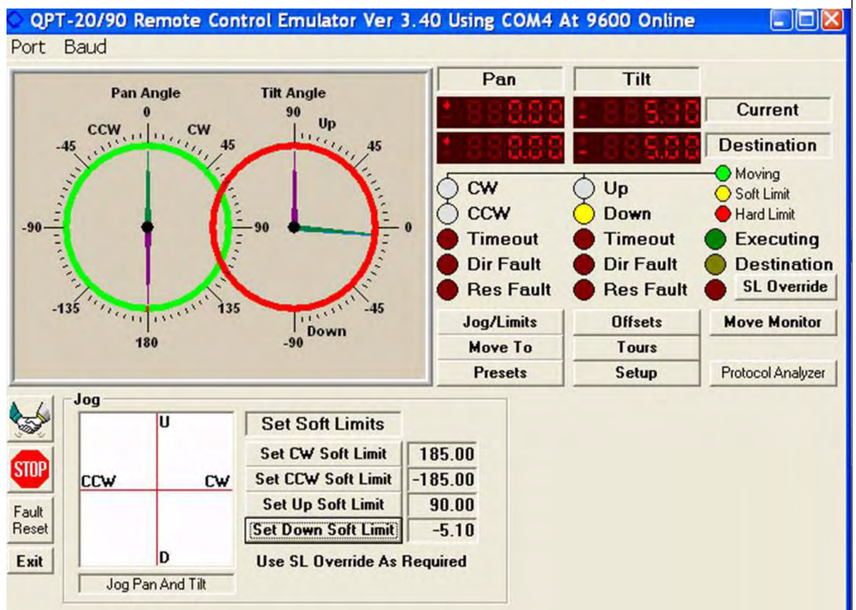
Programming 3

Ground Control Station Software

Antennas (cont.)

Quickset Soft Stop Setup (cont.)

8 Set the tilt to -5 degrees. Click the **Move To Absolute Coord** button. The quickset head will move to this position.



9 Click the **Jog/Limits** button.

10 Click the **Set Down Soft Limit** button. The down soft limit is now set.

Note: If difficulty is experienced moving the actuator head, it may be up against two soft limits at once. Click the SL Override button, then click and hold (for a second or two) in the white screen with the vertical and horizontal lines. The actuator should move off the soft limit. Continue setting the soft limits as normal.

11 Go back to the **Move To** window and set the tilt to 70 degrees.

12 Click **Move To Absolute Coord** and wait for the Quickset to move.

13 Now go to the **Jog/Limits** window and click **Set Up Soft Limit**.

14 Continue repeating this procedure for the pan parameters. Values normally used are +185 for CW, and -185 for CCW.

15 After setting the soft limits, click on the **Setup** button.

16 Click and drag **Maximum Pan Speed** all the way to the right = 255. Now click **Set Maximum Speed**.

17 Click the **Stop** button, then the **Exit** button. Sometimes the program will hang up the serial port. If this is a problem, go into the task manager. The program will still be running. End the program to fix the problem.

4

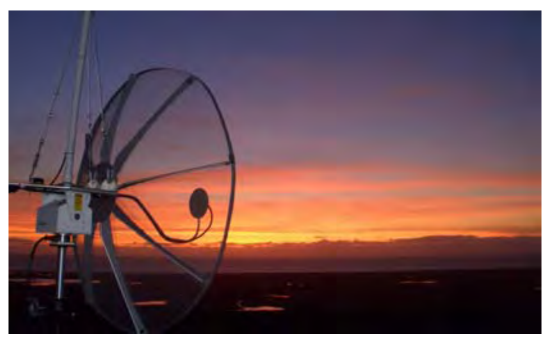
Preflight

Chapter Map			
4.1 Checklists			
Conventions	4-2	Sequence & guidelines	4-3
4.2 Launcher – No-load Test			
No-load preflight inspection	4-4	No-load and dummy launch guidelines	4-5
Gripper brake check	4-5		
4.3 Maritime Operations			
Maritime operations	4-6		

4.1 Checklists

In this section:

- Conventions
- Sequence and guidelines



To ensure that all critical tasks have been performed prior to flight, ensure that all systems have been set up and checked as described in Chapter 2, *Setup*.

- ❑ **Complete the Mission Risk Assessment Worksheet in this chapter.**
- ❑ **Complete the latest approved preflight Briefing checklist. The checklist is found on Insitu's Extranet and in the *Pocket Handbook*.**
- ❑ **Complete the latest approved preflight Inspection Checklist. The checklist is found on Insitu's Extranet and in the *Pocket Handbook*.**
- ❑ **Complete the Interference Check in this chapter.**

Insitu provides and maintains a comprehensive collection of checklists to ensure that all operators use the same accurate and up-to-date procedures. Using the **approved checklists** is critically important and required for the safety of personnel and equipment.

The latest approved checklists are posted and continually updated on Insitu's Extranet:

http://www.insitu.com/extranet

Note: Before using any checklist that has been previously downloaded or printed, confirm that you are using the latest approved checklist posted on Insitu's Extranet.

The Extranet requires a password for access. If you need a password, request one by sending an e-mail to extranet@insitu.com.

Whenever a new checklist or document is released, Insitu's Extranet is updated immediately and a message is automatically sent to notify all registered users.

This section provides general guidelines for using Insitu's Approved Checklists (posted on our Extranet), as well as some additional worksheets and periodic checklists which are referenced throughout sections in this handbook.

Checklists
Conventions
▪ The operator must handle any alarm conditions encountered while using the checklists.
▪ Optional checklist items are indicated at the start of the line with the configuration in parenthesis. For example: "(Mobile GS) AHRS OFFSET – Set." would only be completed if using a "Mobile GS".
▪ A maintenance configuration indicates that an item needs to be completed if a certain part of the aircraft has undergone maintenance and is marked by the "▲" symbol. For example: "(▲Avionics) GPS FIRMWARE – Checked" if avionics have been removed, reinstalled, modified, or replaced.
▪ **Bold type** is used to indicate items that should be committed to memory.
▪ The "●" symbol is used whenever a value(s) associated with the checklist item should be recorded in the Mission Data Form.
▪ The "❍" symbol is used whenever a value(s) associated with the checklist item *may* be recorded in the Mission Data Form – often when a value differs from the default, is unusual, or has to be corrected.
▪ It isn't necessary to record any values in the checklist itself, only in the Mission Data Form where specified.
▪ Additional items may be added by individual people or operations, but nothing shall be removed without Standardization Board approval.
▪ Checklists may be used more often than specified, but not less often.
▪ These checklists must be used as a set since there may be coverage gaps if only some of these checklists are used.
▪ These checklists must be used with the official Limitations matrix found in Chapter 1, *Overview: Standards & Limitations*.
▪ If items are found to be outside specifications, the problem must be corrected before using the Takeoff Checklist.

<table>
<tr><th colspan="3">Checklists</th></tr>
<tr><th colspan="3">Sequence & guidelines – recommendations for approved checklists</th></tr>
<tr><td>1</td><td>Aircraft Preflight/Postflight Inspection Checklist</td><td></td></tr>
<tr><td>2</td><td>GCS Assembly Checklist</td><td>Performed whenever GCS is assembled, modified, or moved.</td></tr>
<tr><td>3</td><td>GCS Startup Checklist</td><td>Perform when powering on for operations.</td></tr>
<tr><td>4</td><td>SkyHook Inspection Checklist</td><td></td></tr>
<tr><td>5</td><td>Catapult Inspection Checklist</td><td></td></tr>
<tr><td>6</td><td>Mission Risk Assessment Worksheet</td><td></td></tr>
<tr><td>7</td><td>Preflight Briefing</td><td></td></tr>
<tr><td>8</td><td>Catapult Launch Checklist</td><td></td></tr>
<tr><td>9</td><td>Takeoff Checklist</td><td>Perform before any aircraft is launched.</td></tr>
<tr><td>10</td><td>Systems Check – Checklist</td><td>This checklist is used to check aircraft post-production (prior to first flight). This check uses all items marked for certain maintenance configurations (since everything on the aircraft needs to be checked).
Note: This is not a Takeoff Checklist.
The only exception to the requirements for the Systems Check is in the case that the aircraft is reprogrammed with a new Mission file but still uses the correct Aircraft, Comm and Reporting files. Then only the takeoff checklist needs to be performed, and the (▲MSparam) items completed.
To be performed whenever an aircraft undergoes:
maintenance,
any disassembly/reassembly,
parameters or software are loaded,
after every 10 flights, after every 100 tach hours, or after every 60 days, whichever comes first.</td></tr>
<tr><td>11</td><td>Systems Check and Takeoff Checklist</td><td>Satisfies both Systems Check and Takeoff requirements.
Note: Exception: engine run <u>time</u> requirement – mandatory after propulsion module maintenance.</td></tr>
<tr><td>12</td><td>Releasing Controller’s Handoff Checklist</td><td></td></tr>
<tr><td>13</td><td>Receiving Controller’s Handoff Checklist</td><td></td></tr>
<tr><td>14</td><td>Auto-Retrieval Checklist</td><td></td></tr>
<tr><td>15</td><td>Post-flight Checklist</td><td></td></tr>
<tr><td>16</td><td>GCS Shutdown Checklist</td><td>Performed when powering down.</td></tr>
</table>

Preflight 4

4.2 Launcher

In this section:

- No-load preflight inspection
- Gripper brake check
- No-load and dummy launch guidelines

These procedures qualifies the launcher prior to aircraft launch. The no-load procedure produces the same aircraft launch results as shooting an orange roto-molded dummy prior to launch.

Note: Two procedures are required to qualify the launcher for aircraft launch.

Launcher
No-load preflight inspection

1. With safety pin in, trigger disconnected, and grippers empty, pressurize cylinder to 20 psi.
2. Pull safety pin. Hand crank winch to pay out strap, carriage will move forward as you crank.
   a. As you crank, look at each pulley – seven pulleys on each side of launcher – to ensure that the cable is captured and that it is rolling freely.
   b. As you crank, look at each roller – two on upper carriage, two on lower bogey – to ensure that they are rolling freely on the track.
   c. Pay out strap until carriage is at the neck of the launcher track.
3. Open valve to vent the pressure in the cylinder.
4. Winch the carriage back to the starting position and insert safety pin.

Launcher

Gripper brake check

1. From starting (aircraft loaded) position, rotate both right and left gripper 180 degrees.
   a. Brake should engage at 85 degrees +/- 5 degrees.
2. Using spring scale, measure tangent brake force at 180 degrees, 12 inches from pivot. For the carbon gripper, gripper feet threaded studs work well.
   a. Brake force at 180 degrees = 40-60 lbs. – this is 40-60 ft-lbs.
3. Adjust brake(s) as needed one hole at a time using brass nut at top of pivot. Replace locking screws, **being careful not to over-tighten**.
   a. Brake force at 180 degrees = 40-60 ft-lbs.

CAUTION: Always re-test after making any brake adjustment.

Note: Brake adjustment nut is left-hand thread on left side; right-hand thread on right side.

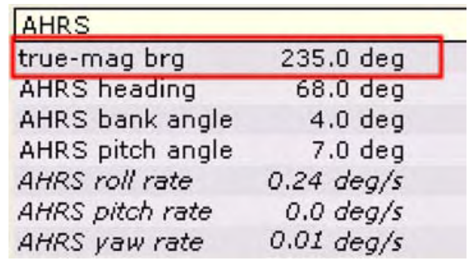
No-load and Dummy Launch Guidelines

1. The No-load procedure should be performed one time prior to launch if successful launches were performed the previous day and weather conditions are similar.
2. The No-load procedure should be performed two times prior to launch if it has been more than one day since the last launch and if weather conditions are vastly different.

CAUTION: If any maintenance was performed on the launcher – except for brake adjustment – the launcher needs to go through maintenance and inspection as described in the *Maintenance Handbook.* Dummy launches must also be performed.

4.3 Maritime Operations

AHRS



The AHRS should be aligned with the ship/GCS axes, securely mounted, and powered as outlined in Chapter 2, *Setup*. The ground-station attitude fields in the I-MUSE tables should start updating after the AHRS has been powered for about a minute. There will be an announcement of “Ground-Station Attitude Updating” when I-MUSE starts receiving AHRS data, and an announcement of “Ground-Station Attitude Not Updating” will be made if the data stops.

Most ground stations use the **Navigat 2100,** an AHRS that outputs true heading. With the **Navigat 2100**, no magnetic correction is required. However, if the AHRS in use outputs magnetic heading, a correction must be applied to convert magnetic to true heading. The local magnetic declination (variation), is entered in the **true-mag brg** field. The psi ground-station attitude field will then increase by true-mag brg amount, so that psi now shows **true** heading. If the AHRS heading is incorrect at certain orientations or slow to update, it is best to have the ship/GCS hold headings and avoid turning. The error can then be corrected by setting **true-mag brg** to the necessary value.

When the FOG (Fiber Optic Gyro) was installed, it is likely that it wasn’t perfectly aligned with the boat. It’s heading may be off from the boat’s heading, as well as its pitch and roll angle. You can make offset adjustments to counter misalignment.

If the heading, pitch, or roll needs adjusting, do that in one of two places: 1) Navigat 2100; or 2) Groundbase. For Navigat 2100 adjustment instructions, see *Navigat 2100 FOG sensor configuration setup* in the *AHRS – Initial setup instructions* provided in Chapter 2, *Setup*.

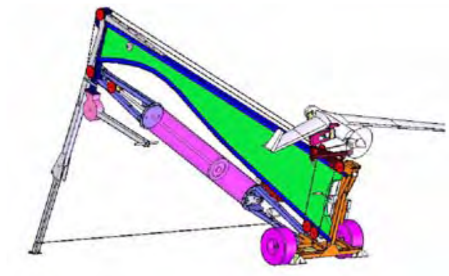
5

Launch

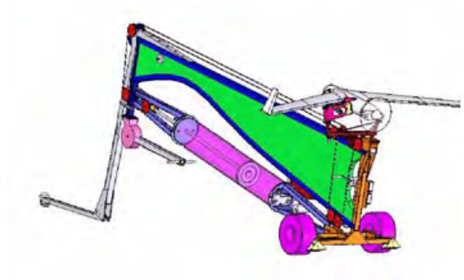
5.1 Overview

The launcher is a pneumatic catapult designed to provide a steady 12g acceleration upon launch. The catapult is mounted on a wheeled frame with a supply tank and air compressor. The 16-foot (~5 m) assembly requires only a small footprint, and deploys easily.

The kickstand (or forward support post) has two positions, which are used for varying wind and terrain conditions:



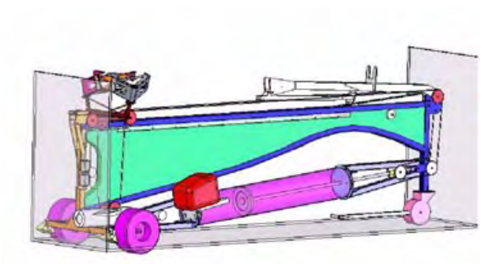
For typical, light wind conditions, the full length is used, and the launch elevation angle is 25º above the grade.



For high wind conditions or steep terrain, it may be necessary to launch at a lower angle; the kickstand is erected in a kneeling position at 12º.

Note: Maritime launchers are equipped with an A-frame kickstand and are not adjustable.

For transport and storage, the kickstand is folded onto the top track.



A drawbar and pneumatic wheels are provided for maneuvering the launcher into position or into storage by hand. The 3-inch pintle hitch may be used only for low-speed towing by a tractor.

5.2 Launch Considerations

Prior to operating a launch, be aware of the considerations outlined in this section:

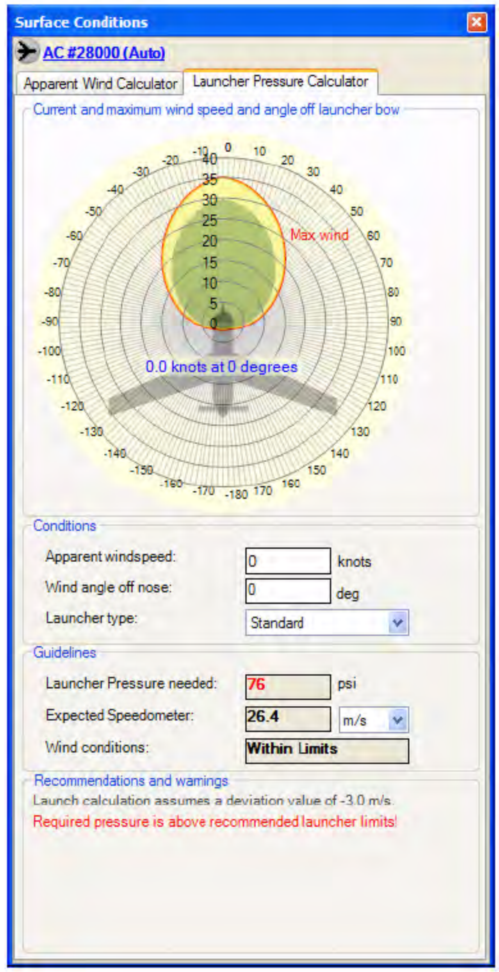
- General guidelines
- Launcher pressure calculator
- Launch & retrieval guidance spreadsheet
- Pressure selection

Launch Considerations	
General guidelines	
Headwind – correction for headwind	▪ A headwind allows the required pressure to be reduced for launch. A factor for this headwind should be applied (i.e. do not reduce speed by the total headwind, but rather a fraction of the headwind – see *Pressure selection* in this table.) Tailwinds are not recommended, though light tailwinds might be possible depending upon aircraft weight and the excess launch speed that is available. Some crosswind is allowable.
Launcher performance – correction	▪ With good record keeping, deviations from expected performance may be accounted for through an increase in pressure. ▪ Older models of the launcher have aluminum gripper systems which cause the UAV to lose between 0.5 and 2.0 m/s (about 1 to 4.5 mph) of airspeed leaving the launcher. This is due to a negative impulse that is applied to the aircraft as the UAV travels forward through the over-center lock mechanism during the release stroke. This negative impulse is not measured on the speedometer as the impulse takes place after the high-speed measurement, but affects the aircraft nevertheless. Therefore, it is necessary to correct the anticipated speedometer reading for this negative impulse when planning a launch. Additionally, if the gripper system is not properly maintained within tolerances, it is possible for this negative impulse to be abnormally large.
Procedural recommend-ations	Select **Checklists and Procedures** from the **Panel** menu on the I-MUSE toolbar. Select **Start New** from the toolbar. Select **Systems Check and Takeoff** and click **Start**. ▪ Always make sure that the barometric altitude matches the GPS altitude before takeoff is commanded. ▪ Always apply offsets to the onboard gyros so that they are within the limits of +/ - 0.01 rad/s before launch. ▪ Try to launch the UAV as light as is possible for the anticipated mission. Typically, fuel burn can be roughly estimated at 0.25 kg (0.55 lbs) per hour, for operations without a fuel reserve. The past history of an aircraft when operating during typical missions will indicate whether the fuel estimator is pessimistic or optimistic in its calculations. ▪ If the pressure or speed required is outside the defined limits, reduce fuel to achieve higher launcher speed. This may have to be done in zero wind conditions. ▪ Keep good records of launches, whether using the aircraft or a dummy. For a launch where there is questionable performance, record the first four intervals from the second line on the speedo LCD, and send this data to Insitu. Also, sending back the completed Mission Data forms gives Insitu the information that might help us to improve fuel estimations.

Launch Considerations	
General guidelines	**(cont.)**
Procedural recommend-ations (cont.)	▪ Meet all requirements in published documents for launcher maintenance. ▪ If a tailwind seems minimal at ground level, it may be larger at altitudes as low as 20 or 30 m (about 65 or 100 feet) above ground level. Placing a flag on top of the SkyHook may help with wind-related decisions. ▪ Dummy launches will show whether there is a nose-down impulse imparted on the aircraft at launch. In a fast, high pressure launch, this effect will be more nose down, and can be corrected by moving the ski ramp backwards by half an inch or so. The slotted holes in the ski ramp allow for adjustments fore and aft. ▪ When using the launch pressure calculator in I-MUSE (or the Launch and Retrieval Guidance Spreadsheet in I-MUSE 5.1.X and earlier), if there are warnings about being outside limits, weight can be adjusted easily to find the reduction in fuel required for a launch that is acceptable. Always remember to use the right margin for your launcher.
Speed – required aircraft speed	▪ The UAV calculates an airspeed required for safe climb-out once the CAT command is sent. This is based on aircraft configuration, weight, and air density. The UAV sets a dynamic pressure to maintain during the takeoff sequence. This is displayed as a True Airspeed in the autopilot table, but is effectively an equivalent speed, as this TAS value increases automatically with altitude gain. ▪ During launch, the aircraft is in an airspeed hold mode, and holds wings level up to a specified altitude. If the launch is slow, the aircraft will pitch over to gain airspeed. Takeoff occurs at a margin above the actual aircraft stall speed, to allow for maneuvering. Takeoff hence occurs at a fixed fraction of the maximum lift coefficient. ▪ For a fixed lift coefficient, an increase in weight necessitates an increase in airspeed. Hence, a heavier aircraft will require a faster takeoff speed. ▪ The aircraft calculates air density based on its OAT reading and its barometric pressure sensor. The lower the air density, the faster the required takeoff speed will be. Operating at high altitude or at high temperature increases the required speed.
Launcher pressure calculator	
	Note: For operations with I-MUSE 5.1.X and earlier, the Launcher Pressure Calculator tool is not available. Use the *Launch & Retrieval Guidance Spreadsheet*, discussed later in this section. The **Surface Conditions** panel in I-MUSE has two tabs: **Apparent Wind Conditions** and **Launcher Pressure Calculator**. The **Apparent Wind Conditions** tab is used to compute correct winds for takeoff and retrieval from shipboard. The **Launcher Pressure Calculator** is used to calculate launcher pressure for the selected aircraft and for evaluating ground wind conditions. To open the Launcher Pressure Calculator in I-MUSE: ▪ Select **Surface Conditions** from the **Panel** menu on the I-MUSE toolbar. ▪ Select the **Launcher Pressure Calculator** tab. **Note: The panel will not display data unless an aircraft or simulator is connected to I-MUSE.**

Launch Considerations

Launcher pressure calculator (cont.)



- ❑ **Aircraft Selector Icon**

  This icon enables selection among all aircraft to which the I-MUSE client is connected.

- ❑ **Current and maximum wind speed and angle off launcher bow**

  This pane displays current surface conditions and a visual indication of operational limits.

Note: A launcher type must be selected for the display to occur.

- ❑ **Conditions**

  Enter readings from the weather station in the Conditions pane.

  Select the Launcher type from the drop-down menu.

- ❑ **Guidelines**

  The results of the calculations are displayed in the Guidelines pane. Red indicates the result is outside Launcher limits.

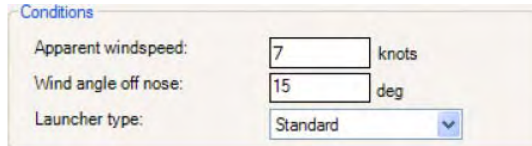
- ❑ **Recommendations and warnings**

  This pane displays information in black and warnings in red.

Launch Considerations

Launcher pressure calculator (cont.)

Conditions



- Apparent wind speed and wind angle off nose

  Enter data from the weather station.

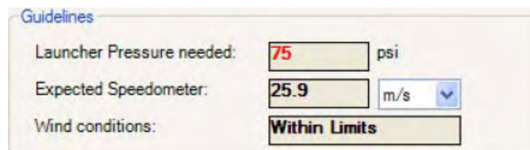
Note: **If the wind speed is gusty, it is recommended to wait for a steady period if possible. Otherwise, use the minimum wind speed in case the wind drops when the aircraft is launched.**

- Launcher type

  Select Standard or Simulator from the drop-down menu.

Note: **A launcher type must be selected for the display in the Current and maximum wind speed and angle off launcher bow pane to occur.**

Guidelines



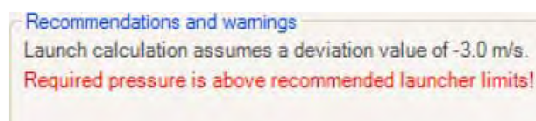
The calculation results are displayed in read-only fields.

Note: **Information displayed in red indicates the results are outside launcher limits.**

The unit of measurement for speed defaults to meters per second.

Launcher pressure calculator (cont.)

Recommendations and Warnings

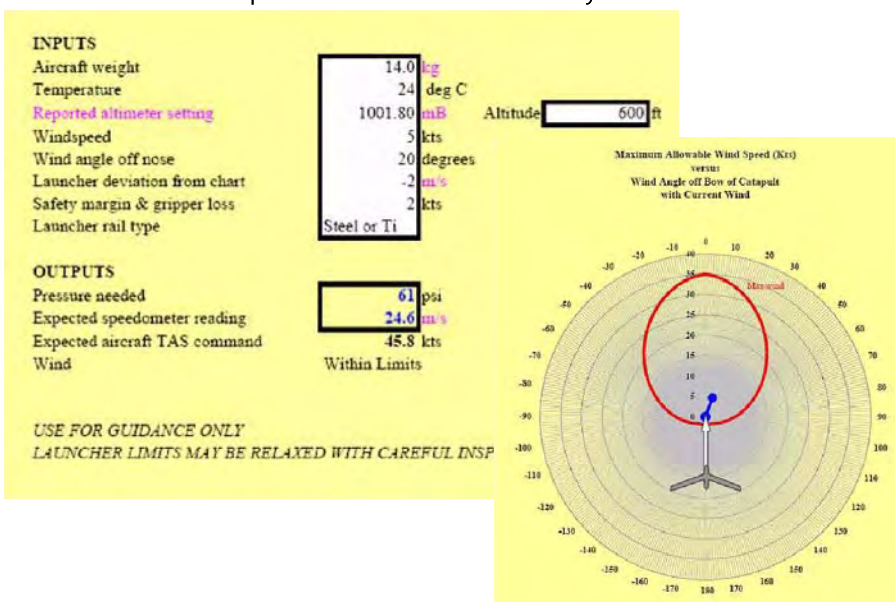


The pressure calculation assumes a launcher deviation of -3 m/s to provide a margin of safety for the following considerations:

- Variability among launchers
- Launch speed at low wind
- Correction for headwind

Note: **Information displayed in red indicates the results are outside launcher limits.**

Launch Considerations	
Launch & Retrieval Guidance Spreadsheet	
	The Launch & Retrieval Guidance Spreadsheet is only used for launch with I-MUSE 5.1.X and earlier. For I-MUSE 5.2 and later, see *Launcher Pressure Calculator*, earlier in this section. Insitu provides this additional tool (an Excel file) to help evaluate winds observed, as well as the selection of fuel loads and catapult pressures. The file indicates warnings whenever the launcher is outside of design limitations. This permits the operator to iteratively change input factors to see their ultimate effect on predicted launcher performance. An operator can, for example, find the aircraft weight that prevents the launcher from being operated outside of its current limits. After the Ground Station software has been installed, the Excel file is located in the *InsituGroup 5 folder* (accessible via a shortcut on the Windows Desktop) and is named *Launch and Retrieval Guidance.xls.* On the software installation CD, this file is located in the same path under the Release directory.



Launch 5

Launch Considerations	
Pressure selection	
Procedure	Use the launch calculator in I-MUSE to calculate pressure. For I-MUSE 5.1.X and earlier, use the Launch & Retrieval Guidance Spreadsheet to calculate pressure, which must be entered manually. In general, pressure selection is comprised of three elements: ▪ Required aircraft airspeed for climb-out ▪ Correction for headwind ▪ Correction for launcher performance Use the following steps to determine the correct pressure selection: 1 Before engine start, find the required autopilot TAS command. This can be done in any one of at least three ways: ▪ Type progressively lower speeds into the I-MUSE autopilot table until the minimum speed is determined. I-MUSE software will calculate this speed automatically based upon the ambient air pressure measured, air temperature, and the aircraft gross weight. Takeoff speed is this value. To access the Autopilot Controls in I-MUSE, select **Standard Tables** from the **Tables** menu on the I-MUSE toolbar. Go to **Standard** > **Main** > **Autopilot Controls** and enter an edit value in the **AP speed** field.

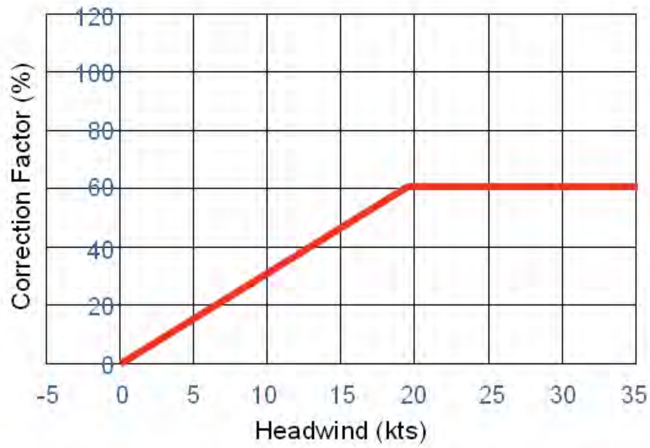
Launch Considerations

Pressure selection (cont.)

Procedure (cont.)

- Use the Launcher Pressure Selection spreadsheet.
- Use manual lookup charts for airspeed selection, as shown in Airspeed Charts.

2 Reduce required speed by the headwind factors shown.



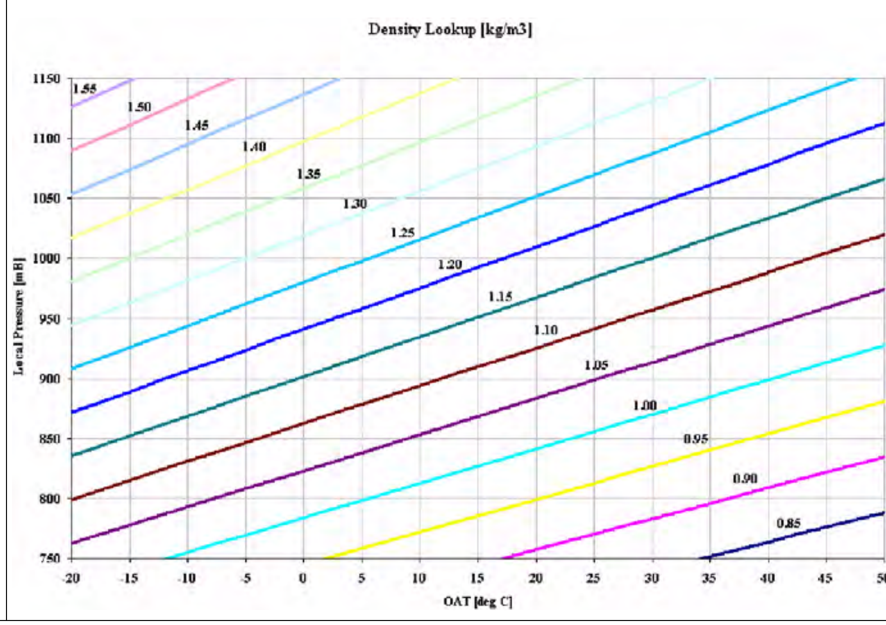
3 Add factor for safety or poor performing launcher grippers.

Situation	Add Factor
Additional safety margin	Variable based on historical data

Based on the recorded history of the launcher, extra margin can be added at the operators' discretion.

Once the desired launcher speed has been determined, look up pressure required on the Launcher Pressure Chart posted on the specific launcher model that you use. If the launcher in question is historically shooting slowly, the expected speed will be slower than the end speed expected from the Launcher Pressure Chart and the desired pressure may need to be adjusted.

Airspeed charts



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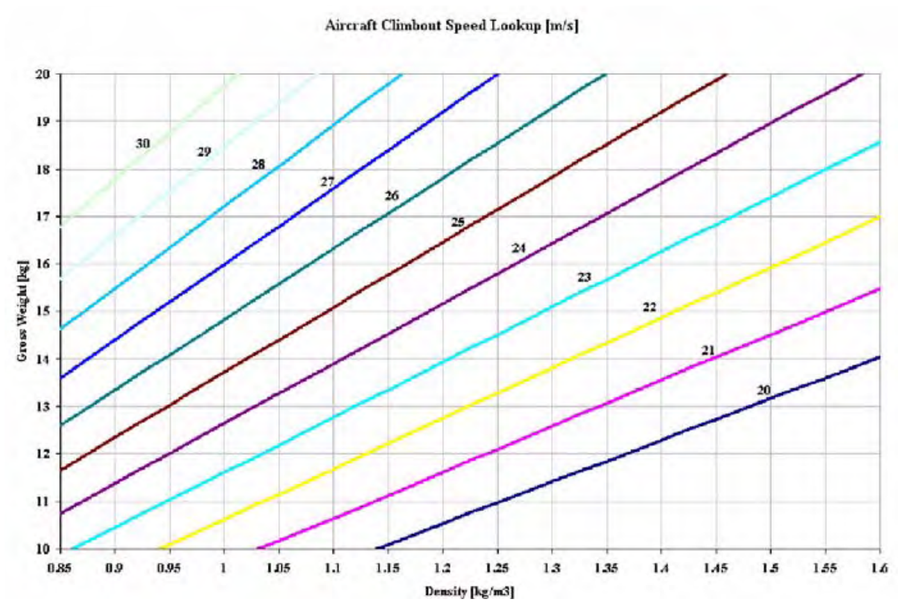
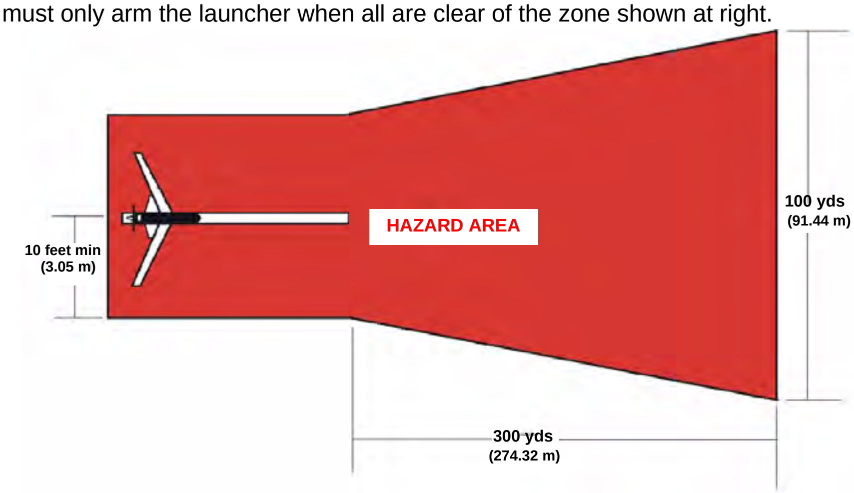
Launch Considerations	
Pressure selection	**(cont.)**
Airspeed charts (cont.)	

5.3

Pre-operation Inspections

In this section:

- Safety requirements
- Basic inspections

Pre-operation Inspections	
Safety requirements	
Equipment WARNING	Safety equipment including helmet, eye protection, and flak vest or float coat are required. 
Burns – hot compressor pipe WARNING	Use caution around the hot compressor pipe to avoid serious burns. 
Caution – use extreme caution when armed WARNING	Whenever the trigger rope is attached to the ring, the launcher is armed and dangerous. Ensure that the safety pin is in place. 
Clearance WARNING	All personnel must maintain a safe distance from the launching operation. Operator must only arm the launcher when all are clear of the zone shown at right. 
General WARNING	Prior to operation, it is the responsibility of the operator to: ▪ Learn and practice the principles of safe machine operation. ▪ Perform the required inspections and tests. ▪ Perform routine maintenance. ▪ Review the important hazard information in this table.

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Pre-operation Inspections	
Basic Inspections	
Bond joint inspection	❑ **Perform every 10 launches as described in the *Maintenance Handbook.***
Brake – setup and adjustment	❑ **Perform as specified or as needed** 1 Both brakes should be set to 40-60 ft-lbs. (54.23-81.35 newton meters) when the gripper is rotated 180 degrees from loaded position.  **Note: It is important to check and set the brake settings before launching over 50.54 knots (26 m/s).** ▪ Hook scale approximately 12 inches (30 cm) from pivot on lower foot stud, and pull gripper through 180 degrees while watching readout. 2 Adjust brakes in one-hole increments using brass nut at top of pivot. Replace locking screws with light torque. 3 Do not overtighten bolts. **CAUTION: Important! Always re-test after making brake adjustment.** **Note: Brake adjustment nut is a left-hand thread on left side and a right-hand thread on the right.**
Gripper opening check	❑ **Perform as specified or as needed** Procedures for checking the gripper opening are similar to those described in *Brake setup and adjustment*, earlier in this table. **Note: There should always be 6 inches (~15 cm) minimum distance between the gripper halves. There should always be 4 inches (~10 cm) minimum distance between the fixed diagonal brace and the swinging diagonal brace. If one or both grippers has opened too far, the gripper brake nuts may need to be adjusted as described in the *Maintenance Handbook*.**
Launcher inspection checklist	❑ **Perform prior to every operation** Prior to every operation and use of equipment, Insitu's **approved checklists** must be used to ensure the safety of personnel and equipment. ❑ **Inspect the launcher using the Catapult Inspection Checklist. The checklist is found in the *Pocket Handbook* and on Insitu's extranet.** For routine, weekly, and monthly system checks, see the Maintenance Handbook.
Lower pivot inspection	❑ **Perform every 10 launches as described in the *Maintenance Handbook.***
Pusher block padding	❑ **Perform as described in the *Maintenance Handbook.***

5.4

Basic Launch Procedure

In this section:

- Completing the launch checklist
- Loading the aircraft
- Engine run-up
- Charging the cylinder
- Launching the aircraft
- Retrieving the carriage
- Adjusting for aircraft/dummy changeover

WARNING!

Do not operate the equipment unless you have been trained and certified by an authorized Insitu representative. Failure to operate the equipment properly may result in serious injury or death.

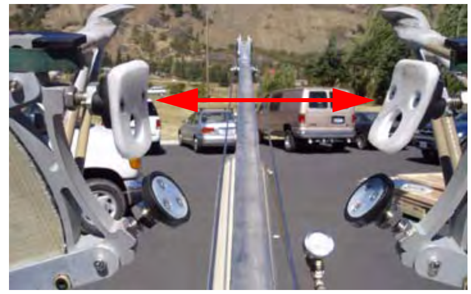
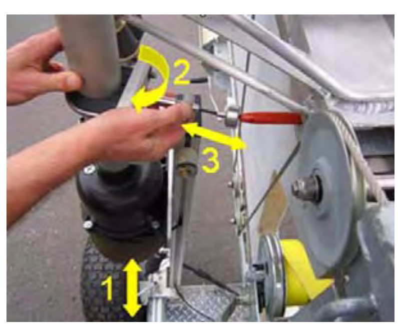
Basic Launch Procedure	
Completing the launch checklist	
	To ensure that all vital steps are performed in the correct order: ❑ **Use the latest approved launch checklist found in the *Pocket Handbook* and on Insitu's extranet.**
Loading the aircraft	
	Note: Launcher is shipped with carriage in retrieved position, ready for aircraft loading. However, if carriage retrieval is needed, refer to *Retrieving the carriage*, later in this table. **Note: Load the aircraft with the cooling system retracted. Operate the cooling system as described later in this section** 1 Locate safety pin and place it through carriage and rail. Engage speedometer magnet to help secure safety pin. **Note: Before loading dummy into gripper, adjust the lower feet as per *Adjusting for aircraft/dummy changeover*, later in this table.**  

<table>
<tr><th colspan="2">Basic Launch Procedure</th></tr>
<tr><th colspan="2">Loading the aircraft (cont.)</th></tr>
<tr><td></td><td>
Two operators are required to load aircraft or dummy. The First Operator hands the nose of the aircraft to the Second Operator between the grippers.The Second Operator positions himself at the front side grippers, usually one foot on a tire and the other on the launcher frame.

 
Both operators support the aircraft while the First Operator seats both trailing edges against the pusher block and ensures the feet are seated correctly. To accomplish this, the First Operator pushes forward on the left or right gripper while pulling back on the aircraft while the Second Operator keeps the fuselage in line with the fwd hooks. This is performed on both the left and right grippers


2 Once the trailing edges are seated against the pusher blocks, the operators work together to close the grippers.
3 The First Operator pulls back and controls the angle of attack to ensure that fwd hooks on the gripper align with the wing roots. The Second Operator slowly closes the two fwd hooks and helps guide the wing root into the hook.
<u>CAUTION</u>: Do not force the gripper closed with extreme force. If you experience difficulty, check all interface points and start over.
</td></tr>
<tr><td>Pusher block height</td><td>

1 Pusher block overhang gap should not exceed 0.1 inch (~1/4 cm) to wing top skin.
2 When correctly set, Fuselage B will have ~0.1 inch (~1/4 cm) gap, while Fuselage A will have zero gap. (This setting allows changeover with no adjustment; setting Fuselage B to zero gap may not accommodate Fuselage A.) The pusher block overhang gap is adjusted with the lower gripper feet.
</td></tr>
</table>

Basic Launch Procedure	
Loading the aircraft	**(cont.)**
Thrust load – over-center adjustment	1 The **upper** feet control thrust load. Screw **out** (counter-clockwise) for **higher** thrust load; screw **in** (clockwise) for **lower** thrust load. Thrust resistance should be 30-50 lbs. Fuselage A&B may have different thrust loads for identical settings, but both will fall into acceptable range.  **CAUTION: Over-squeeze could result in fuselage damage.** a. Adjust both right and left feet evenly. b. Adjust in half-turn increments, and tighten jam nut after each adjustment.
Prop guard	Install the prop guard after loading the aircraft. 
Cooling system	1 Remove nozzle plug and secure it into the storage bracket.  2 Utilizing the four adjustments as shown, align the airstream into the inlet cowl of the aircraft configuration that is being launched. Make sure all clamps are locked.  

Launch 5

Basic Launch Procedure

Loading the aircraft **(cont.)**

3 Measure the distance from the cooling nozzle to the inlet cowl. The distance must be greater than 1 inch (2.5 cm).

CAUTION: Failure to comply with the preceding step may result in cooling system retraction failure, which could cause aircraft loss.

4 Actuate retraction by hand to verify clearance from launcher grippers and aircraft.

Note: **Once slide position for a particular aircraft configuration is established at the base, mark the position with a permanent marker to return to that position.**

5 Turn the blower on and adjust speed to achieve desired cooling level. The power switch is located at the launcher remote.

Note: **When the blower comes on, the blower speed runs at 100%. To adjust the blower speed, push and hold the + or - button. Blower speed will increase or decrease accordingly.**

Note: **For 28i engine operation in temperate climates with an OAT at or above 20°C, after engine start, use supplemental cooling air to the maximum extent possible.Within the constraints of safe operations, minimize the static period of time on the catapult prior to launch while the engine is operating.**

6 The cooling boom will retract automatically when the launcher safety pin is pulled.

CAUTION: Visually verify that the cooling system is clear of the aircraft path before pulling trigger rope.

WARNING!

The airstream exits the cooling system nozzle at nearly 100 mph and is very loud. Ear protection is recommended when blower is running.

WARNING!

Stay clear of the cooling system arm when extended for cooling. Stand clear of launcher cooling system when armed to avoid being struck when system retracts.

Basic Launch Procedure

Engine run-up

RPM comparison with baseline

Before flying a new aircraft, obtain a baseline wide open throttle (WOT) RPM by performing an engine run-up. Record the baseline WOT RPM. Prior to every flight, conduct an engine run-up and compare the results with the baseline. If the RPM at WOT is 10% less than the baseline, replace the engine module. For example, if the baseline RPM at WOT is 6,800 RPM when the aircraft is new, then 10% of the baseline is 680. Subtract this from the baseline to find that the engine module should be replaced when RPM at WOT is less than 6,120.

Note: A propeller change may reduce the baseline RPM by 2%. For a valid engine health assessment, the outside air temperature (OAT) should be within 20°F (11°C) of the baseline OAT, and the pressure altitude (PA) should be within 500 feet (150 meters) of the baseline PA.

CAUTION: Operating an aircraft with a WOT of 10% less than the baseline RPM may result in loss of the aircraft. Exercise caution when the baseline RPM loss is greater than 5%, especially with a heavy aircraft, high density altitude, and when there is little headwind component over the CAT. Engines with RPM loss greater than 5% have reduced climbing ability.

Charging the cylinder

1 Plug site power into pigtail located at air compressor.

Note: If an extension cord is needed, a 12 AWG extension cord is recommended.

2 With power connected, ensure that rail speedometer is powered on and armed.

WARNING!

Safety pin must be in place before pressurizing the cylinder.

3 Locate release ring at rear of launcher, then locate release/ trigger rope and carefully attach it.

Launch 5

Basic Launch Procedure

Charging the cylinder (cont.)

4 Switch on the air compressor and close the remote valve to pressurize the cylinder.

5 Pressurize the cylinder per the chart posted on your launcher. Launchers vary, as do operating variables. In addition to using your launcher's specific Pressure Chart, use a test dummy to check for operating variables in question.

Note: If cylinder is pressurized to exact pressure and there is a delay before launch, some pressure can bleed off. It may be necessary to depressurize and start over. To avoid this, some operators find it useful to pressurize up to 5 psi above the intended launch pressure. If taking this tactic, just before launch, open valve slightly using the yellow handle to bleed to desired pressure.

Late model ship launchers are equipped with unloaders to allow compressor start-up at any pressure.

Note: This chart is a *SAMPLE*. Be sure to use the current chart posted on the specific launcher model that you use.

***SAMPLE* Launcher Pressure, PSI**

Launcher Speed, m/s	Aircraft Launch Weight					Aircraft Speed, m/s
	12kg	14kg	16kg	18kg	20kg	
20	35	37	40	42	45	18
21	38	40	43	46	49	19
22	41	44	47	50	53	20
23	44	47	50	54	58	21
24	48	51	54	58	62	22
25	52	55	59	63	67	23
26	56	60	64	68	72	24
27	60	65	69	73	77	25

Sample Launcher Pressure, PSI chart

.

CAUTION: Do not exceed a launcher speed of 28 m/s (54 knots) or 80 psi.

6 When pressure is reached, turn off compressor.

You are now ready to start the engine and launch the aircraft or dummy.

Basic Launch Procedure

Launching the aircraft

1 Get go-ahead from ground station.

2 Check and call out "All clear?"

3 Pull safety pin.

4 Count down aloud, "3, 2, 1."

5 Pull trigger rope.

6 Check end speed.

Retrieving the carriage

1 Depressurize cylinder by opening bleed valve.

2 Remove trigger rope from release shackle.

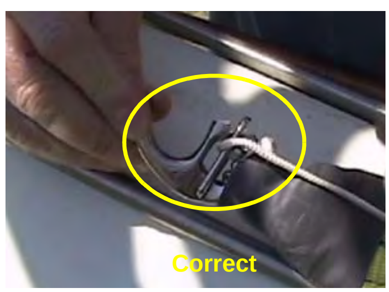
WARNING!

Failure to depressurize cylinder prior to cranking back carriage or releasing the trigger can result in serious injury, death, or equipment damage.

3 Rotate winch handle to reel-out strap. Feed loose end through aft post if necessary.

4 Connect snap-shackle on end of strap, to the carriage pin. Pull the trigger loop to open the hook, and then snap it on.

Note: **Never loop the rope over the hook.**



5 Ensure that the trigger line ring is facing up, and that there are no twists in the strap.

Basic Launch Procedure

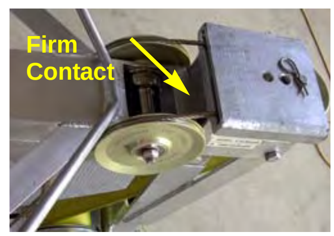
Retrieving the carriage (cont.)

6 Reel in strap, while observing all pulleys and wheels to make sure that they are centered on track and turning freely and centered on track.

WARNING!

Do not allow carriage to roll forward, as the resulting slack cable may lead to derailment.

7 After carriage makes **firm contact** with aft post, continue to turn the crank for two to four clicks. This ensures that the carriage will not creep forward during pressurization.



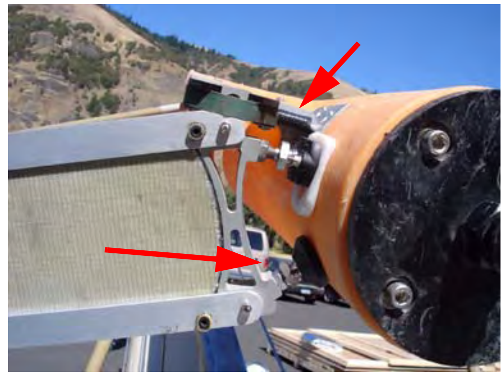
Note: Cable tension will build up slightly as you approach aft post. This is normal.

8 Insert safety pin. Verify that both upper carriage and lower carriage rollers are on track.

Adjusting for aircraft/dummy changeover

1 Aircraft fuselage A&B require no adjustment for changeover when correctly adjusted, (see *Pusher block height adjustment*, earlier in this table).

- Adjust lower feet to approximately 1/2 inch (1-1/4 cm) nominal from hex-to-AL brace. (May need slight adjustments)

Basic Launch Procedure	
Adjusting for aircraft/dummy changeover	**(cont.)**
	2 Dummy launches require an adjustment of the lower feet. **Note: Lower feet should be screwed in completely for dummy launches.**  3 Install edge trim as shown. ▪ Use edge trim when launching dummy with lightweight gripper. (Edge trim for dummies is supplied with all lightweight grippers.)  **Note: Dummy launches should be made, if possible, to check the condition of the launcher and whenever any component is changed. If you can't do a dummy launch, perform a no-load sequence. Whenever operating, the catapult should be exercised prior to launch. This includes pressurizing the cylinder to 20 psi and slowly releasing the strap, easing the carriage forward to the neck of the track.**

5.5 Mobile Operations

In this section:

- Launch

Mobile Operations

Launch

Use the following considerations in regard to mobile launch operations:

- The launch sequence may well require the ground station to maneuver; this is most likely for ensuring a favorable wind at the launcher. Under no condition should the ship be changing heading during launch or approach.
- Communication must be good between all involved parties as the launch is prepped, and throughout the climb-out.
- Dummy launches should be made, if possible, to check the condition of the launcher. If you can't do a dummy launch, perform a no-load sequence.
- If at sea, sea swells may affect the angle of the launch ramp, and hence the launch should be timed so it is at a desirable position (not pointing towards the sea). Certain installations may have a high ramp angle, and with swell, alarms may sound on pitch angle "Nose high," etc. Assuming the reported angles are correct, these alarms should not be taken as critical.
- After launch, the aircraft will go to its pre-defined hold point in preparation for recovery, and orbit until told otherwise. This behavior should be discussed with local authorities and other users of the area to determine acceptability. It is possible some ship captains may want a longer climb-out, followed by an immediate tracking of a nearby flightplan.
- It is a good idea to have a flightplan nearby the launch point, ideally the lost-communication circuit, in the event of problems.

Note: For ship-based launch, if space is limited, use a hold offset to force the aircraft to turn away from the superstructure.

6

Note: **This chapter contains procedures that may be more difficult than other system procedures. For assistance, contact Insitu's Operations Support Group:**

- **Inside the U.S.: 866-637-4691**
- **Outside the U.S.: 509-637-4691**

Flight

6.1 Guidelines

In this section:

- Speed – Aircraft speed guidelines
- Altitude – Operating altitude
- Video manipulation

Flight is controlled by Insitu's Multiple UAV Software Environment (I-MUSE). I-MUSE provides an intuitive and graphics-based tool for route planning, monitoring, and operation. In general use, the term I-MUSE often refers to the I-MUSE client software. I-MUSE may run in full-control mode in GCS and simulators, or in the read-only mode for monitoring and use in network clients. I-MUSE runs under Microsoft Windows XP using the .NET framework.

Map Control icons: Once you have connected to a server and at least one aircraft (as described in Chapter 3, *Setup*), several icons appear in the Map Control area. These icons provide information about the aircraft and its route.

Toolbar and context menus provide many of the commands you can issue to an aircraft.

Context menus: There are various context menus that can be brought up by right-clicking on the Map Control area or some of the icons represented on it.

Guidelines	
Speed – Aircraft speed guidelines	
Maximum level speed	▪ Maximum speed that the operator can command is set by a minimum usable C_L – the corresponding speed hence depends upon altitude and weight, but is generally around 40 m/s (77 knots) at lower altitudes. ▪ Exercise caution when operating at higher speeds, mostly due to a finite engine power available to the aircraft. There is a point where wide open throttle will not provide the power required to maintain altitude, and as the autopilot controls speed via pitch control, the aircraft will descend to maintain the commanded speed. The point at which the ability to maintain altitude is lost varies, and depends upon local conditions, gross weight, and altitude. ▪ As a rule, the higher the gross weight, the lower the speed at which the aircraft will start to lose altitude. Although the operator should be wary of such altitude loss, close observation is not required up to approximately 38 m/s (74 knots). ▪ Setting an appropriate lower altitude alarm limit can help to catch the onset of altitude loss. A typical value might be about 40 m (~130 feet) lower than the commanded altitude. ▪ It is important to note that high speeds dramatically reduce the endurance capabilities of the aircraft, and operational performance is likely affected at high speed. These factors include camera performance and noise signature. **Note: For 28i engine operation in temperate climates with an OAT at or above 20°C, follow these additional procedures:** **1 After launch and when sufficient altitude exists, incrementally increase climb-out airspeed 5 to 15 knots in order to provide additional cooling airflow.** **2 During climb-out, closely monitor CHT and command intermediate level-offs (step-climb) as necessary to maintain the CHT below 150°C.** **3 In-flight operations should be conducted so as to avoid prolonged operations with high RPM and or CHT nearing the caution range limits. If possible, maintain the RPM below 6,000 and CHT within the 120-140°C optimal ranges.** **4 Adjust dash TAS as necessary while transiting between target areas.** **5 Adjust loiter TAS to ensure sufficient cooling air flow exists to maintain CHT and RPM within optimal operating ranges.** **Factors such as obstacles and terrain avoidance should always be considered when adjusting aircraft performance parameters for optimal engine ranges. If required to maintain safety-of-flight, do not hesitate to utilize published engine operating limitations.** **WARNING!** **Operating temperature limits should be constantly monitored and not exceeded. CHT readings above published limits require immediate operator intervention.**

Guidelines	
Speed – Aircraft speed guidelines	
Never-exceed maximum allowed speed	▪ While in normal operation, altitude hold though elevator feedback is not enabled; but upon enabling the feedback, speed control is not as tight (as the aircraft will change pitch attitude to hold altitude). ▪ Commanded TAS is displayed in green (as in approach mode), and there will be speed transients as the aircraft holds altitude tightly. If at a high speed, the transients can be higher than the maximum allowed speed command, possibly by 4 or 5 m/s (7.8 or 9.7 knots) depending upon local conditions. ▪ The autopilot normally limits the load factor to six, which limits turns and aerobatics at high speed to avoid stressing the airframe. ▪ Dynamic pressure increases with the velocity squared. This means small increases have a large effect at higher speeds. The wing and winglet servos only have a certain amount of torque available to deflect the surfaces. Hinge moments may exceed this limit in an over-speed condition. For example, in a high speed pull-up, the required amount of surface deflection might not be reached, due to the dynamic pressure at that speed. This is one example of how aircraft components (such as servos) are iteratively selected for performance, size, and power draw to match the operating envelope.
Normal stall speed (flaps neutral/wings level)	▪ UAV stall speed generally occurs when the wing can no longer create enough lift to sustain equilibrium in flight. Although stalls can occur at any speed and any attitude, UAV operators generally are concerned with flight at minimum speed. Stall speed goes up with gross weight or bank angle. Generally pilots want to fly with a margin above stall speed to take into account wind gusts or the need to maneuver. The software system is designed to provide such a margin when used normally. However, there are advanced settings that can change this margin. Use caution before making such changes.
Operating speed	▪ For maximum endurance, operating speed should be minimum speed. Operationally, it is good to loiter at a speed slightly higher than this to provide some extra margin for gusts, etc. A typical mission might transit at high speed, but then slow to loiter once in the target area. ▪ Speed commands should be done in small increments, to avoid attitude transients. A general rule is to step speeds by 2-3 m/s (~4-6 knots) at a time. ▪ The takeoff sequence will occur automatically at minimum speed, and once complete, the operator can proceed safely with any speed changes. It is not advisable to change speed during the takeoff and climb-out sequence, as a higher speed will result in a slower climb rate, (this rule is valid for all flight conditions). ▪ Before initiating an approach, it is advisable to bring speed close to the expected autopilot-selected approach speed. This varies with weight and local conditions (for example wind speed), but a large difference in speeds at this point may result in a sharp pitch motion. Normal approach speeds vary, but are in the 23-26 m/s (~ 45-50 knots) range.

Guidelines	
Speed – Aircraft speed guidelines	
Software-limited minimum speed	▪ The minimum speed that the operator can command is set somewhat above the estimated stall speed in order to leave a margin for flight in gusty air and for maneuvering. ▪ The ground station can properly enforce the minimum-speed limit only if it has accurate values for weight and altitude. These are normally estimated continuously by the flight computer and passed periodically to the ground. However the estimates can go awry; for example, due to improper initialization of the aircraft weight, a reset of the flight computer, or incomplete reporting of the flight-computer state when a new ground station assumes control.
Altitude – Operating altitude	
Normal operation	▪ The telemetry and video streams need a line of sight link. The further away the operating area, the higher one might have to fly to maintain this communication. This limit disappears with the switch to satellite communications, but the data link is of a low bandwidth, which means video may not be feasible, and only periodic reports from the aircraft are possible. This does not lend itself to ISR missions using the video system, hence line of sight is important to maintain. ▪ It is important to consider the local area terrain and control station antenna location before attempting any operation at low altitudes.
Battlefield environment	▪ In a battlefield environment, it is advisable to fly above the reach of small arms fire, which is around 800 m AGL or 2,625 feet AGL. ▪ The noise signature of the aircraft depends on muffler configuration, speed flown, and indirectly, weight (which affects power required). The ability to discern the aircraft on the ground depends on these aircraft parameters, plus local temperature, wind, and background noise. ▪ With a muffler, lower altitudes are more achievable than with a straight exhaust pipe. The behavior is fairly subjective, but experience suggests that 500 m or 1,640 feet AGL will be fairly stealthy at loiter speeds.
Emergencies	▪ The higher you fly, the more time is available to handle an emergency situation, should one arise. One should remember that the glide-slope for an average aircraft is around 12-13 to 1 with the engine stopped; a failure some distance from home at low altitudes (outside this gliding range) might prevent a runway recovery. Use the time available to find a safe landing area, in the appropriate order of priority as specified in *Emergency Procedures*, later in this chapter.

Guidelines	
Video manipulation	
Note: **Video feeds from aircraft. It is viewed and controlled in both I-MUSE and ObjectTracker. For additional I-MUSE and ObjectTracker information, see related topics later in this chapter.**	
Camera	The camera turret is locked for launch and storage. Unlock the camera in flight using the **Camera Turret Settings** panel in I-MUSE. The lock/unlock button is treated like any other mode in I-MUSE. To manually lock the camera on the ground, refer to the *Maintenance Handbook*. **EO** The Alticam XXX-780 has an IR light filter in place. Remove and reinsert the filter using **night vision** in I-MUSE (**filter IR** in Groundbase). Night vision mode lets in more light, and has been found very useful in low-light situations. **IR** Operation of the Alticam 600-6000 IR Camera Turret is very similar to operation of the Alticam 600 EO Camera Turret. The Alticam 600-6000 provides remote manual focus capabilities designed to operate with I-MUSE 5.1 and later, and corresponding Helmsman and ObjectTracker software. For systems equipped with this payload, a turret control panel in I-MUSE controls brightness, contrast, polarity, zoom, and focus. Images are rendered such that the hottest and coldest parts of the target appear in black and white, and temperatures between the extremes appear in relative scales of gray.  **Note:** **Older cameras cannot be focused during flight. For focus problems with such cameras, refer to the *Maintenance Handbook.***

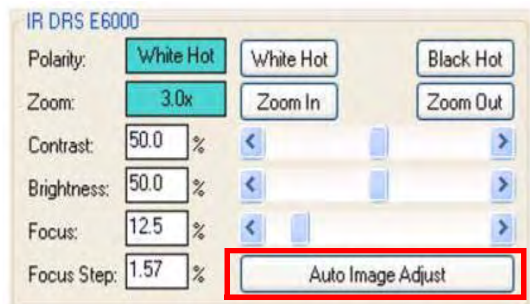
Guidelines

Video manipulation (cont.)

Camera (cont.)

Auto Image Adjust commands the camera to perform a one-point calibration to balance contrast and brightness, usually creating the optimal image. Engaging this button performs both a flat-field correction and an auto-gain correction, resetting the grayscale of the image. It prevents the image from getting washed out, and often fixes any lines or bad pixels in the image. During the adjustment, the camera lens closes for approximately one second. ObjectTracker will lose its lock when the lens closes.

Note: Use the left hat to focus the Alticam 600-6000 camera with the ObjectTracker joystick. For joystick functions, refer to the DRS 6000 functions in the *ObjectTracker Quick Reference Card,* later in this chapter.



Use the OT Joystick or the I-MUSE Turret Panel to perform auto image adjust and manual focus.

Auto Image Adjust automatically sets the contrast and brightness to optimize the grayscale of the dominant part of the image frame, resulting in a generically good image. However, targets are not always visually dominant, and may require manual adjustments to contrast and brightness. While this is capable of revealing details on a small part of the image, the cost is to the rest of the image.

CAUTION: Improved imagery using manual contrast and brightness controls is difficult to achieve and risks degrading imagery. Do not adjust contrast or brightness unless you are experienced with the IR camera.

Once adjusted from the default setting, manually adjusted contrast and brightness settings persist, even after an auto image adjustment. When switching targets, always recenter contrast and brightness display offsets to mid-range. Failure to do so may result in washed out or dark images, and may make it appear as if the camera or auto image adjust feature is not working.

Guidelines

Video manipulation **(cont.)**

<table>
<tr>
<td>Camera (cont.)</td>
<td>
Operation
If the IR image is inadequate, cycle through these steps until the image achieved is adequate:

Click on Auto Image Adjust.
Recenter contrast and brightness display offsets to mid-range, then click on Auto Image Adjust.
Slowly adjust the focus through its entire range and set to the best point.
Reset the camera.
Reset the turret.

</td>
<td>
Important!

Because the camera lens closes for approximately one second, do not use the Auto Image Adjust feature when tracking a hard-to-follow target.
Do not overuse the manual focus. This feature can bring the IR image into approximate focus, but will not achieve the same image sharpness as seen with the EO cameras. Continual adjustments to improve focus after an adequate image has been obtained have been known to result in inadequate focus. Stop adjusting when adequate focus is achieved.

Operation Summary

Engage the Auto Image Adjust feature approximately once per minute.
Manually focus the camera once per target.
Always use Auto Image Adjust before adjusting contrast and brightness.
Reset contrast and brightness to 50% before changing targets.

</td>
</tr>
</table>

Guidelines	
Video manipulation	**(cont.)**
Camera (cont.)	**Operation** ❑ **During pre-flight** – Check turret health, center gimbal angles, and center gyro bias. Changing gyro bias in flight is not recommended. ❑ **Immediately before launch** – Lock the turret. (This step is included in the I-MUSE checklist.) ❑ **Immediately before capture** – Lock turret. ❑ **While not in use** – Keep turret locked for transit. With power on, the lock function performs four actions: ▪ Engages the mechanical lock mechanism. ▪ Drives outer tilt stage motor up, against its stop. ▪ Rotates outer pan stage and align camera so that it is positioned forward and the camera points up and to the right. ▪ Zooms the camera to 18x. All four actions are required to protect the camera for launch. With power off, only the mechanical lock is engaged. **Turret Micro-vibration** Operators have occasionally reported that the camera will not focus at high zoom (>12x). This condition is not a camera focus problem; it is a very small amplitude vibration of the turret made visible by the elimination of larger amplitude vibrations. This problem is only present at low shutter speeds (<250) at certain engine speeds. To avoid this problem, do not operate the camera turret at low shutter speeds (<250) with high zooms (>12x). If this is not possible, increase engine speed to above 6,000 RPM or decrease engine speed to below 4,000 RPM. **Turret Hold vs. Stabilized Mode** The performance of Hold mode and Stabilized mode is similar with the new camera turret. Most operators prefer Hold, but some prefer Stabilized

Guidelines	
Video manipulation	**(cont.)**
Camera (cont.)	**Turret gyro bias adjustment** The turret has gyros used for inertial stabilization. These sensitive instruments often develop a small amount of bias, which results in a turret that drifts or moves with jerks when in the inertially stabilized steering mode, hold mode, and stabilized mode. After several hours of flight, the bias of the gyros may change. Adjust the turret's gyro biases after: ▪ All turret resets – not camera resets. ▪ Any power loss to the turret, because the gyro bias adjustments were lost. The setting of the biases is done with the joystick hat switch or with the keyboard commands (see *ObjectTracker – Quick Reference Card*). **Note: The gyro bias of the IR cameras needs adjustment less often than EO cameras because the IR cameras have a set zoom at 3x, and cannot be adjusted with as much precision as EO cameras.** Set the gyro biases when the turret is stationary. If necessary, it is possible to adjust the gyro biases in flight, but the results will be less accurate. **On the ground** 1 Zoom out fully. 2 Place the turret into stabilized mode. 3 Look for any perceived drift of land features, and bump the joystick hat switch in the direction of the drift (see *ObjectTracker – Quick Reference Card*). 4 Zoom in several steps. 5 Repeat from step 3 until optical zoom is reached or drift has reduced as much as possible. **In flight** 1 To minimize the effect of aircraft motion on screen motion, fly the aircraft straight and level, and point the turret straight ahead at the horizon. **Note: If the turret is not pointed straight ahead, sideways video drift caused by aircraft motion will be visible, even when looking at the horizon.** 2 Zoom out fully. 3 Place the turret into stabilized mode. 4 Look for any perceived drift of the land features, and bump the joystick hat switch in the direction of the drift (see *ObjectTracker – Quick Reference Card*). **Note: Use the horizon – not the aircraft body – to zero out the drift. In stabilized mode, the horizon should appear stable while compensating for aircraft attitude.** 5 Zoom in several steps. 6 Repeat from step 4 until maximum optical zoom is reached or drift is reduced as much as possible.

Guidelines

Video manipulation (cont.)

Camera (cont.)

DRS E3500 Camera Specifications	
Lens	25 m focal length
FOV	~18°
Range in total darkness	<1,000 feet (300 m) for optimal images.

Overview

The DRS E3500 camera is capable of identifying cars and trucks, and detecting and tracking the movement of individuals, in total darkness. The DRS E3500 camera cannot be focused during flight. It is a fixed-focus model with one field of view. The turret and camera assembly must be removed from the camera bay in order to focus the camera.

Note: When a long range focal point is not available, such as with ship-based deployments, focus camera at objects at least 100 feet (30 meters) away or more. Focus through the opaque IR payload bay window is not required. Focus the camera at the estimated temperature of the mission. A temperature change of 10° F (-12° C) will cause the camera to lose some focus.

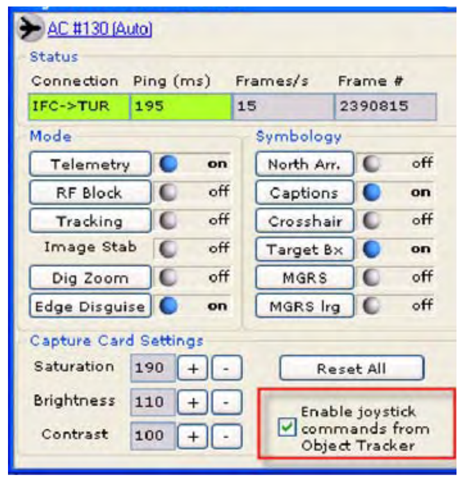
For detailed procedures on focusing the camera, refer to the Maintenance Handbook.

Focus problems during flight

Reports of focus problems during a flight can be due to many factors, most of which are hard to reliably duplicate on the ground. Operational missions have found that adjusting altitude of the aircraft is an effective method of changing OAT and increasing camera focus. Evaluate the IR image after launch, before proceeding. Extreme changes in temperature and humidity at altitude can change the effective focus, and moisture or condensation on the window would likewise cause image degradation.

CAUTION: Do not aim the camera at the sun; damage to the camera sensor can occur.

Guidelines	
Video manipulation	**(cont.)**
I-MUSE	Video can be viewed and configured in I-MUSE by selecting **Video Sources** from the **Video** menu on the I-MUSE toolbar. This menu will have options for each video input that is currently available. To control the turret from I-MUSE there are several options: ▪ To enable camera control by mouse, click in the **Video** panel in I-MUSE. The camera will move corresponding to the direction the mouse is clicked. ▪ Use **Camera Turret Settings** to control the turret. To open this panel, select **Camera Turret Settings** from the **Panel** menu on the I-MUSE toolbar.
ObjectTracker	Camera and turret are generally controlled through ObjectTracker. Some ObjectTracker joystick commands are enabled through a connection to I-MUSE, including **Snapshots** and **Orbit** commands to the UAV, which must be enabled in the GCS I-MUSE client. To enable ObjectTracker commands, open **ObjectTracker Status** panel by selecting **ObjectTracker Status** from the **Panel** menu on the I-MUSE toolbar and enable the checkbox in the lower right corner. Disable ObjectTracker commands in all other connected I-MUSE clients. For more information about ObjectTracker, see *I-MUSE Reference* documentation in the online **Help**.



Guidelines	
Video manipulation	**(cont.)**
ROVER Avionics	The ROVER-Compatible L-Band Avionics unit (ROVER Avionics) allows transmission of video for viewing on a ROVER-III ground receiver. The ROVER Avionics transmits unstabilized video with no overlays over an analog L-band wireless link. The range of this system is 10 km within line of sight. The ROVER Avionics is based on the standard ScanEagle avionics, with the addition of an expansion board in the avionics expansion slot, an L-band transmitter assembly mounted to a heat sink on the bottom of the avionics bay, and a blade antenna mounted to the bottom of the avionics bay. **Operation** ROVER Avionics has one controllable input: on/off. Use the **L-Band** button in the Video Transmit Power section of the Camera/Turret Settings Panel in I-MUSE to toggle between on and off.  **Note: The transmitter takes 15 seconds to power on after confirming the setting change in I-MUSE.** **Viewing Video** To view the video over the ROVER Avionics L-band link, use an L-band receiver, such as the ROVER-III ground receiver. The Insitu GCS does not currently include a capability to view L-band video. **Troubleshooting** In case of GPS dropouts, turn off the L-band transmitter. It is possible, although unlikely, that transmitters can amplify spurious signals in the air and cause interference with the GPS receiver.

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6.2 I-MUSE

In this section:

- Operations overview
- Autopilot controls
- Coordinate control
- Icons
- Menu – Context menu
- System monitoring – Master Caution
- Toolbar

I-MUSE	
Operations overview	
Uses	I-MUSE software suite is used in these areas: ▪ Ground Control Stations (GCS) ▪ Forward Ground Control Station (FGCS) ▪ Forward Eyes ▪ Network Ground Stations ▪ S-VEST ▪ Standalone Flight Simulation ▪ Hardware-in-the-Loop (HiL) Simulators
Components	I-MUSE software suite consists of these components: ▪ I-MUSE client - main interface, connects to I-MUSE servers to view or control multiple GCS and multiple aircraft. ▪ I-MUSE server - software that runs on a GCS or simulator computer to allow multiple I-MUSE clients to connect. ▪ Groundbase - engineering layer software that runs paired with each I-MUSE server for real-time communication with If/C or aircraft. ▪ FlightSim - simulation software that replaces Groundbase in a standalone FlightSim configuration or runs on a simulation computer in an HiL.
Checklists	Checklists and procedures are essential when controlling the aircraft and GCS. By reducing a task to sequential steps, operators work in a safe, efficient, and consistent manner. The **Checklists and Procedures** panel provides a way to start, organize, and complete specific checklists and procedures in I-MUSE. Checklists currently implemented in I-MUSE are: ▪ Systems Check ▪ Takeoff ▪ Systems Check and Takeoff ▪ Auto-Retrieval The **Checklists and Procedures** panel reduces complexity and operator workload by presenting each step of a checklist or procedure, and the knowledge and means required to complete it. If a step requires a specific user interaction, you will be told what needs to be done and presented with the necessary user interface elements. This addresses the two largest issues when operating complex systems: knowing what to do and how to do it. For more information about I-MUSE Checklists and Procedures, see *I-MUSE Reference* documentation in the online **Help**.

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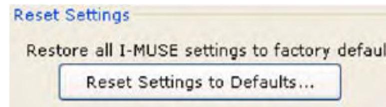
<table>
<tr><th colspan="2">I-MUSE</th></tr>
<tr><td>Trouble-shooting</td><td>
I-MUSE includes a button that resets all I-MUSE settings to factory defaults. It is located on the General Settings tab; select Settings from the File menu on the I-MUSE toolbar. Use this feature when:



I-MUSE is in an undesirable state that you are unsure how to remedy. For example, the predefined work spaces or plots have been modified and you wish to restore them to their original form.
I-MUSE is inoperable due to repeated error conditions. This usually manifests itself as a dialog box explaining that I-MUSE has encountered an error. The reset feature restores I-MUSE to an operable state.

For more information about resets, see I-MUSE Reference documentation in the online Help.
</td></tr>
<tr><td>User interface</td><td>
Coordinate Controls

Coordinate Controls are a common user interface element in I-MUSE. They display and specify locations in both earth-fixed and relative formats, in a variety of units. Regardless of where they are found, Coordinate Controls are generally configured in the same way. For additional Coordinate Control information, see that topic later in this table.

MapPacks

MapPacks collect and organize reference imagery, piloting charts, and digital terrain elevation data into convenient packages with user-defined names and descriptions. They are an essential component to flight and mission planning. All MapPacks that could potentially be used over the course of a mission should be prepared ahead of time for easy switching mid-flight. Multi-gigabyte map packs may slow system performance. It is recommended to split large data sets into smaller chunks, utilizing the capability to switch MapPacks while in flight.

Digital terrain elevation data is used to provide feedback on elevation safety while planning routes and orbits and to derive accurate geo-location information. Operating without DTED may elevate flight and mission risks.

In most cases, digital map data is provided by the operational customer. A standard operating set would include the following:

Level 1 DTED for entire operating area
CADRG charts (particularly 1:250 JOG) for route planning
1 m CIB or other reference imagery (up to 5 m is useful)

For more information, see MapPacks, later in this section; see also I-MUSE Reference documentation in the online Help.

System monitoring: Master Caution

Master Caution is affected by the most severe condition assigned to a subsystem in I-MUSE alarms. Master Caution is reflected in:

Color of aircraft icon on:

I-MUSE map.
Connected Aircraft Status Display (top-right-corner).

Color of tabs at top System Monitor.

For more information, see System monitoring – Master Caution, later in this section.
</td></tr>
</table>

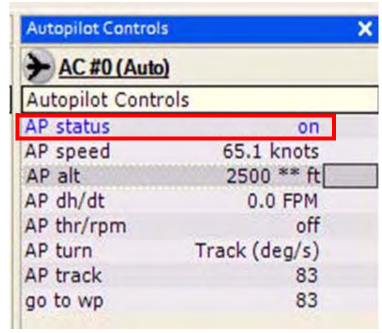
I-MUSE

Autopilot controls

AP status

Parameter

Global autopilot status.



What it Shows

- OFF — Autopilot OFF, control surfaces under pilot's console control
- ON — AC Autopilot ON
- SAFE g — Autopilot ON, commanded to SAFE settings from ground

Automatic Software Function

- SAFE a — Autopilot ON, SAFE commanded by aircraft (often means uplink failure) OR from other groundstation

Entries Accepted

Enter **ON** to turn autopilot on from **SAFE** mode.

Note: **If pilot's console switch is enabled and <u>OFF</u> the AP will switch back off, this is the usual case on the ground.**

Enter **SAFE** to command safe settings when AP is **ON** or **OFF**.

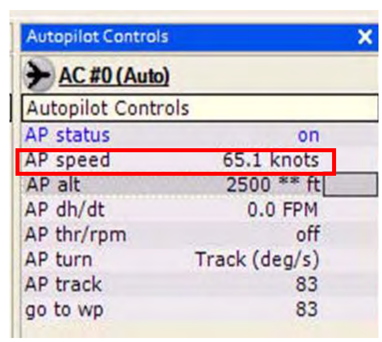
Note: **To go from <u>OFF</u> to <u>ON</u>, use the pilot's console switch, or enter <u>safe</u> then <u>on</u>.**

Further Explanation

If aircraft loses uplink, it will automatically fly at **SAFE** settings.

AP speed

<u>CAUTION</u>: Increment airspeed in five-knot steps, not large margins.



Parameter

Autopilot airspeed controller input and status.

What it Shows

- OFF — Elevator set by pilot's console (not recommended)
- 65.1 kts — Autopilot controlls aircraft to achieve commanded airspeed

Entries Accepted

Enter an airspeed in currently displayed units to command that airspeed.

Entry will only be accepted between min and max TAS.

I-MUSE

Autopilot controls (cont.)

AP speed (cont.)

Further Explanation

The autopilot is airspeed-centric; all other values, including altitude, will be sacrificed to achieve the commanded airspeed.

When commanding maximum speed, aircraft may not be able to hold commanded altitude.

- **Min TAS** is usually approximately 45 knots.
- **Max TAS** is usually approximately 75 knots.

To calculate speed for **Max Range**, use the **Speed Opt** field.

Speed for shortest time en route is maximum speed for level flight.

Minimum airspeed command results in:

- Max endurance.
- Best climb rate.
- Best glide (in case of engine failure).

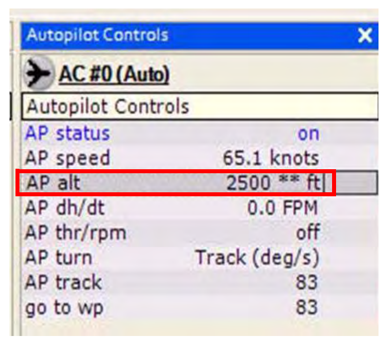
Commanding greater airspeed briefly causes the aircraft to nose down and lose altitude.

Commanding lesser airspeed briefly causes the aircraft to nose up and gain altitude.

AP alt

Parameter

Autopilot altitude controller status.



What it Shows

OFF	Altitude-hold off
1500 fp	Holding waypoint (flightplan) altitude
1500 **	Holding altitude shown, overriding waypoint altitude
cyc	Climb/descent altitude cycling

Automatic Software Function

Entries Accepted

Enter an altitude to set commanded altitude:

- When orbiting, the setting is used for the current and future orbits.
- When tracking a route, the setting is used until the next waypoint becomes active and supersedes this value.

CAUTION: Do not enter OFF. This will turn off the altitude controller. To recover, enter an altitude. Enter fp to return the controller to tracking waypoint (flight plan) altitude.

I-MUSE

Autopilot controls (cont.)

AP alt (cont.)

Further Explanation

Altitude cycling is not used in normal operations.

Directing the AC to a waypoint or segment removes any overrides and immediately causes the AC to climb or descend to the altitude of the waypoint to which the AC is tracking.

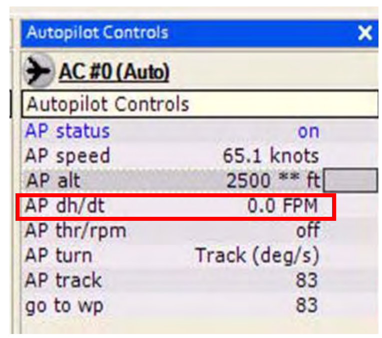
Turning on climb/descent rate controller causes altitude controller to turn off.

Commanding a **Throttle/RPM Hold** causes the altitude controller to turn off.

AP dh/dt

Parameter

Altitude-rate controller status.



What it Shows

- OFF — Altitude rate controller off
- 0.0 — Holding altitude
- 100 fpm — Engine regulated for climb rate 100 fpm
- CWS — Climb-rate target set by pilot's console throttle input

Entries Accepted

to command climb/descent rate, enter a number in units indicated.

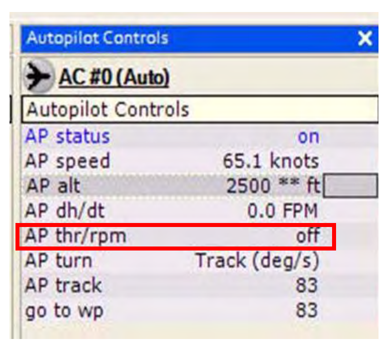
To level off, enter **0**; to hold that altitude, enter **altitude hold**.

To enter climb-rate CWS (not common), enter **CWS**.

To cancel CWS, enter **0**.

AP thr/rpm

CAUTION: Any input turns off automatic altitude maintenance.



Parameter

Autopilot throttle/RPM controller status.

What it Shows

- OFF — Throttle control by autopilot altitude controller OR pilot's console (if AP alt and AP dh/dt controllers are off)
- KILL — Zero RPM commanded
- 0.36 — Throttle area fraction – set by entry or by aircraft
- 3800 rpm — RPM target: set by entry

Automatic Software Function

I-MUSE

Autopilot controls (cont.)

AP thr/rpm (cont.)

Entries Accepted

Entry in this field turns on throttle control or RPM control and turns off altitude control.

To command min throttle, enter **0**. AC responds with actual min throttle fraction.

To command max throttle, enter **1**. AC responds with actual max throttle fraction.

To command more than min throttle, but less than max throttle, enter a fraction representing desired percentage of max throttle.

To command RPM Controller hold, enter a value between min and max RPM limits.

Further Explanation

Until reaching min alt, it is normal for AC to be in **Throttle hold** at **max throttle** during **climbout**. It will also hold min throttle during **procedure turn**.

In approach, throttle commands are accepted but may be quickly overridden by the approach sequencer.

During all other phases of flight, it is abnormal to be in throttle/RPM hold and an alarm will show.

Commanding **max throttle** causes the aircraft to gain altitude.

Commanding **min throttle** causes AC to lose altitude (depending on winds).

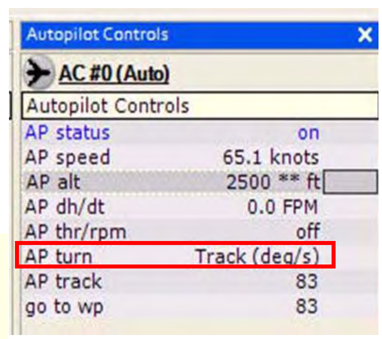
To achieve lower RPM, vary the **min throttle limit** as needed.

CAUTION: Be careful not to go so low that the engine quits.

AP turn

Automatic Software Function

CAUTION: Any input will turn off track.



Parameter

Autopilot turn-rate controller status.

What it Shows

- track — Aircraft is tracking a route, adjusting for winds as needed
- orbit — Aircraft is tracking an orbit, adjusting for winds as needed
- appr — Aircraft is tracking approach
- 0 — Zero turn rate commanded
- # deg/s — Turn rate controller holding a turn at indicated value in indicated units.
- CWS — CWS Turn mode active. Turn-rate target set by pilot's console aileron input.
- OFF — Aileron/rudder set directly by pilot's console
- raster — Raster search (not common)
- square — Square search (not common)
- payld — Payload guidance (not common)

<table>
<tr><th colspan="2">I-MUSE</th></tr>
<tr><th colspan="2">Autopilot controls (cont.)</th></tr>
<tr><td>AP turn (cont.)</td><td>Entries Accepted

When a turn rate is commanded, the aircraft attempts to hold that turn rate and does not adjust for winds.

To command straight and level, enter 0.

To command a tight radius turn, enter 12 (deg/sec). To command a wider turn radius, enter a smaller number. Commands greater than the maximum are truncated automatically.

Positive entries turn right; negative entry turns left.

To achieve a desired heading, alternate entry of a turn rate and 0 until desired heading is achieved.

To control aircraft turn rate with the pilot's console aileron input (emergency procedure), enter CWS.

To cancel CWS then command waypoint or orbit, enter 0.

Note: To command aileron/rudder directly with the pilot's console, enter OFF. To recover, enter 0.

CAUTION: This is dangerous and is not an approved operating procedure.

Further Explanation

Controlling turn rate is an alternative to tracking. Any input will turn off track. When a turn rate has been commanded, the estimated aircraft track will be displayed as a Map overlay. Note that this is a best estimate of the track which will be followed and not necessarily the actual track. Winds aloft are considered in the estimate.

If the turn rate command is zero, the track indicated will be a straight line.

Note: Zero turn rate generally results in straight ahead flight with wings level; however, this is not guaranteed. Zero turn rate is actually zero yaw rate. Winds or AC damage may yield other attitudes or flight paths.

If the turn rate command is a positive or negative number, the track indicated will be a curve.

If there are winds aloft, they will be accounted for in the estimate.

Raster and Square search modes are not used in normal operations. To recover from accidental activation, command a turn rate or waypoint.</td></tr>
</table>

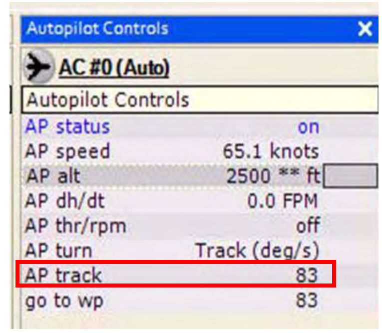
I-MUSE

Autopilot controls (cont.)

AP track

Parameter

Tracker status.



What it Shows

- OFF — Tracker off
- # — Tracking on, tracking segment leading to waypoint number displayed
- # pndg — Tracking suspended pending new navigational data or sufficient altitude
- CWT — Control wheel tracking mode active
- appr — Approach

Automatic Software Function

Entries Accepted

Enter a waypoint number to track to that waypoint. Only valid waypoints are accepted.

To turn on control wheel tracking, enter **CWT**.

To cancel CWT, enter **ON** or enter a waypoint.

Further Explanation

To enable the tracker, make an entry into this field or into the AP track field.

To track to (rather than go direct to) a waypoint, make an entry into this field.

See also *Go to wp* later in this section.

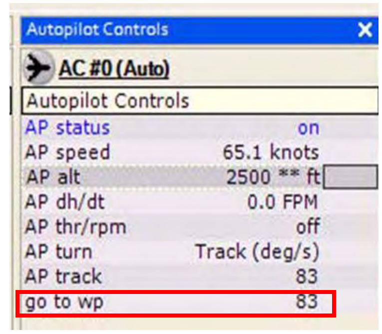
I-MUSE

Autopilot controls (cont.)

Go to wp

Parameter

Go to waypoint.



What it Shows

Waypoint currently being tracked (if the tracker is enabled).

Value/ Example	Range	Meaning
94	0-99	If AP track is **ON**: ▪ Aircraft is currently tracking to this waypoint. If AP track is **OFF**: ▪ This is the waypoint that would be tracked if AP track were on.

Entries Accepted

Enter a waypoint number to go direct to that waypoint.

Further Explanation

To enable the tracker, make an entry into this field or into the **AP track** field.

To go direct to a waypoint (rather than track to a waypoint), make an entry into this field.

See also *AP track* earlier in this section.

I-MUSE

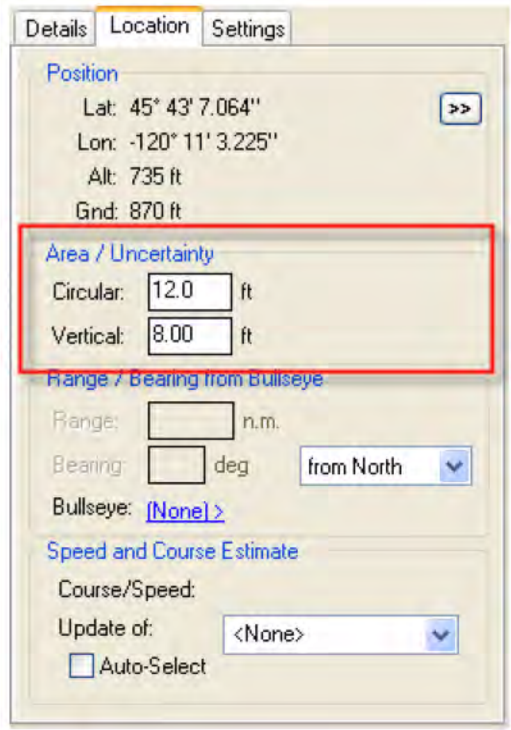
Coordinate controls

Location tab

The **Location** tab provides an interface for viewing or editing location values directly with the keyboard, and includes circular and vertical error probability fields.

Targets can be assigned both a circular and a vertical error probability. Circular defines a radius around a given target location. Vertical defines a distance above or below the target.

If the Circular property is non-zero, it will be displayed on the I-MUSE map as a circle around the target. This circle is only displayed for the currently selected target.



When a new target is marked in I-MUSE, both Circular and Vertical properties are set to zero. If a target is marked via Object Tracker, Object Tracker will calculate and send the circular error probability value associated with the target location. When the target is displayed in I-MUSE, it will then contain CEP values that were calculated by ObjectTracker.

Cursor-on-Target supports circular and vertical error properties. If a target received via CoT contains valid values for either of these properties, when the target is displayed in I-Muse it will have the associated Circular and Vertical properties set.

Relative tab

The **Relative** tab provides an interface for viewing or editing location values relative to a specific object that has been identified as the bullseye.

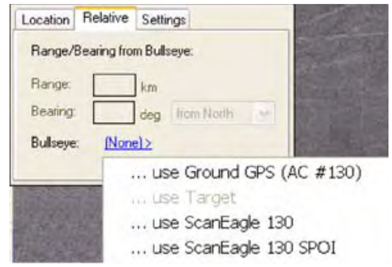
I-MUSE

Coordinate controls (cont.)

Setting the bullseye

To set the bullseye from a Coordinate Control in I-MUSE:

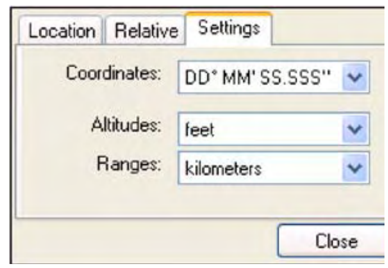
- Click on the link in the **Bullseye:** field. This may be the current bullseye or it may be (None)>.
- Select the desired bullseye from the menu.



Settings tab

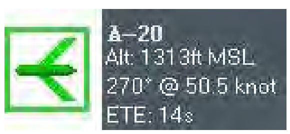
The **Settings** tab provides an interface for configuring units in the Coordinate Control.

Settings changes to any Coordinate Control affect the settings of all Coordinate Controls.



Icons

Aircraft

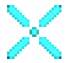
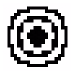


Represented by green, plane-shaped icons, Aircraft are accompanied by a label detailing the aircraft's identification number, altitude, velocity, and estimated time of arrival to the next waypoint or orbit center.

A green square around the aircraft indicates that it has a DGPS solution with good uncertainty and satellite lock times are good.

A yellow square around the aircraft indicates that it does not have a DGPS solution. It does have a GPS solution, giving the aircraft a valid world position.

A red square around the aircraft indicates it that has no DGPS or GPS solution and its location on the map is only an estimate.

I-MUSE	
Icons	**(cont.)**
Blue Force Tracks 	For situational awareness, friendly aircraft and moving ground transport are represented by a blue X.
Breadcrumbs 	When the option for creating breadcrumbs is enabled by the main I-MUSE session, the aircraft leaves a breadcrumb trail of green dots as it flies, showing its actual flight path rather than the theoretical dot-to-dot path laid out by the waypoints and tracks.
Bullsey 	The bullseye is a point of reference that is set in order to gather range and bearing information to a selected target.
Coordinate Hold 	The four blue arrows denote the point at which the payload should be pointed when **Coordinate Hold** is activated. When activated, the target green square of the **SPOI** should be centered upon these arrows.
Engine kill perimeter 	The large, yellow square with the dashed outline indicates the engine kill perimeter. If the aircraft is outside the engine kill perimeter and it loses communication with its Ground Control Station, the engine ignition will be cut by the on-board ScanEagle software (after a predefined time-out period) for safety purposes.
GPS uncertainty 	The color and size of the breadcrumbs drawn behind the Aircraft icon on the Forward Eyes map is an indication of the status of the aircraft GPS when the breadcrumb was dropped. This allows for analysis of behavior that may be contributing to GPS problems.
Ground station 	The blue triangular icon represents where the GCS is located.
Sensor coverage area 	If the **Video Outline** option is set to on, a large quadrilateral composed of green, dashed lines represents the area that a payload covers, taking into account the aircraft's altitude, the angle of the payload's aim, and the operating parameters of the payload. For instance, if the aircraft is carrying a camera, the quadrilateral represents the boundaries of the video feed the camera is able to pick up. As the aircraft moves, the shape and size of the quadrilateral may change depending on the factors listed above.
SPOI - Sensor point of interest 	When the **Show Video Center** option is set to ON, the SPOI (a green target square) represents the point at which the aircraft's payload is directed, accompanied by the identifying number of the aircraft associated with the payload. For instance, if the aircraft is carrying a camera, then this icon represents the point at which the camera is pointed and the center of the video coverage. If no data is being received from the turret, a red SPOI is shown at a default location.

I-MUSE

Icons (cont.)

Target Types

A one- to seven-letter code labels targets as one of the predefined CoT types. CoT type codes are case sensitive. A label translating what type the code represents is displayed beside every target that is visible in the map area. Any target type that begins with the two and three letter sequences given in the following target descriptions have associated target icons.

Unknown

a-u-G: unknown ground (yellow trefoil)

a-u: unknown other (yellow X)

Neutral

a-n-G: neutral ground (green square)

a-n: neutral other (green X)

Friendly

a-f-G: friendly ground (blue rectangle)

a-f: friendly other (blue X)

Hostile

a-h-G: hostile ground (red diamond)

a-h: hostile other (red X)

Tracks

The straight lines connecting waypoints are the paths or tracks that the aircraft will attempt to follow during its flight. The segments are normally pale blue, but when the aircraft begins to travel a particular track, it will turn white. If the track is long enough, there are directional arrows (light blue triangles) indicating in which direction the aircraft travels.

When a waypoint is moved or a new waypoint is created, a temporary track is drawn, represented by a dashed orange line. Orange directional arrows may also be provided for this temporary track if it is long enough.

If there are multiple aircraft being represented in Map Window, there will be some tracks represented by a faded red line. These are tracks that are associated with the route of aircraft that are not set as the active aircraft at the time. Once the aircraft associated with that track and route is set to active, the track will turn blue.

I-MUSE	
Icons	**(cont.)**
Waypoints    	Waypoints represented by a blue circle indicate points that have already been approved into the active aircraft's route. These waypoints are also accompanied by their identification number and altitude. If there are multiple aircraft being displayed in Map Window, some of the waypoints may be represented as a dull red circle. These indicate waypoints that are a part of other aircraft's route. **Note: Aircraft cannot share waypoints. Though they may appear to share abort routes (flight paths programmed directly into Helmsman, the avionics software, used in case of a reset), the positioning of the waypoints are merely coincidental, and are actually each aircraft's abort route superimposed atop each other.** The route denoted by blue pentagon-shaped waypoints is the route that the aircraft flies when it has lost communication with the ground control station. It will stay in this route for a certain amount of time (specified in the mission parameters on the aircraft) attempting to regain communication. If the time period elapses before communication is re-established, the aircraft will execute an appropriate runway landing based on wind conditions and the predefined approaches in the mission parameters.
Wind Flags 	Wind information is represented by tan-colored flags accompanied by the angle from which the wind is blowing (in degrees) from north and its speed (in knots).

Menu – Context menu	
AC #X: Direct to WP #	The aircraft calculates a track from its current location to the commanded waypoint and attempts to fly that track.
AC #X: Orbit and Slew to LABEL	Commands the aircraft sensor to slew to the coordinates of the right-click that opened the context menu. Commands the aircraft to track to and initiate an orbit around the coordinates of the right-click that opened the context menu.
AC #X: Orbit...	Opens the Orbit panel to allow specification and command of a specific orbit. The coordinates of the right-click that opened the context menu will automatically populate the location portion of the panel.
AC #X: Slew to LABEL	Commands the aircraft sensor to slew to the coordinates of the right-click that opened the context menu.
AC #X: Track to WP #	In autopilot, aircraft calculates an extension of the indicated segment past the previous waypoint and then attempts to intercept that segment at the closest point. If a point on a future segment in the indicated route is closer, the aircraft will track to that segment.

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I-MUSE	
Menu – Context menu	**(cont.)**
Antenna: Point here...	Opens the Point Antenna panel to allow specification and command of antenna pointing direction. The coordinates of the right-click that opened the context menu will automatically populate the location information in the panel.
Camera: Point here	Initiates a Coordinate Hold at the location of the right-click that opened the context menu. The camera will slew to and remain fixed upon this point until it is commanded to do otherwise.
Delete	Deletes the target which was right-clicked to open the context menu.
Details	Opens the Target Manager panel. The target which was right-clicked to open the context menu will be selected by default.
Lock	Locks an unlocked target so that it can't be moved nor have its details edited.
Map: Center here...	Opens the Enter Coordinate panel to allow specification and command of the map center location. The coordinates of the right-click that opened the context menu will automatically populate the location information in the panel.
Map: Zoom in	Zooms in, centers map on coordinates of the right-click that opened context menu.
Map: Zoom out	Zooms the map out and centers it on the coordinates of the right click that opened the context menu.
Route: Change altitude…	Opens the Route Editor panel, allowing editing of the altitude for an entire route. The route which was right-clicked to open the context menu will be selected by default.
Route: Change WP # properties…	Opens the Route Editor panel which allows waypoint properties to be edited. The waypoint which was right-clicked to open the context menu will be selected by default.
Route: Create new	Opens the New Route altitude panel and initiates Route Creation mode. Has the same effect as left-clicking the Create New Route button on the I-MUSE toolbar.
Route: Discard changes	Deletes a template route or discards changes to an existing route.
Route: Insert waypoint after WP #	Inserts a new waypoint in the center of the segment which was right-clicked to open the context menu. The route will then need to be uploaded to the active aircraft, or have the changes discarded.
Route: Move	Attaches the route which was right-clicked to open the context menu to the cursor. This enables moving the entire route as a single object. To drop the route, double left-click on the desired location. The route will then need to be uploaded to the active aircraft, or have the changes discarded.
Route: Upload to AC #X	Initiates an attempt to upload a template route to the active aircraft. The color of the route will change from orange to blue to indicate that the upload was successful.
Send via Network	The target is sent out over the network using the targeting channel as specified in the I-MUSE settings. If the channel is not enabled, nothing will happen. Has the same effect as selecting the target in the Target Manager panel and clicking the **Send** button.

I-MUSE	
Menu – Context menu	**(cont.)**
Target: Create here	Creates a new target at the coordinates of the right-click that opened the context menu.
Target: LABEL >	Opens cascading menu of target options.
Unlock	Unlocks a locked target.
System monitoring – Master Caution	
Aircraft icon 	The color of the aircraft icon on the I-MUSE Map indicates the Master Caution state of the system. Under normal operating conditions for the current phase of flight, when there are no active caution or warning alarms sounding, the aircraft icon is green. A yellow aircraft icon indicates at least one active caution alarm and red indicates at least one active warning alarm. Some caution messages relate to the GCS display in the System Monitor but do not affect aircraft Master Caution. For more information about the Aircraft Icon, see *I-MUSE Reference* documentation in the online **Help**.
Connected Aircraft Status Display	The Connected Aircraft Status Display gives a snapshot of the aircraft Master Caution status for all connected aircraft. For more information about the Connected Aircraft Status Display, see *I-MUSE Reference* documentation in the online **Help**. 
Plots	**System parameter plots & plot views** Plots enable visualizing system parameters as they change over time. Predefined work space configurations in I-MUSE provide appropriate plot views for various phases of flight. Plot individual parameters in **Engineering Tables** by right-clicking on each data item. For more information about I-MUSE Plots, see *I-MUSE Reference* documentation in the online **Help**.

I-MUSE

System monitoring – Master Caution (cont.)

System monitor panel

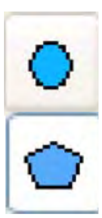
The System Monitor provides feedback regarding the overall health of the system. It provides information about alarms that are currently sounding and the severity of each alarm. There is a breakdown of aircraft health by sub-system and a list of recent conditions and messages.

An operator should strive to maintain a green aircraft during all phases of preflight and flight itself. If the aircraft is yellow or red, the operator should attempt to address the problems indicated in the System Monitor. Help is available for each alarm by double-clicking on that alarm in the Conditions or Messages list. Silencing audio alarms can be done on an individual, aircraft, or system-wide basis. This action should be done with caution, however, since such alarms are deemed important enough to have an audio component.

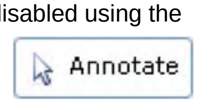
For more information about the System Monitor panel, see *I-MUSE Reference* documentation in the online **Help**.

Toolbar

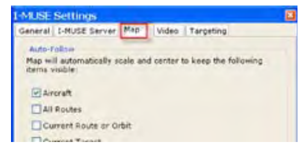
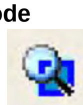
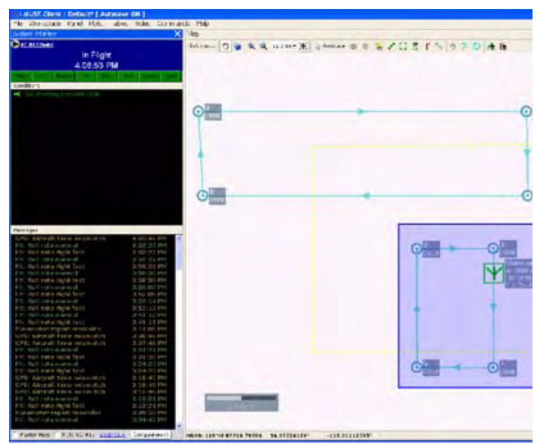
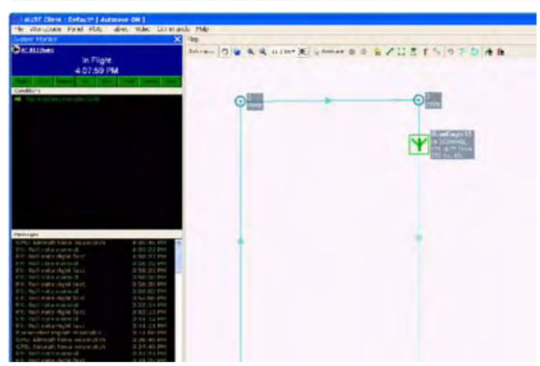
Annotations

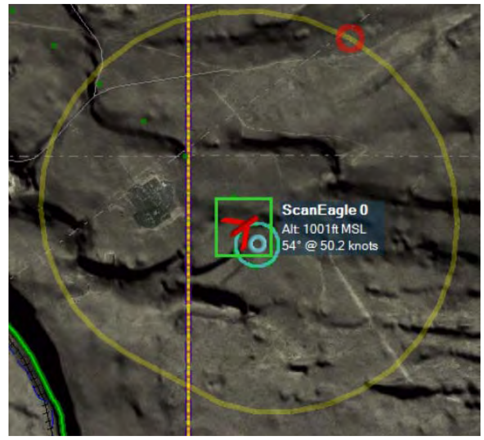


Annotations provide the ability to directly markup the I-MUSE map to show ROZ (restricted operating zones), landmarks, or other areas of interest. They enable drawing and formatting polygons or ellipses on the map for reference or demarcation. They may define flight boundaries, airspace restrictions, or other areas of interest. Once annotations are loaded they will remain visible until they are unloaded, even when I-MUSE is shutdown and restarted. Annotation layers can contain multiple annotations and are stored as files. The annotations are for informational purposes only and do not have any effect on the operation or behavior of the aircraft. Annotation creation mode can be enabled/disabled using the **Annotate** icon on the I-MUSE toolbar.



For more information about Annotations, see *I-MUSE Reference* documentation in the online **Help**.

I-MUSE		
Toolbar		**(cont.)**
Auto-Scale 	I-MUSE provides Auto-Scale functionality to keep specified objects visible on the map display at all times. This means that the map will resize and update automatically to keep all selected objects in view. To configure Auto-Scale properties, click the **Settings** button on the I-MUSE toolbar. Auto-Scale can be enabled/disabled using the **Auto-Scale** icon on the I-MUSE tool bar.	 
Breadcrumbs	When Breadcrumbs are enabled, the aircraft will leave a trail behind it, marking where it has been and the condition of GPS systems at that point. Breadcrumbs are enabled/disabled using the **Toggle Breadcrumbs** icon on the I-MUSE toolbar. Breadcrumbs can be removed using the **Delete Current Breadcrumbs** icon on the I-MUSE toolbar. For more information about Breadcrumbs, see *I-MUSE Reference* documentation in the online **Help**.	  
Drag Zoom mode  	To set viewable area of the map, click and drag out a box. (Do not center and repeatedly click on **Zoom In**.) When **Drag Zoom** is selected, the cursor appears as a magnifying glass. Click and hold the button down on one corner of the area that you wish to set as the new viewing area on the map. Drag diagonally to the opposite corner. A blue box outlining selected area appears. After releasing the mouse button, the map updates, setting view to selected area. Once the map has updated, I-MUSE automatically switches from **Drag Zoom** mode to **Pan Mode**. The cursor appears as the hand icon to reflect this. To cancel **Drag Zoom** while creating the box, press **Esc** before releasing the mouse button.	 

I-MUSE	
Toolbar	**(cont.)**
Glide range 	 The Glide Range button enables/disables the Glide Range display for the active aircraft. When Glide Range is enabled, a yellow circle indicating the estimated maximum Glide Range is displayed on the I-MUSE Map. A red circle on the Glide Range boundary indicates the estimated point of impact in the event of an engine-out. **Note: The glide range indicator parameter is based off of <u>min speed</u>.** The Glide Range display is not visible by default on a fresh installation of I-MUSE. It automatically becomes visible if the engine stops for the active aircraft. To enable or disable the Glide Range display, click on the Show/Hide Glide Range toggle button on the Map toolbar. **Note: This does not project the estimated path onto the terrain. It only uses DTED below the aircraft; it will not be correct in hilly or mountainous terrain. The display automatically updates as the aircraft gets closer to the estimated point of impact.**
Map dimming 	The map dimming button enables/disables map dimming for contrast in map packs and as needed for operating conditions. Use this feature to make flight plans. Aircraft and other indicators stand out against the map data.

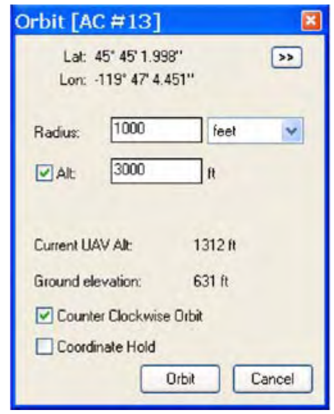
<table>
<tr><th colspan="2">I-MUSE</th></tr>
<tr><th colspan="2">Toolbar (cont.)</th></tr>
<tr><td>

Orbit command

</td><td>

To issue orbit commands:

- Drag and drop an aircraft onto any point of the map that is not an accepted waypoint in the active aircraft's route; or
- Using the **AC#: Orbit...** option in the **Map Control Context Menu**.



Both methods automatically fill in latitude and longitude measurements, approximating point:

- The aircraft icon was dropped; or
- You right-clicked to bring up the context menu.

Click the **Orbit** icon to bring up the **Orbit** panel. This panel enables commanding an orbit at a specific location using a Coordinate Control as well as specific radius, altitude, direction, and **Coordinate Hold** options. Once the orbit is specified, click **Orbit** to command the aircraft to track to the location and initiate the orbit.

</td></tr>
<tr><td>

Pan mode

cursor appearance in Pan Mode

To move the map, click and drag anywhere on the map.

Note: Allow some processing time for map updating after moving it.

</td><td>

Interactive elements can be discovered by hovering the mouse over various items while in Pan Mode. The items highlight with a blue background or halo. They can be moved around the map by clicking and holding the left mouse button while moving the mouse to a new location then releasing at the desired spot.

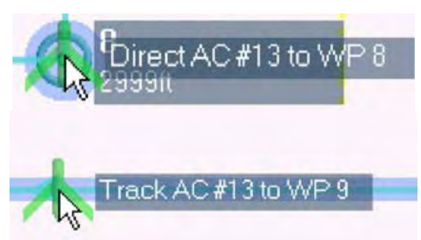
When I-MUSE is connected to a server and an aircraft is shown flying in the Map Control area, the hand-cursor can also grab onto three classes of objects and drag them into new positions: **Waypoints of active aircraft**, **Active aircraft**, and **Targets**.

Waypoints of active aircraft

By clicking and dragging one of the waypoints to a new position, you can alter the plane's flight path. When you move the waypoint to a new position, it turns into an orange triangle, indicating that the new position has not yet been approved into the route. For information on how to accept or undo route changes, see *I-MUSE Reference* documentation in the online **Help**.

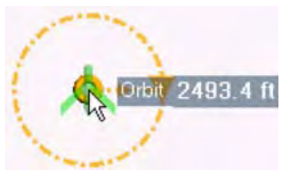
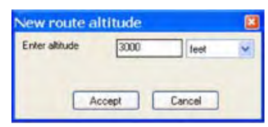
Active aircraft

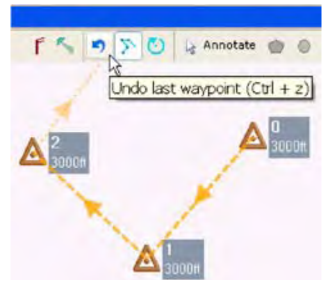
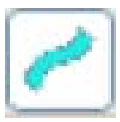
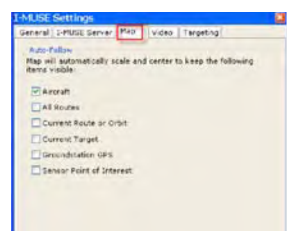
To change aircraft behavior, click and drag aircraft icon while it is in flight. When you click and drag the aircraft, the icon that represents the aircraft continues to fly on its programmed path. However, a small aircraft icon appears under mouse cursor.



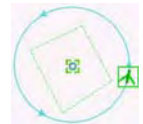
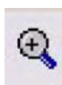
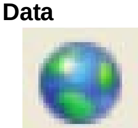
When the aircraft is released above an approved waypoint, a white line appears between the aircraft's current position and the new waypoint, indicating the track that the aircraft will follow if released. When released, the aircraft will fly direct to the waypoint and continue along the new route that is associated with that waypoint. When the aircraft is released above an approved segment, a white line appears between the aircraft's current position and the new segment, indicating the track that the aircraft will follow if released. When released, aircraft tracks to the new segment and continues along the new route.

</td></tr>
</table>

I-MUSE	
Toolbar	**(cont.)**
Pan mode (cont.)	If you attempt to drop the aircraft on a waypoint that has not yet been added to its route (the waypoint is represented by an orange triangle), it will not work. **Note: Waypoints that have not yet been accepted into an aircraft's route (represented by orange triangles) are transparent to the aircraft; i.e. the aircraft will behave as if the waypoint does not exist, and the area where you drop it is exactly the same as any other point of the map.**  When you drop the aircraft anywhere on the map that does not contain an acceptable waypoint, that point is presumed to be the center of a new orbit command. After dropping the icon, the aircraft will fly to and initiate the orbit. For more information, see *Orbit command*, earlier in this table. **Targets** Targets can exist in one of two states, locked or unlocked. Locked targets cannot be dragged around the map until they are unlocked. Unlocked targets can be dragged around the I-MUSE map using the cursor while in Pan Mode. For more information about Targets, see *I-MUSE Reference* documentation in the online **Help**.
Route planning 	The Create New Route tool allows you to create new routes or add to old ones. Upon clicking the **Create New Route** icon, a **New route altitude** box opens asking for a confirmation of the altitude for any aircraft following the new route to fly.  Create new waypoints by clicking anywhere on the map. Every left click will create a waypoint in the shape of an orange triangle (a waypoint not yet approved in a route). Once you start setting waypoints down, a dashed orange line will form between each of the waypoints. Orange arrows in the middle of the tracks indicate the direction in which the aircraft will fly when on this route; the direction follows the order in which you lay down the waypoints.  **Note: Advanced planning should be used when creating waypoints. Once a waypoint has been created, Helmsman, the aircraft avionics software, does not allow it to be deleted. A waypoint can be removed from an aircraft's route so that the aircraft no longer flies to it, but it will remain visible in Map Control until the next time Helmsman is reset.** The **Undo Last Waypoint** button on the I-MUSE toolbar deletes the last waypoint placed on the I-MUSE map. This button can be used repeatedly to undo an entire route, but is only active while in Route Creation mode. Once a route has been terminated, it can only be removed by right-clicking and selecting **Route: Discard Changes**. For more information about Route Planning, see *I-MUSE Reference* documentation in the online **Help**.

I-MUSE	
Toolbar	**(cont.)**
Route planning (cont.) 	To create a closed loop, after setting down all desired waypoints, click on a previously created waypoint. A menu opens. Select **Join this route at WP**#. If you do not wish to create a closed-loop route, to end the route creation process, double-click the location of the last desired waypoint. Notice arrows on last track that denote direction the aircraft will fly is doubled up. The aircraft will fly a circuit between the last two waypoints if there is no loop in the route.  For information on how to add unassociated flight paths to an active aircraft's route, see *I-MUSE Reference* documentation in the online **Help**. To cancel a new route while you are making it, press **Esc**.
Sensor Coverage 	The **Sensor Coverage** button on the I-MUSE toolbar enables/disables display of Sensor Coverage for the selected aircraft. When Sensor Coverage is enabled, a light green layer indicates sensor coverage during the current mission. The display of Sensor Coverage is cleared by using the **Delete Sensor Coverag**e button on the I-MUSE toolbar.  **Sensor Coverage Display in I-MUSE**
Settings	The **Settings...** button on the I-MUSE toolbar opens I-MUSE settings with the Map settings tab selected by default. This tab is used to configure Auto-Scale properties.   For more information about I-MUSE settings, see *I-MUSE Reference* documentation in the online **Help**.

I-MUSE	
Toolbar	**(cont.)**
SPOI	When the Sensor Point of Interest (SPOI) is enabled, a green box will be displayed on the I-MUSE map to indicate the point on the ground corresponding to the center of the unstabilized video frame as calculated by camera telemetry and currently loaded Turret Target Altitude. SPOI is enabled/disabled using the **SPOI** icon on the I-MUSE toolbar.   When I-MUSE client, Groundbase and Object Tracker are controlling the same aircraft through the same IfC, and I-MUSE and Groundbase are running on the same machine, target altitude is automatically adjusted within the system. I-MUSE publishes DTED altitude of the SPOI coordinate to ObjectTracker regardless of turret mode and ObjectTracker uses that altitude in coordinate hold commands. If DTED data is not available, I-MUSE will publish the last target altitude. If there is target altitude available, the default value is 1.22 meters. In this case, manual adjustment may be necessary. See the I-MUSE on-line reference information for manual adjustment instructions. **Note: If operating with I-MUSE 5.1.X or earlier, DTED data does not automatically set the turret target altitude.**
Toggle Estimated Time Enroute (ETE)	The **Toggle Estimated Time Enroute** button on the I-MUSE toolbar enables/disables ETE labels. When ETE labels are enabled, ETE data for waypoints and the aircraft are displayed. When ETE labels are disabled, no ETE data will be displayed. 
Toggle Target Labels	When **Target Labels** are enabled, all targets on the I-MUSE map will be displayed with their data label visible.  When Target Labels are disabled, Target Labels are only shown for a target when the mouse is over that target.  Labels can be enabled/disabled using the **Target Labels** icon on the I-MUSE tool bar.  For more information about targeting, see *I-MUSE Reference* documentation in the online **Help**.
Toggle Tracking Antenna Beam 	When the Show Tracking Antenna Beam is enabled, I-MUSE displays the coverage pattern of the antenna beam. The aircraft should remain within this pattern to maintain a communication link with the Ground Control Station. This feature does not provide the ability to control the antenna and is intended for reference purposes only.  The Show Tracking Antenna Beam can be enabled/disabled using the **Tracking Antenna Beam** icon on the I-MUSE toolbar. For more information about the tracking antenna beam, see *I-MUSE Reference* documentation in the online **Help**.
Undo Last Waypoint 	The **Undo Last Waypoint** button on the I-MUSE toolbar deletes the last waypoint placed on the I-MUSE map. This button can be used repeatedly to undo an entire route, but is only active while in Route Creation mode. Once a route has been terminated (not uploaded), it can only be removed by right-clicking and selecting **Route: Discard Changes**.

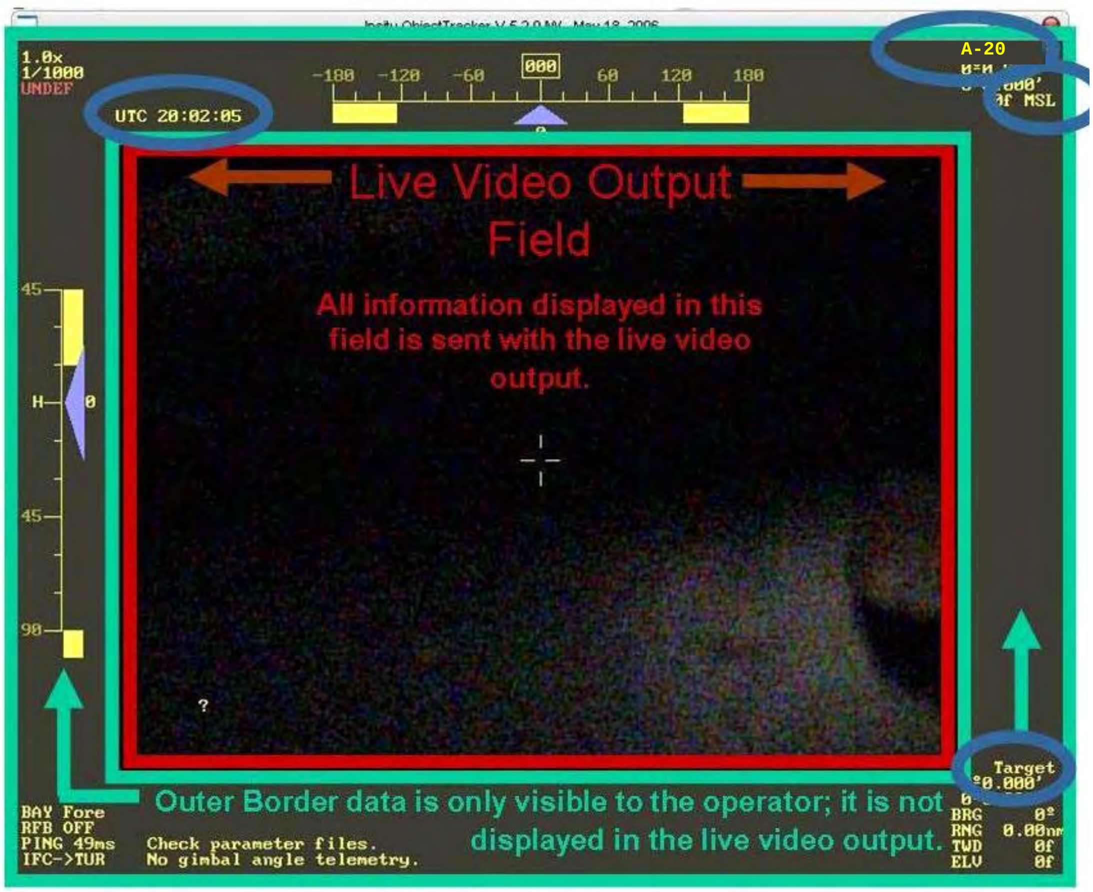
I-MUSE	
Toolbar	**(cont.)**
Video Boundary 	When the Video Boundary is enabled, a green dashed line will be displayed on the I-MUSE map to indicate the boundary of the onboard sensor coverage area.  Video Boundary is enabled/disabled using the **Video Boundary** icon on the I-MUSE toolbar.
Windfinding	When Windflags are enabled, I-MUSE will display windfinding data as reported by the aircraft. This data is represented by flags that are placed around the map as updates are received from the aircraft and reports the velocity and the direction of the wind at that location.  Windflags are enabled/disabled using the **Windflags** icon on the I-MUSE toolbar. **Enable / Disable**  Windflags can be removed using the **Delete Current Windflags** icon on the I-MUSE toolbar. **Remove** 
Zoom in / out  	As the tools' names imply, clicking on these two buttons will zoom in and zoom out the map view by a factor of 2x. For more information about Drag Zoom, see *I-MUSE Reference* documentation in the online **Help**. **Note: With I-MUSE 5.2 and later, scrolling the mouse wheel zooms the map view to the point under the cursor. Scroll down to zoom out. Scroll up to zoom in. If another mode is active and requires the use of the mouse wheel (such as specifying an orbit radius when dragging the orbit center point), then the zoom feature is temporarily disabled.**
Zoom to Show All Map Data 	Clicking this button will show all available map data as it exists in the currently selected MapPack.

6.3 ObjectTracker

In this section:

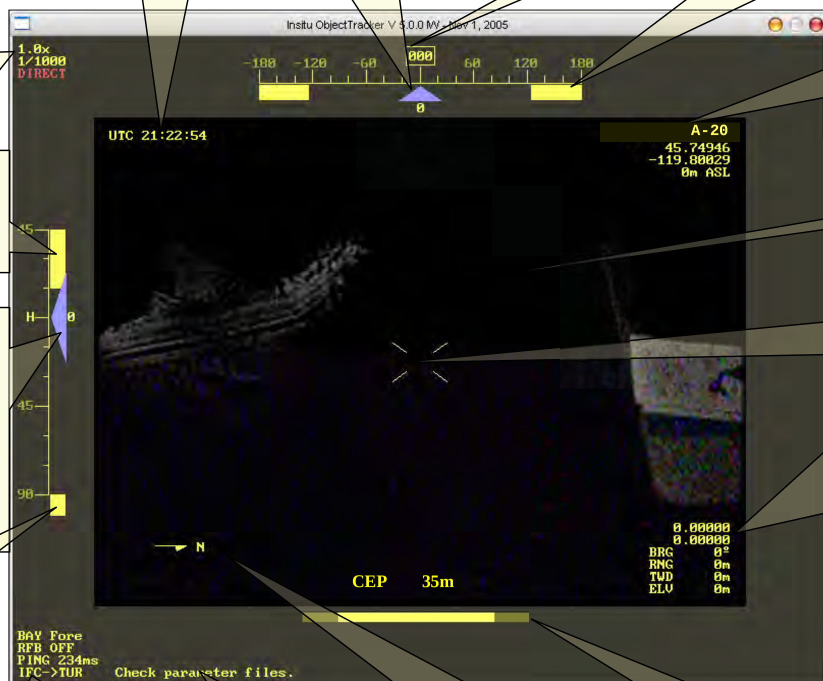
- Overlays
- Contrast enhancement
- Quick reference cards
- Troubleshooting

Overlays and a heads up display on the ObjectTracker screen provide information such as current shutter speeds, proximity to video occlusion due to the airframe, and target coordinates. ObjectTracker overlays, can be configured to the user's preference (e.g. text can be modified in the **Target** or **Aircraft** fields). This section provides details of ObjectTracker user interfaces including screen overlay options and speedpad, joystick, mouse, and keyboard use.



ObjectTracker

Overlays



Payload Info
*** Camera Zoom**
*** Shutter Speed**
*** Turret Steering Mode:**
When not in Hold mode, the steering mode is light red.

UTC Time Display:
Shown in HH:MM:SS or DTG (kbd: 7)

Turret Pan Position w/ FOV:
Indicates offset from Aircraft heading, as well as approximate horizontal FOV.

Heading of the Aircraft (deg)

Pan Occlusion Area:
Based upon current tilt angle

Aircraft Info:
Aircraft Name / Number: Customize using configuration files
Location (kbd: F2 [mgrs: on/off], 2 [mgrs precision], Ctrl+F2 [dms/dec])
Altitude (kbd: Ctrl+0 [ft/m])

Tracking Box (not shown):
When on, crosshairs appear in the box.

Crosshairs:
The current crosshairs:
- Appear inside the tracking box, and will resize with the box; or
- Are not shown if the box is too small.

There are 5 different crosshair modes. (kbd: 6)

Tilt Occlusion/Upwards Limit Area:
Based upon current heading, the offset of the turret from the Aircraft

Turret Tilt Position w/ FOV:
Indicates turret position relative to the Aircraft body or relative to the horizon (kbd: 9). Occlusion and limit displays are visible only when shown relative to the Aircraft body. The vertical FOV is an approximation.

Target properties:
The target is defined as the center of the box when it is on, and the center of the video when the box is off.
- **Location** (kbd: F2 [mgrs: on/off], 2 [mgrs precision], Ctrl+F2 [dms/dec])
- **Bearing** of the target relative to the aircraft in degrees
- **Range** to the target in meters on the ground
- **Target width** (the horizontally viewed distance on the ground across the middle of the video in meters) describes the ground distance across the width of the box when on
- **Target elevation** (kbd: Ctrl+9 [ft/m]) set by the operator in IMUSE/GB

Nadir Spin Area:
When the turret enters this area, it spins 180 degrees.

Active Bay: Auto-detects bay switches, but has an override if they are wired backwards (kbd: 0).
RF Block State
Ping Time (round trip): Colored light red if over 280.
Connection Status
TMP ###: Turret temperature (not shown)

North Indicator:
Can be optionally displayed as a floating N around the center of the video (kbd: 8)

Warning Messages:
Shows any of the following messages:
"Check parameter files" (The local files have not been validated by telemetry, or the files don't match.)
"No gimbal angle telemetry" (The current turret is not reporting telemetry.)
"Turret is locked, steering is disabled" (displayed in light red)

Target Geolocation Accuracy
Use the Target Geolocation Accuracy feature to obtain a more accurate geolocation estimate when tracking a target in coordinate-hold mode. To begin processing, press and hold down the joystick Mark Target button. The display at the bottom of the ObjectTracker window indicates that the feature is active. The bar graph and CEP data are displays of the intermediate results of the Target Geolocation Accuracy processing. Continue to hold the Mark Target button down until the CEP (uncertainty factor) reaches a steady state. Release the Mark Target button to send enhanced target location estimate to I-MUSE.

ObjectTracker

Contrast Enhancement

Real-time contrast enhancement for both EO and IR video is used on low-contrast imagery to achieve a noticeable increase in clarity, as in the examples below. To achieve the desired effect, two controls are blended: 1) Enhancement Effect, and 2) Adapt for Small or Large Objects.

IR image without contrast enhancement

Enabling Contrast Enhancement

To toggle contrast enhancement on or off, press Ctrl-F9.

Adjusting Contrast Enhancement

Command all adjustments via keyboard, as described below. The results of keyboard inputs are displayed only through changes to the image.

Note: Restarting ObjectTracker resets contrast enhancement to the default settings.

IR image with contrast enhancement

Increase/Decrease Enhancement Effect

To increase the enhancement effect, press the Apostrophe key ('). Each time the key is pressed, the contrast increases incrementally.

To decrease the enhancement effect, press Shift-Apostrophe ("). Each time the key is pressed, the contrast decreases incrementally.

Adapt for Small or Large Objects

To adapt the effect for smaller objects on the screen, press Ctrl-Apostrophe ('). Repeat the keystroke until desired effect is achieved.

To adapt the effect for larger objects on the screen, press Ctrl-Shift-Apostrophe ('). Repeat the keystroke until desired effect is achieved.

ObjectTracker

Quick reference card – Speedpad & joystick

ObjectTracker – Quick Reference Card
Speedpad and Joystick Operation

ObjectTracker Speedpad Key Assignments

Key	Function	Function with Shift + selected key
01	Increment shutter speed Increases contrast##	N/A
02	Increment turret steering mode	Reset camera
03	**Points camera forward**	**Command wings level**
04	N/A	Reset turret
05	Raise brightness*	Command +5 knots airspeed increase
06	Decrement shutter speed* Decreases contrast##	N/A
07	**Points camera left**	**N/A**
08	**Points camera down**	**N/A**
09	**Points camera right**	**N/A**
10	Lower brightness*	Command -5 knots airspeed decrease
11	Cycle mark and caption visibility	N/A
12	Toggle display*	Stop ObjectTracker (ESC key)
13	Toggle noisy frame filter	Mapped to keyboard's Enter key
14	Save hold point	Parks and switches active turret

Items in **Bold** are Speedpad home position keys.
Items with * apply only to units with EO Alticam cameras.
Items with ## apply only to units with IR Alticam 600-6000 cameras.

(Speedpad components have been highlighted for clarification.)

* Only available if I-MUSE is communicating with the same If/C as ObjectTracker, and **Enable Joystick Commands from ObjectTracker** is enabled in the ObjectTracker panel in I-MUSE.

(Joystick components have been highlighted for clarification.)

026-010110 v1.5 ObjectTracker v.5.2 rel. SEP07

6 Flight

ObjectTracker

Quick reference card – ObjectTracker mouse and keyboard

ObjectTracker Mouse Commands			
Left click	Designate object at click coordinates for tracking, and engage ObjectTracker (yellow tracker box visible). The tracker will bring object to screen center and keep it there.		
Right click	Disengage tracker (tracker box disappears) and steer camera (open loop) to bring clicked coordinates to screen center.		
Click wheel	Toggle between Scroll wheel modes (see below).		
Scroll wheel	*Mode 1*: Grow or shrink tracker object box. *Mode 2***: Step camera zoom in or out.		
ObjectTracker Keyboard Hot Keys			
For more information on ObjectTracker keyboard hot keys, refer to the ObjectTracker section of I-MUSE online help.			
F2	Toggles coordinate display mode between lat/lon and MGRS.	Ctrl + F2	Toggles lat/lon format between degrees and DMS.
F3	Reserved.		
F4	Restarts application and dumps debug info.		
F5 / F6	Adjusts Matrox capture card brightness.		
F7 / F8	Adjusts Matrox capture card saturation.		
F9 / F10	Adjusts Matrox capture card contrast.	Ctrl + F9	Toggles ObjectTracker adaptive contrast enhancements. See I-MUSE online help for more information.
F12	Resets all Matrox card display settings to default.		
` (accent/tilde)	Toggles captions on ObjectTracker output video.		
' (quote)	Decreases the amount of enhancement when the adaptive contrast enhancement is enabled.	Shift + '	Increases the amount of enhancement when the adaptive contrast enhancement function is enabled.
Ctrl + 1	Toggles ObjectTracker digital image zooming.		
2	Toggles MGRS precision between 4 and 5 characters.		
3	Toggles the thick lines and large font option for the ObjectTracker display.		
4	Toggles old overlay information on the ObjectTracker display.		
5	Toggles video clipping on the ObjectTracker display.		
6	Cycles through ObjectTracker crosshair formats.		
7	Toggles the time display format between UTC and DTG.	Ctrl + 7	Cycles target width display modes.
8	Toggles the north arrow display formats.	Ctrl + 8	Cycles ground range display modes.
9	Toggles tilt indicator shown relative to aircraft body.	Ctrl + 9	Toggles TGT elevation format between m and ft.
0	Toggles turret bay switching.	Ctrl + 0	Toggles UAV altitude format between m and ft.
\	Rescan the ObjectTracker system for connected joysticks.		
+ / -	Increase or decrease camera exposure time. Observe symbology for confirmation.** *Increase or decrease contrast.***		
=	Upload PC time to the turret.**		
t	Increment turret steering mode. Look for feedback on ObjectTracker captions. *Off*: No turret steering; *Direct*: No gyro feed-back. Stick commands pan & tilt motor speed; *Stabilized*: Inertial stabilization of the turret is active. Stick drives line-of-sight; *Hold*: Coordinate hold. Stick drives hold point on surface of Earth.		
d	Toggles symbology display. Observe symbology for confirmation.**		
k	Restores the previously saved turret state.	Shift + k	Stores the complete active turret state.
e	Toggles edge disguising.		
r	Resets camera.** (This can be useful to set the automatic exposure baseline in flight.)	Shift + r	Resets Alticam turret.
z	Steps camera zoom in.	Shift + z	Steps camera zoom out.
g	Decreases object tracking error feedback gains.	Shift + g	Increases object tracking error feedback gains.
b	Decreases camera brightness. Observe symbology for confirmation.**	Shift + b	Increases camera brightness. Observe symbology for confirmation.**
h	Turns highlighting of the pattern matching search region off.	Shift + h	Turns highlighting of the pattern matching search region on.
q	Turns debug tones off.	Shift + q	Turns debug tones on.
Ctrl + f	Toggles ObjectTracker RF noise filter. This filter looks for snow or bars in the image and diverts noisy frames from ObjectTracker image flow. Look for confirmation in object tracking captions. If image remains frozen for many seconds, then all frames are noisy; try turning off the filter.		
Shift + j	Changes the active turret without parking.		
Ctrl + j	Changes the active turret with parking. Saves current target location; turns off box if it was on; parks turret in direct mode pointing forward; changes active turret; centers active turret on saved target.		
Space bar	Freezes video image; clears color distortion.		
Shift + arrow	Zooms out, switches to direct mode, and sends the turret to one of the four home positions (up, down, left, and right).		
Ctrl + arrow	Adjusts the turret gyro bias. Works like the joystick's upper hat.		

Items with ** apply to units with EO Alticam cameras.
Items with ** apply to units with IR Alticam 600-6000 cameras.

ObjectTracker	
Troubleshooting – recovery from common issues	
Brightness is wrong**	Point camera at scene of interest; reset camera with ‘r’ in ObjectTracker interface. This sets baseline brightness. Also restart ObjectTracker to restore default brightness/contrast settings for Matrox.
Image seems to have motion blur or is too grainy**	Check that exposure time is set to ~1000Hz. If setting is too low, picture will look blurry, which is often mistaken for motion blur or poor focus. If setting is too high, picture looks grainy.
Joystick is unresponsive	Check that: a) ObjectTracker window has focus, b) target altitude is below the UAV, and c) steering mode is NOT set to OFF.
Target box is jumping around	Pull joystick trigger to switch to manual steering of HOLD point (until there is sufficiently rich texture available for ObjectTracker to lock onto) and then pull trigger again to engage tracker, or increase Matrox contrast setting (F10) to provide more texture for the tracker.
Altitude is not registering	Ensure tracker is off, and hands are off joystick when altitude is uplinked from Groundbase.
ObjectTracker PC stuck in boot-up	Remove all USB drives and try again. Make sure a USB keyboard is plugged in, or else the joystick will be mistaken for a keyboard.
Orion not recognized by Matrox license manager	Wait for completion of boot to run ObjectTracker. May be as long as 2 minutes after power up. Run Matrox license manager; verify that license is present.
Joystick sensitivity is asymmetric	Joystick may need to be calibrated. Use DirectX calibration utility: Control Panel > Game Controllers > Properties > Calibration tab
Zoom buttons not reliable**	Any buttons pushed while camera refocus is in progress will be ignored.
Range/coordinate displays are wrong	Check that telemetry reporting file in ObjectTracker directory is up-to-date.
Can’t change turret modes	Make sure I-MUSE joystick deadband is set high enough, or else I-MUSE joystick will send steering commands even with hands off. This prevents ObjectTracker from making mode changes.
Zeros on target coordinates	The turret may think it is looking above the horizon.
"?" where north arrow should be	Gimbal angle telemetry is off.
Steering mode indicator not synched	The turret should be powered up in GroundBase before starting ObjectTracker.
Note: Items with ** apply to units with EO cameras.	

ObjectTracker v4.23.03, rel. 23-Dec-05

6.4 Satellite Communication (SatCom)

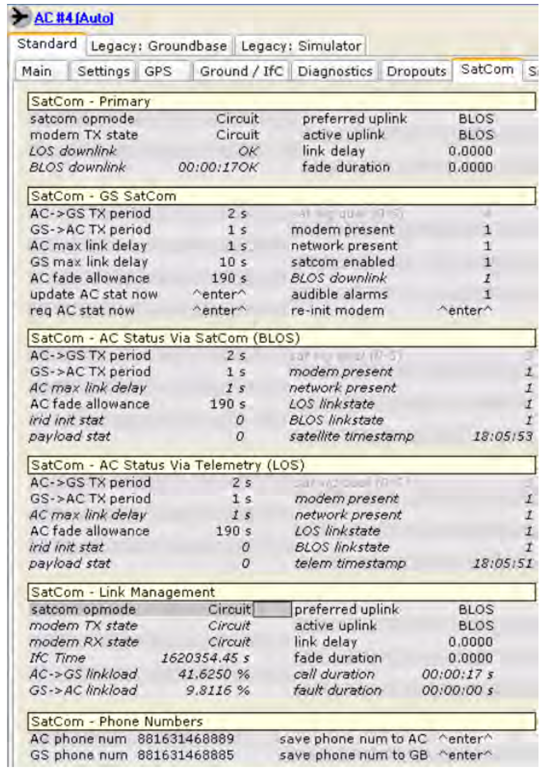
Satellite communication (SatCom) extends the effective range of the system by providing communication via an iridium satellite data modem when operating beyond line of sight (BLOS). Due to low SatCom bandwidth, video is not available when communicating via the iridium modem. However, streaming freeze-frame image transmission is available at a reduced rate compared to LOS. Iridium SatCom-based communications for BLOS provides health monitoring, location data, and control.

Overview

Iridium SatCom capabilities require both:

- An iridium modem-equipped aircraft; and
- An iridium modem connected to the I-MUSE computer in a GCS via a serial port.

Configure I-MUSE for iridium communications by selecting **File➪Settings...** from the main menu. In the resulting dialog, select the **I-MUSE Server** tab. Click the **Iridium modem** checkbox and choose the COM port (serial port) that the modem is connected to. If required, launch I-MUSE Server via the **File➪Launch I-MUSE Server** menu item. When a connection to the server is established, go to the **Engineering Tables** panel and select the **Standard➪SatCom** tab.



Note: An explanation for each field of the SatCom menu is provided in the I-MUSE online reference information.

Satellite Communication (SatCom)	
User Interface	
SatCom – Primary	A grouping of primary indicators for satellite communications. These fields are largely copies of fields found in other SatCom tables.
SatCom – GS SatCom	Settings and indicators pertaining to the iridium modem connected to the groundstation.
SatCom – AC Status Via SatCom (BLOS)	Read only. Settings and indicators pertaining to the iridium modem in the aircraft as reported via the BLOS link. The BLOS link is synonymous with the iridium SatCom link.
SatCom – AC Status Via Telemetry (LOS)	Read only. Settings and indicators pertaining to the iridium modem in the aircraft as reported via the LOS link. The LOS link is synonymous with the omni/directional antenna link. If the aircraft goes beyond the line of sight of the directional antenna, this table is not updated.

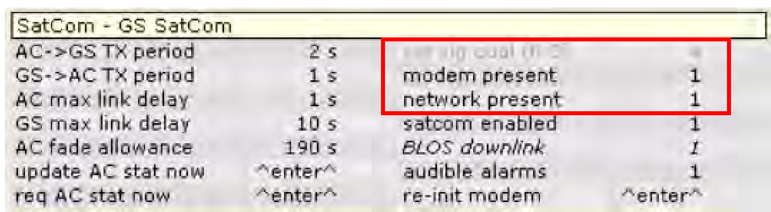
Satellite Communication (SatCom)

User Interface (cont.)

SatCom – Link Management	Dial out or terminate phone call. To dial out, type **DIAL** in **SatCom opmode**. To terminate the call, type **DIS** in **SatCom opmode**. This table also accepts changes to the preferred uplink. The ground control station sends commands to the aircraft using only one link (LOS or BLOS). Input the desired link type in the **preferred uplink** field. The **active uplink** field displays which link is in use. During flight, if BLOS is the preferred uplink and BLOS fails, the GCS switches to LOS for uplink. However, if LOS is the preferred uplink and LOS fails, it will not switch to BLOS for uplink; once out of LOS range, BLOS must be set as the preferred uplink. Downlink occurs on both links simultaneously.
SatCom – Phone Numbers	Input of the aircraft's phone number. Only the ground control station can initiate a call. After entering the aircraft's number and establishing communication with the aircraft, saving the number in the aircraft allows automatic detection when a LOS link is established with the aircraft in the future. The **GS phone num** field only needs to be entered in troubleshooting scenarios.

Startup

1. Make sure both the AC and GS modems are present (1), the network is present (1), and the satellite signal quality is good (minimum of 3, with 5 being the best quality).



Note: Network will not appear to be present until the modem is present. Sat sig qual may appear before, at the same time as, or after the network becomes present.

- If modem is not present, reinitialize modem by pressing Enter in the re-init modem field, or cycling power to the individual modem on the iridium box.
- If signal quality is poor, ensure nothing obstructs the ground iridium antenna (clear view of the horizon).

Troubleshooting Satellite Communication

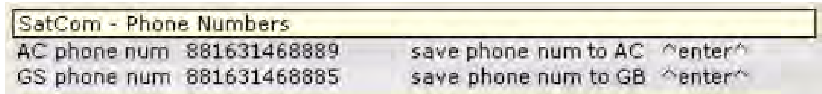
1. Check position of aircraft.
2. Check Orbitron for satellite position(s), to assure line-of-sight communication with satellite(s).
3. Check the antenna cables and connections and that the antenna is vertical within the fin.

Note: The iridium system is a low-earth orbit system, and satellites have a horizon-to-horizon pass of five to seven minutes. The satellites could pass low on the east / west horizons, so if operating in a valley, the satellite signal quality will be poor / interrupted.

Satellite Communication (SatCom)

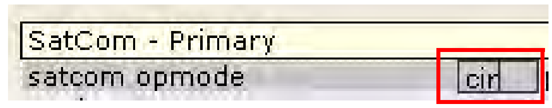
Startup **(cont.)**

2 Enter the aircraft phone number if necessary.



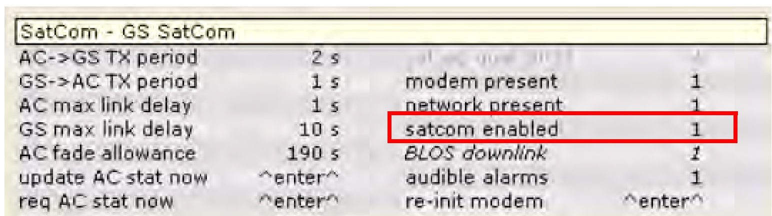
Establishing a Connection

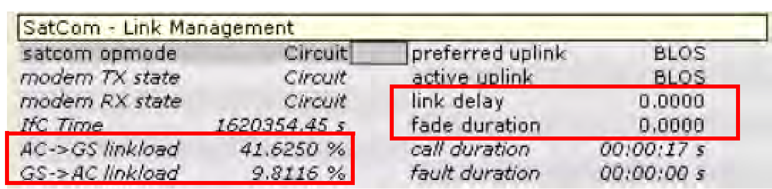
Type **Dial** into the **satcom opmode** field. This will cause I-MUSE to dial the aircraft via iridium.



Note: There will be a query asking to confirm BLOS as the preferred uplink.

When SatCom is enabled, 1 is listed in the SatCom enabled and BLOS linkstate fields. When the aircraft is dialed, the first indication that the aircraft has answered is when the modemTxState and modemRxState change to Circuit. AC->GS linkload will be approximately 50%. Check uplink and downlink by watching the change in link delay and fade duration times, as well as the linkload percentages while commanding a small airspeed change and looking at the response time.





Iridium communication – low bandwidth

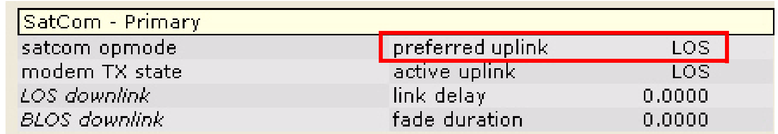
Communication over iridium modems is limited to 2400 bps. Data to be downloaded is buffered on the aircraft. A practical limit for downlink is 2000 bps to allow for fluctuations in downlink bandwidth. To get a good feel for the downlink via iridium alone, you can disable the LOS link by switching to the directional antenna (use GS Ant # 0) and physically disconnecting the directional antenna fiber cable. Be sure to either reconnect or switch back to the omni antenna afterwards.

Note: Sat sig qual fields do not update during dialing or during a call. If difficulty is experienced obtaining the SatCom link, type DIS in <u>SatCom opmode</u> to disconnect. For ground and air, ensure that modems are present and satellite signal quality is good. If these actions have no effect on uplink, downlink, link delay, and fade duration, the call has not been made. Reattempt to establish a connection by disconnecting the call (if it doesn't do this automatically), checking aircraft modem and ground modem status, and dialing again.

Satellite Communication (SatCom)

Launch/Flight

For launch, LOS must be the active uplink. To ensure LOS is active, type **LOS** in the **preferred uplink** field.



Note: BLOS can be connected for launch, but LOS must be the preferred and active uplink.

After launch, enable power and telemetry to all payloads as required. Certain payloads may have been disabled for takeoff and may be safely powered on for the mission phase of flight. Iridium SatCom can be enabled now as well. If both video transmitters were not turned on for launch, they can be turned on now.

When both BLOS and LOS links are available, data is downloaded via both links at the same time. However, data is uploaded via only one link at a time, as designated by the **preferred uplink** and **active uplink** fields. When BLOS is the preferred uplink, it remains active as long as the SatCom link is present. Upon loss of the SatCom link, the active uplink automatically changes to LOS. However, if LOS is the preferred uplink and the LOS link is lost, the active uplink does not automatically change to BLOS, even if a BLOS link is available; the preferred uplink must be changed manually to BLOS.

Note: Since data is downloaded via both links, information may still be received from the aircraft via the BLOS link, but information will not be able to be sent to the aircraft.

For approach, LOS must be the active uplink. Without active LOS, DGPS information is not available to the aircraft. Disable BLOS during pre-approach: Type **DIS** in the **SatCom Op Mode** field to disable the BLOS link.

Note: If necessary, BLOS can be left on as a backup through recovery.

Timeouts

A fade is defined as no data for two occurrences of:

- **AC->GS TxPeriod** plus **GSMaxLinkDelay** (for downlink).
- **GS->AC TxPeriod** and **ACMaxLinkDelay** (for uplink).

During a fade, only link management packets are sent. If the fade lasts another period of:

- **GSMaxLinkDelay**, the ground disconnects and redials.
- **ACFadeAllowance**, the aircraft will consider the comm lost and commence the lost comm procedure after the regular **link timeout period** expires.

These delay periods allow approximately three minutes to reestablish the link. If unable to reestablish the link after three minutes, change the preferred uplink to LOS.

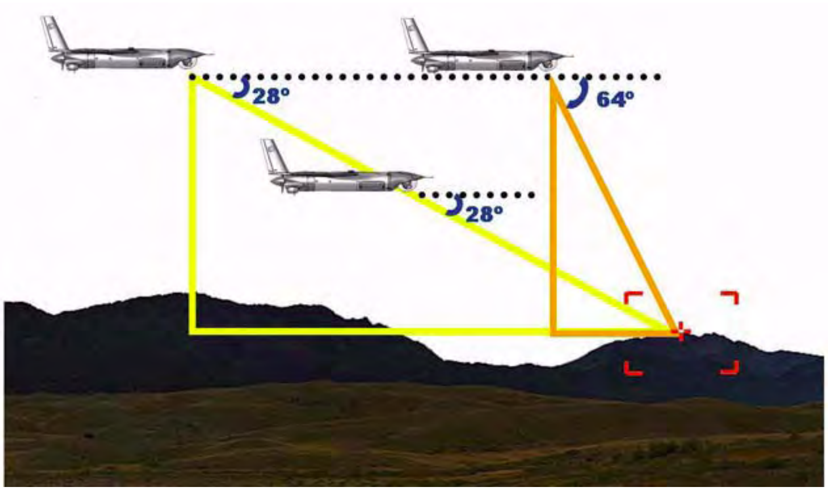
Troubleshooting

Note: Communication loss is usually due to line-of-sight loss with the iridium satellites. Check for line-of-sight obstructions to satellites before troubleshooting SatCom.

Note: For maritime operations, the ship’s superstructure may obstruct line-of-sight communications between the ground system and satellite. Move communications antennas to higher locations. If unable to raise communications antennas, it may be necessary to change the heading of the ship.

SatCom does not accommodate video imagery, but allows positive control of the aircraft in the event that the primary communications link fails. If SatCom fails, the audio alarm "SatCom downlink failure" is heard. Visually, the **BLOS downlink** field appears yellow (if BLOS is the preferred uplink). Troubleshoot by performing the *SatCom Downlink Failure* emergency procedure. See the *Pocket Handbook.*

6.5 **Geolocation**



Geolocation is most accurate when the depression angle is closest to 90 degrees – when the camera is looking nearly straight down. Geolocation becomes increasingly less accurate as the depression angle decreases – as the camera is moved away from the downward view. The depression angle is the angle created by:

- The horizontal plane of the aircraft (the dotted line in the figure); and
- The line from the camera to the target (the slanted line of the triangle – the hypotenuse).

The greater the depression angle, the greater the geolocation accuracy. In the figure, the aircraft above the yellow triangle will have lower geolocation accuracy than the aircraft above the orange triangle, because the depression angle of the yellow triangle is low. Flying toward the target will increase the depression angle.

Note that flying forward and downward will not significantly improve geolocation accuracy if the depression angle is unchanged. Geolocation accuracy is greatly dependent on depression angle, and is only nominally affected by distance from the target. To increase depression angle, fly toward the target without changing elevation.

Geolocation	
Operating Guidelines	
To geolocate a stationary target:	
3 Ensure high resolution digital terrain elevation data (DTED) is loaded in I-MUSE for the area of interest.	
Note: High resolution DTED ensures accurate SPOI.	
4 Ensure GPS has low uncertainty.	
5 Sync barometric to GPS altitude.	
6 Verify that turret target altitude is updating or enter it manually if DTED is not available.	With I-MUSE 5.1.X and earlier: ▪ DTED does not automatically set turret target altitude; it must be set manually in the **Camera/Turret** settings panel.
7 With I-MUSE: Enter a tight orbit, orbit once, then press and hold the mark target button on the ObjectTracker joystick while keeping the ObjectTracker box with the target in the exact center. The longer the button is held, the more accurate the data. Two orbits is optimal. Release the button and the marked target should be very accurate with small uncertainties.	With I-MUSE 5.1.X and earlier: ▪ Overfly the target and mark the target when looking nearly straight down. Since the camera typically spins and loses a target when looking directly straight down, mark the target just before the nadir.
Note: If the ObjectTracker box loses the target while the button is held down, geolocation data will be highly suspect.	
With S-VEST2: Capture a video clip with a high depression angle and geolocate within frames.	
With map reference (I-MUSE, C2PC or other): Use video footprint on map, I-MUSE snapshot with footprint on map, S-VEST clip projected onto map or live video to locate target area on reference map and mark target at visually determined point vs. the reference map.	
When I-MUSE client, Groundbase and ObjectTracker are controlling the same aircraft and I-MUSE and Groundbase are running on the same machine, target altitude is automatically adjusted within the system. I-MUSE publishes DTED altitude of the sensor point of interest (SPOI) coordinate to ObjectTracker regardless of turret mode and ObjectTracker uses that altitude in coordinate hold commands. If DTED data is not available, I-MUSE will publish the last target altitude. If DTED is not available, I-MUSE does not automatically publish an altitude to ObjectTracker. ObjectTracker will continue to use the last altitude that it received. When no DTED is available, the altitude can be manually updated via the I-MUSE Camera/Turret panel. See the I-MUSE online reference information for manual adjustment instructions.	

Geolocation

Data Flow & Accuracy

Geolocation accuracy is driven by the variables that feed positioning calculations. Knowing how to use the most precise data source available limits geolocation errors. These instructions and figures show the movement of data within the UAS and provide tips to limit errors.

Variables

Software uses several variables to determine where the camera is looking (this assumes the target is on the surface of the Earth).

- Aircraft state

  Inertial and air-data sensors are used to produce an aircraft state estimate — where the aircraft is and how it is oriented.

- Camera state

  Turret gimbal-angle sensors report data used to calculate where the camera is looking.

- Turret Target Altitude

  In I-MUSE 5.2 and later, turret target altitude is automatically updated using DTED. In I-MUSE 5.1.X and earlier, target elevation is entered manually by directly entering the altitude, or by commanding **hold here** on the map; this sends the DTED elevation at that point to the turret.

Note: ObjectTracker is not involved when commanding hold here; if ObjectTracker is on when commanding hold here, I-MUSE will first turn off ObjectTracker.

  For ObjectTracker to obtain target elevation, terrain data is loaded in I-MUSE, and I-MUSE continually sends elevation data to ObjectTracker for the point that ObjectTracker is trying to track. I-MUSE uploads a target altitude based on its estimated geolocation, then it indexes the DTED and sends that to ObjectTracker, which then sends the information to the turret.

- Terrain data

  Terrain data is obtained from DTED found in MapPacks. I-MUSE can be used with a GCS, Forward Eyes, Network Ground Control Station, or Forward Ground Control Station. Each instance of I-MUSE can produce its own geolocation data. If different DTED is loaded into each I-MUSE, geolocation information may vary.

Primary Output

A digital elevation model is viewed in a primary output, such as I-MUSE or ObjectTracker. The operator sets the turret target altitude (in I-MUSE 5.2 and later, this is automatically updated using DTED data), and the primary output calculates target or video information. How the location of that position is determined depends on how the primary output sees and displays the pixel array. Although information is available in various fields, the source may often be the same. The following methods that are used for geolocation are color-coded for comparison with the corresponding data output:

SPOI

The location of the present sensor point of interest (SPOI) is always the location of the center pixel of the video, or frame center projection (FCP). With the SPOI at the center of the video, software considers data from previous steps in the process, and uses the location of the pixel array in the center of the frame to determine the location. In I-MUSE 5.2 and later, GPS altitude is used. In I-MUSE 5.1.X and earlier, this calculation uses barometric altitude from the aircraft state estimate; when viewing data that uses SPOI for geolocation, to increase accuracy, update barometric altitude to use GPS altitude.

Geolocation

Data Flow & Accuracy

Four Corners

Software considers the variables to determine the location of each of the four corners of the video.

OT Target Location

ObjectTracker projects a box with four corners around, or crosshairs on, the target. ObjectTracker calculates the location of each of those corners or the location of the crosshairs, depending on which mode it is in. In I-MUSE 5.2 and later, a position and uncertainty are reported to I-MUSE whenever a target is marked from ObjectTracker. Results are short-term averaged. To increase accuracy of the position, press and hold the **mark target** button. These results are long-term averaged for the duration that the button is pressed, producing a more accurate position.

Sensor Pose

The position of the platform (aircraft latitude, longitude, and altitude) and turret (azimuth, elevation, and roll) are used to calculate where the camera is looking. This calculation is most accurate when the camera is looking down, and becomes increasingly less accurate as the camera is moved away from the downward view.

Secondary Output

Data can be fed from the primary user interface to a secondary user interface, such as Falconview or Terrasight. Be aware of the data source that is providing the geolocation data. When a secondary user interface uses data from I-MUSE or ObjectTracker, some error can occur due to screen translation error.

- S-VEST calculates the frame-to-frame flow of pixels to improve the geolocation accuracy.
- Secondary user interfaces fed directly from sensor pose data do not suffer from screen translation error. Be aware of any additional applied filters that may affect accuracy.

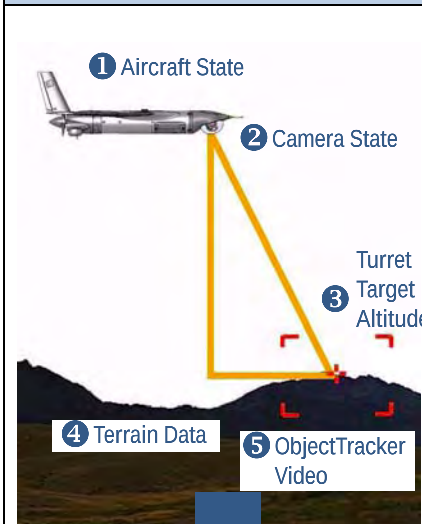
  Note: Coordinates on overlays sent directly from the servers are not subject to the screen translation error. The error occurs when this information is consumed by another operating system.

- Passing results from I-MUSE to Terrasight doesn't have inherent inaccuracies, but can become skewed in time. There may be more jitter and more lag when viewing data from a secondary output.
- Altitudes that are fed via cursor-on-target are first converted from mean sea level (MSL) to height above ellipsoid (HAE) datum. FalconView converts the altitudes back from HAE to MSL, but it uses a slightly different formula than I-MUSE, so small errors can be introduced. In this case, the geolocation position in I-MUSE should be considered more accurate.

Geolocation

Data Flow Chart

Variables



1 Aircraft State

Inertial and air-data sensors are used to create an aircraft state estimate.

Inertial and air-data sensors
• GPS • Static pressure • Roll, pitch, and yaw rate gyros • Forward acceleration • Downward acceleration

Aircraft state estimate
• Latitude • Longitude • Barometric altitude • Roll, pitch, heading

2 Camera State

Turret gimbal angle sensors	
• Pan • Scan	• Tilt • FoV

3 Turret Target Altitude

4 Terrain Data

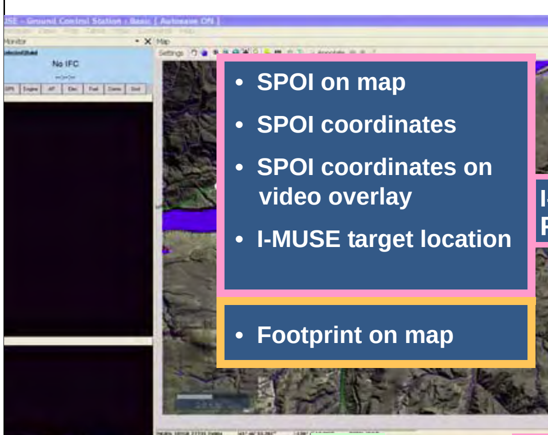
- Terrain data loaded in I-MUSE

5 ObjectTracker Video

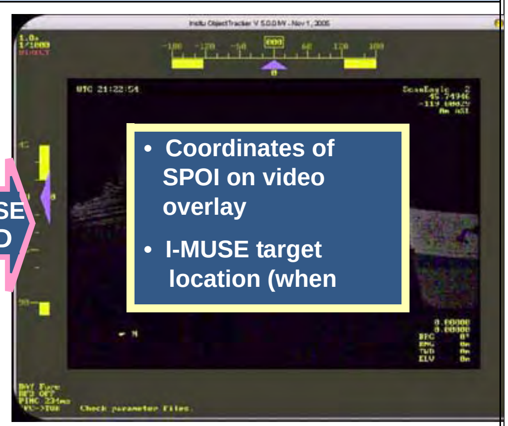
- Center of the box (row, column)
- Box size

Primary Outputs

I-MUSE (Forward Eyes, Forward Ground Control Station, Network Ground Control Station, Ground Control Station)	**ObjectTracker**



I-MUSE FEED



ESD FEED

S-VEST (Terrasight)

Global motion vector. Pixel location comes from ESD fed

CoT FEED

Falconview

Latitude, longitude, altitude, and SPOI are reported using

I-MUSE FEED

I-MUSE Video Output Overlays

SPOI coordinates on overlay.

OT FEED

OT FEED

ObjectTracker Video Output Overlays

SPOI coordinates on overlay

Flight 6

6.6 ## ISR Operations

In this section:

- Controls for ISR operations

For more information, see *ObjectTracker*, in this chapter.

ISR (Intelligence, Surveillance, and Reconnaissance) operations are performed using ObjectTracker, an Insitu ground station component.

ObjectTracker steers the camera on-board the aircraft and provides a 5x improvement on the operator's ability to point the camera. ObjectTracker uses object tracking algorithms that are aware of the object being tracked, either because the object is visually distinct from the scene or because a designated object pattern is stored for comparison with subsequent frames. This method provides optimal tracking, while simplifying workload.

Steering the Turret

The turret has a variety of steering modes in which it can operate. The turret can be controlled in all steering modes with various user input devices. If the current turret steering mode is off, the turret switches to direct mode when the joystick is deflected, or when a mouse button is pressed within the application.

ISR Operations	
Controls for ISR operations	
Joystick	Steering the turret or tracking designator: The joystick steering is setup to mimic flight simulators, where deflecting the joystick forward corresponds with moving the turret (or the box if it is on) downwards, which will cause the scene in the video to move up. Deflecting the joystick to the right would correspond with moving the turret (or the box if it is on) to the right, causing the scene in the video to move left. The opposite joystick deflections will have the opposite effects.
Keyboard / Nostromo n52 SpeedPad	▪ **Keyboard/Nostromo n52 SpeedPad -** The following features are used to change various settings of the turret, camera, and ObjectTracker software. ▪ Keyboard: The ObjectTracker window must be the active window for the keyboard commands to work. ▪ Nostromo n52 SpeedPad: For ObjectTracker installations, the SpeedPad's buttons are set up to mimic a keyboard; the scroll wheel mimics a mouse's scroll wheel. View and customize mappings by bringing up Nostromo loadout manager and editing ObjectTracker controller profile. A Nostromo n52 SpeedPad must be connected to the system to see the ObjectTracker profile in the loadout manager. This means that all of the Nostromo buttons have a corresponding keyboard command; but not all of those keyboard commands are exposed in the quick reference card. Users can also record series of commands to perform repetitive operations. These commands get recorded as an easily modifiable script. One example may be to have the script save the current complete turret state before sending a command to reset the turret, and then restore the state after a discreet period of time when the turret has probably completed resetting. The ObjectTracker window must be the active window for the SpeedPad commands to work.

ISR Operations	
Controls for ISR operations	**(cont.)**
Mouse	▪ To designate targets or steer the turret, click on the image. ▪ To point the camera at a location, right-click the location on the screen. ▪ For continuous turret motion, click repeatedly. ▪ To turn of the tracking box, right-click.
Widgets – I-MUSE widgets	This I-MUSE control can adjust some ObjectTracker settings. ObjectTracker supports making targets, taking snapshots, and orbiting SPOI functions by sending a message to all instances of I-MUSE that are connected to the same If/C as ObjectTracker. **Targets** ▪ **Make Targets** This feature differs from the local ObjectTracker specific target storage system. A click of the joystick button sends a message to the connected I-MUSE to mark the current SPOI as a target. **Snapshot** ▪ **Take Snapshot** When the joystick button is pressed, a message is sent to the connected I-MUSE to take a snapshot of the current video image. **Orbit SPOI** When the joystick button is double-clicked, a message is sent to the connected I-MUSE to command the aircraft to orbit about the current SPOI, using the same altitude and radius as the last orbit. The button to the right commands a clockwise orbit, and the button to the left commands a counterclockwise orbit.

6.7 Tactics

In this section:

- Overview
- Mission planning
- Mission execution

Note: Contact Insitu for details and ongoing developments on these topics.

Tactics	
Overview	
Operational relationships	▪ The customer ▪ The product ▪ Primary roles
Operational layout	▪ Communications ▪ Responsibilities
Mission planning	
Typical missions	▪ BDA: Battle Damage Assessment ▪ CAS: Close Air Support ▪ Convoy Escort ▪ Feint Maneuver Observations ▪ NAI: Named Area of Interest ▪ On-Call for Improvised Operations ▪ Open Area Search ▪ Perimeter Security / Sentinel ▪ Pre-Operation Planning ▪ Rapid Response (e.g. Point of Origin Tasking) ▪ Route Reconnaissance ▪ Search and Rescue ▪ Surface Search & Surveillance ▪ Vehicle Tracking
Mission execution	
Guidelines	▪ Airspace coordination / de-confliction ▪ Plan daily activities to avoid complacency ▪ Treat each target as the most important task for the day ▪ Ground Track and Time-on-Target diversity ▪ Keep fresh mind and eyes in seat at all times

Tactics	
Mission execution	**(cont.)**
Search	▪ Target types: stationary, moving vehicle, ship or boat, lines of communication, drifting targets in the water. ▪ Factors affecting detection: target, detection requirements, surface conditions (sea state, ground haze, dust), altitude, cloud layers below/above, visibility, sun-angle, thermal crossover, camera settings and performance, video signal performance. ▪ Camera settings: zoom / field of view (FoV), shutter speed, brightness, contrast, stabilization, white hot or black hot (IR), screen clutter. ▪ Search patterns: ladder search, expanding box search, expanding circle search, walking barrier search, zig-zag search.
Situational awareness	▪ Type, time, position, certainty ▪ Coordinates (lat / lon, MGRS, etc.) ▪ Range and bearing information ▪ Remember customer / ROE ▪ Describe area carefully, from large to small ▪ If you think that you were detected, let others know ▪ Be reluctant to change targets if essential target information has not been passed ▪ Consider possibility of revisiting target if other targets in deck are of high interest
Target position mensuration	▪ Initial datum from CPOI (central point of interest) ▪ Compare to imagery for update
Target surveillance	▪ Flight patterns: ▪ Payload patterns: raster search view, rolling box view, moving target work, line of communication (LOC) work

Target talk-on or turnover (FAC, UAV, Tac-Air)	▪ Verify "Tally" on contact
	▪ Make them verify objects within FoV
	▪ Use compass directions
	▪ If video is broadcast:
	    ▪ FoV directions
	    ▪ Provide wide and narrow FoV views for max SA
	▪ Target classifications
	    ▪ High Value (HVT)
	    ▪ Time Sensitive (TST)

6.8 Handoff

In this section:

- Aircraft handoff – GCS to GCS
- Listen-only mode

Handoff
Aircraft handoff – GCS to GCS

This section describes handoff from one GCS to another when both GCS are equipped with Transmit enable/disable switches. This switch is built into the GCS and essentially disconnects the If/C transmit line to the modem(s) when the switch is in the disable position. When the switch is in the enable position, the If/C has full command authority and the GCS functions normally. Only one GCS should have transmit enabled at any given time, but many GCS can operate in listen-only mode with transmit disabled.

The handoff procedures are detailed in *I-MUSE Reference* documentation in the online **Help**.The handoff procedure should be closely followed to avoid control conflicts or lost communications with the aircraft. *I-MUSE Reference* documentation in the online **Help** includes a checklist for the releasing controller, i.e. the controller who is handing-off the aircraft. The other checklist is for the receiving controller, the controller who is receiving control of the aircraft. The receiving controller's checklist contains a setup checklist section that guides the operator through setup of the GCS for control of the aircraft when starting in listen-only mode. As such, it may be considered a Setup and Start checklist in addition to containing the actual handoff procedure.

Handoff requires two-way communication between the controllers. In the past this has been voice communication via two-way radio or telephone, but other means such as network chat or voice-over-IP could be used as long as the link is reliable and has a minimal delay.

The handoff procedure, detailed in the checklists, requires the receiving GCS to have its transmit switch disabled so that it can listen to aircraft telemetry (including payload) but not transmit. The controlling GCS synchronizes the receiving GCS to the aircraft by downloading parameter reports (and files as necessary) once the aircraft is within range of the receiving GCS. Full downlink and synchronization is thus attained and verified before the handoff occurs. Handoff consists of the releasing controller disabling transmit closely followed by the receiving controller enabling transmit and verifying control of the aircraft, all coordinated by two-way communication between the controllers. The releasing controller can then monitor telemetry and payload downlink in listen-only mode if desired.

Listen-only mode

A GCS with its transmit switch in the disabled position (or without transmit capability at all) may wish to synchronize with the aircraft so that it can observe the aircraft in listen-only mode. Parts of the handoff checklists may be used to synchronize a listen-only GCS to an aircraft even if no handoff is intended (or handoff is to occur at a later time). In this case, an abbreviated version of the *Handoff Briefing Between Controllers* and the *Synchronize Receiving GCS* sections from the *Releasing Controller's Handoff* checklist would be used on the controlling end and the *Receiving Controller's Handoff* checklist from the beginning through *When Receiving Telemetry From Aircraft* would be used on the listen-only end.

6.9 Maritime Operations

In this section:

- Antenna characteristics and ship orientation
- Mission files and lost comm

Maritime Operations	
Antenna characteristics and ship orientation	
Overview	One main difference with a mobile ground station setup is that the tracking antenna and tracking camera are operated in a **rotating ground station** mode (*cmd mode* is RGS as opposed to FGS). One of the issues with ground station rotation is that the antenna unwind azimuth varies. Insitu's standard antenna system does not use slip rings, and only allows for rotation from center of +/- 190° or so. Since the antenna is aligned with the mobile ground station (in some direction, generally pointing straight forward), the situation can easily occur where the ground station orientation changes, and the antenna unwinds (spins a full circle to carry on tracking). Depending on aircraft distance from the ground station, there may be significant dropouts in video or telemetry. This should be avoided by managing the relative positions of the aircraft and the ground station. Some ability to control ground station heading is desirable, and operations in the bad azimuth should be minimized, especially at long distance. Some mobile ground stations may restrict where antennas can be placed. This means there is potential for significant blocking (for example: due to ship super-structure). A dual antenna system can overcome some of these problems, but creates its own technical issues. For operation at short range, using omni antennas for telemetry overcomes the problems with antenna unwind, and an Attitude & Heading Reference System (AHRS) is not needed. Omni range depends on the type of antenna used. A patch type antenna (such as used in Forward Eyes) may be good for approximately 6 miles (10 km), but has a beam width of about +/- 45° (requiring some minimal pointing). Other omni antennas such as the muffin type or whip style may only be useful for a little over 3 miles (5 km).
Antenna Position	The ground station antenna position will not be a fixed lat/lon when moving. The procedure is to set the reference position *@GS GPS*, and then apply appropriate offsets for the actuator. These offsets are in the ground station coordinate system, so *x* is forward, *y* is right and *z* is down. The offset is from the tracking actuator to the SkyHook GPS. Note that these relative offsets change if the SkyHook boom is deployed or retracted. Again, *cmd mode* is set to *RGS*.

Maritime Operations

Antenna characteristics and ship orientation (cont.)

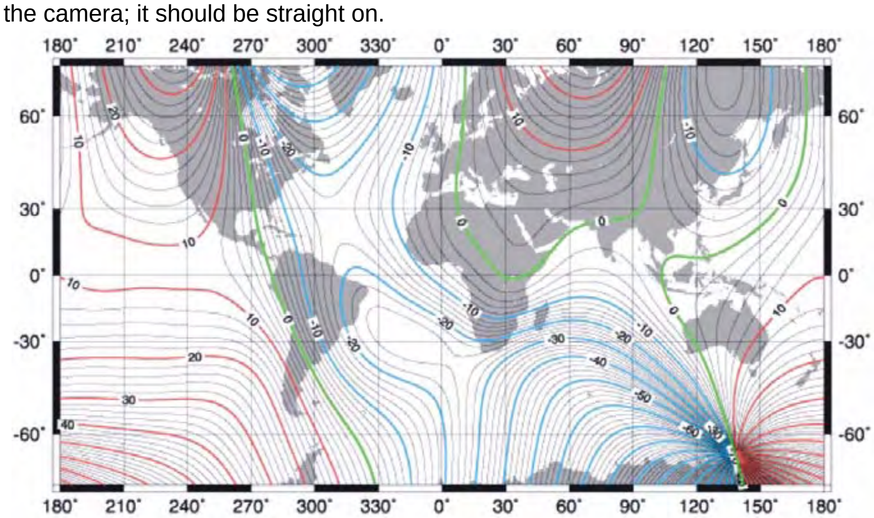
Errors in AHRS and magnetic offset adjustment

Note: This topic only pertains to AHRS models with magneto-meters.

It is desirable to use an accurate feed from the moving platform for attitude and heading information. This is often not possible due to unavailability, technical difficulties, or integration time constraints. In this case, if operation outside of omni antenna range is needed, an AHRS must provide this information. For each installation, the AHRS may need to be calibrated to provide heading information. This entails some maneuvering by the base, which must be arranged.

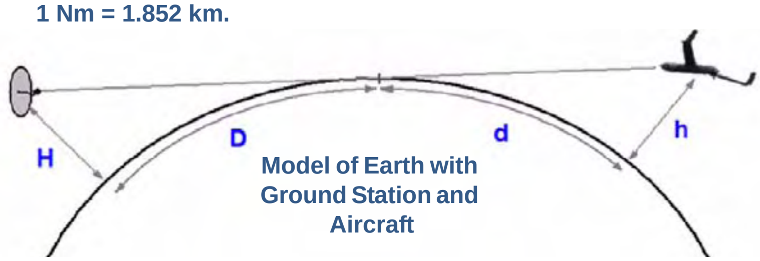
Once a calibration sequence has been completed, the reported heading must be checked against the local reference (if available). It is likely there will be errors in heading that will change with direction. Ideally errors are less than a couple of degrees. Place AHRS in a location where magnetic effects are at a minimum (away from electronics, power leads, etc.), as these will induce heading errors.

The AHRS in current ground stations outputs true heading, so no offset is typically needed. However, it is possible that at distance, improved video or telemetry can be gained by adjusting the magnetic offset to compensate for heading errors from the AHRS. It is a good practice only to adjust the offset by a degree or two at a time, and remember what the original number was. The *pan || x* field controls the orientation between the actuator and the ground station, and once found during installation, should not change. Remember this is the angle the actuator has to pan to point the same direction as the ground station (i.e. if at 0° pan, it is pointing to starboard by 10°, *pan || x* is -10°). Where possible, it is also a good idea to sight the aircraft when it is at short range to check for tracking errors. Assuming the aircraft is close, a rough indicator of alignment can be checked by looking at the antenna with the camera; it should be straight on.



World Magnetic Declination:
For use with magnetic heading AHRS

For magnetic AHRS, it is important to remember that local magnetic declination changes with position. It also varies from published data at times, but should be within a degree or two of what is expected (see chart for rough declination values).

Maritime Operations	
Antenna characteristics and ship orientation	**(cont.)**
Ground station – unique parameters	As is good practice in any ground station location, a list should be kept (perhaps on the computer desktop) with all the parameters that need to be set regularly. This should include tracking antenna and camera offsets. Another list should include all serial connections used, and their port numbers. This helps in debugging problems, and re-connecting items in the event of equipment failure (for example the If/C or I-MUSE computer).
Line of sight consideration	While line of sight should always be taken into consideration, once the ground station starts moving, the areas where coverage is good may vary. For operation at sea, this is not usually an issue (limits should be kept in mind on distance and altitude), however operations from a mobile ground station on land may be affected by local terrain. Problems can be minimized by keeping above a certain altitude. A few methods are available to assist in line of sight calculation, notably Falconview and its threat editor tool, and ViewShed Analysis in Global Mapper. Mission file setup should account for the operating area terrain and the potential ground station position. If at sea, some simple modeling of a spherical earth can be used to estimate radio horizon distances, and line of sight distance depends on both ground station height and aircraft height, as illustrated. As a simple rule: $D = 1.23\sqrt{H}$ and $d = 1.23\sqrt{h}$ where *D* and *d* are in nautical miles, *H* and *h* in feet. Thus, line-of-sight (LOS) distance $= D + d = 1.23(\sqrt{H} + \sqrt{h})$. **Note: This assumes Standard Refraction as given by 4/3 Earth model, and 1 Nm = 1.852 km.**  Example: Ground station antenna height is 70 feet MSL. Aircraft height is 200 m MSL = 656 feet. What is line of sight distance? $D = 1.23\sqrt{70} = 10.29Nm$ $d = 1.23\sqrt{656} = 31.51Nm$ Total line of sight distance is then 41.8 Nm = 77.4 km. The mathematical formula for LOS distance ignores the ***excess attenuation*** as the RF signal skims the surface of the Earth (i.e., near the center-point in the illustration). Excess attenuation can be as great as 20-30 dB when operating at the theoretical LOS range. So it is best to operate the aircraft with some range margin relative to max LOS range. This keeps the RF path away from the surface of the Earth, minimizing excess loss, thereby providing greater link reliability.

Maritime Operations	
Antenna characteristics and ship orientation (cont.)	
Line of sight consideration (cont.)	Excess attenuation starts to become a factor when the actual distance to the aircraft exceeds 50% to 80% of the mathematical LOS distance. For a ground antenna that is low to the ground (less than 10 feet (3 meters)), excess attenuation may be a factor if the actual distance to the aircraft exceeds 50% of the mathematical LOS distance. For a GCS antenna mounted on a roof of a building or the deck of a ship, excess attenuation may be a factor if the actual distance to the aircraft exceeds 75% of the mathematical LOS distance. When preparing a GCS for potential long-range missions, ensure maximum practical GCS antenna height is achieved. This delays onset of excess attenuation, even though the mathematical LOS horizon does not change very much. If intermittent communications occur on a mission, when operating at long range and low altitude, check the LOS range equation to see if the actual range to the aircraft is greater than 50% of the maximum LOS range. If this is the case, consider increasing aircraft altitude (if operationally feasible).
Tracking camera position	Tracking camera position is set in a similar manner to the tracking antenna. When using an AHRS for heading, the position offsets (such as **cam xB fm base**) are relative to the ground station, not north, east and down. The co-ordinate system is the same; however the offsets are from the SkyHook GPS to the camera. **Pan to TD** is sometimes hard to find (by looking at the GPS/rope), and entering a value for **pan || x** might be more useful. This entails finding the reported camera pan angle where it is exactly parallel to the ground station *x* axis (forward). **Appr cam mode** is RGS. A camera is nice to have (particularly for the preflight sequence and safety), but as long as there is an observer in place for retrieval, it is not absolutely necessary.
Mission files and lost comm	
	Use the following guidelines to prepare Mission Files for handling lost communication: ▪ If the ship is expected to travel some distance, it is generally best to update the mission file fairly often, moving the housekeeping/lost-comm flightplan and base location to a point *ahead* of the ship on its expected path. ▪ Once communicating to the aircraft, move the homecoming flightplan periodically so that it is close to the ship. ▪ On Comm Failure, point the tracking antenna to one of the waypoints. Whenever possible, move the Lost Comm Flight plan with the moving ground station.

6.10 Emergency Procedures

In this section:

- General guidelines
- Aircraft behavior – Unexplained
- Communications – Failure
- Electrical system – Failure
- Flight control – Failure
- Ground control station – Restart
- Mobile ground station
- Powerplant – Failure

To handle emergency and failure situations effectively and timely, the UAV operator **must**:

✓ Know the system well enough to respond appropriately when unique and unexpected situations arise.

✓ Memorize the standard emergency guidelines and procedures described in this chapter.

✓ Know and utilize the resources that are available, including: Insitu's Emergency Procedure Checklists, applicable documentation, and engineering assistance.

This chapter provides recommendations for handling various emergencies and failures. Because each situation is unique, the UAV operator or mission commander must know the system well enough to respond appropriately when new situations arise, and must bear responsibility for the safe conduct of any flight.

As described ...

- **Know the emergency procedure standards**
- **Use the Emergency Procedure Checklists**

Ensure that emergency checklists are immediately accessible for each flight and its operator. UAV operators must be thoroughly familiar with every checklist to quickly diagnose problems and promptly take corrective action. Operators cannot rely on learning the procedure during the emergency.

Insitu provides and maintains a comprehensive collection of checklists to ensure that all operators use the same accurate and up-to-date procedures. Using the **approved checklists** is critically important and required for the safety of personnel and equipment. The latest approved checklists are posted and continually updated on our Extranet:

http://www.insitu.com/extranet

Note: Before using any checklist, confirm that you are using the latest approved checklist posted on Insitu's Extranet.

The Extranet requires a password for access. If you need a password, contact Insitu.

Whenever a new checklist or document is released, Insitu's Extranet is updated and a message is sent to notify all registered users.

Emergency Procedures	
General guidelines	
	Each checklist assumes that these checks have been made: 1 Check airspeed 2 Check altitude 3 Check tachometer Additionally, as time allows, take the following steps during any anomaly, emergency, or failure: 4 Scan aircraft state for other problems 5 Download full parameter report(s) These steps can lead to detection of additional problems that may be present.
Standards	Dealing with an anomaly, emergency, or failure typically involves these steps on some level: 1 **Detect** (e.g. hear “Generator Undervolt” and “Battery Current Low” alarms) 2 **Diagnose** (recognize, e.g. generator has failed) 3 **Take prompt corrective action** (e.g. return to base, etc.) **Note: The first two steps are necessary in order to take corrective action. Taking corrective action before correctly diagnosing the problem can lead to greater problems.**
Sequence – priorities for handling emergencies	1 **Aviate:** Keep the aircraft flying safely. 2 **Navigate:** Control where the aircraft is and where it is going. 3 **Communicate:** Communicate to keep others aware of your intentions and to seek assistance. (Communicate with ATC, range-safety, crew, engineering help, including Insitu HQ.) **Note: While a timely response is often critical, remain calm and methodical during emergencies to avoid panicked actions that exacerbate the situation. Remember the available resources. For example, a phone call for engineering assistance can often lead to new insight.**
Landing priorities	Since many emergencies can lead to non-SkyHook landings, memorize these recommended landing priorities: 1 Clear of people and property 2 Clear of obstructions and rough terrain (avoid water) 3 Near ground station or safe retrieval location 4 Wings level 5 Minimum airspeed 6 Into wind

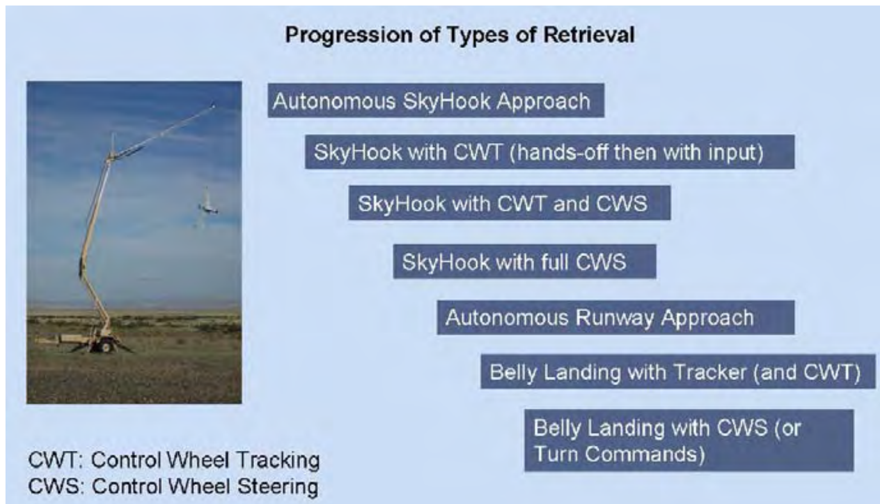
Emergency Procedures

General guidelines (cont.)

Retrieval types – priority progression

The first priority is to avoid damage or injury to people. The remaining priorities deal with minimizing damage to the aircraft itself. In certain operational scenarios, maximum damage impact may be preferable to priorities 2 through 6 if the aircraft cannot be returned to a safe retrieval location.

The progression of retrieval types range from a fully autonomous SkyHook retrieval to a CWS belly landing, as follows:



Note: **SkyHook with full CWS retrieval is often not possible due to a lack of appropriate bore-sight vantage point and skilled CWS operator.**

Aircraft behavior – Unexplained

Action

Unusual behavior may require immediate action. Diagnose the problem if possible, to determine what action should be taken (if any), and note the anomaly for later investigation. Include the following steps:

1. Download full parameter report(s)

   Request parameter report (**F11**) to synchronize I-MUSE with the aircraft state. This ensures that you are observing accurate data and may alert you to problems such as a Helmsman reset.

2. Check autopilot settings

   Check the autopilot table to ensure that the anomalous behavior is not caused by the autopilot being in an unintended state (e.g. altitude hold off, payload or monitor control on, etc.)

3. Check aircraft state

   Scan the aircraft state for problems. This includes the aircraft state variable table, navigation table, wind estimate, weights, c.g., output bits, GPS status, etc.

Emergency Procedures	
Communications – Failure	
Comm – not reacquired	**Action** Use the *Comm Not Reacquired* checklist whenever communications failure persists. It includes instructions for using FlightSim in replay and simulation modes to estimate and predict aircraft position, behavior, etc., during failed uplink.
Comm – reacquired	**Action** Use the *Comm Reacquired* checklist whenever normal communications are reestablished following downlink or uplink failure.
Downlink – failure	Downlink failure may be due to a problem with the aircraft, RF link, or GCS, so downlink failure can be an exercise in debugging. When downlink is lost, uplink is often (but not always) also lost. **Action** If the failure persists, use the *Comm Not Reacquired* checklist. If downlink is reacquired, use the *Comm Reacquired* checklist.
Link – poor or intermittent	The *Poor or Intermittent Link* checklist provides troubleshooting steps for a poor or intermittent communications link.
Uplink – failure	Use the *Uplink Failure* checklist when the aircraft is not receiving messages from the ground despite good downlink. Uplink failure can exist if a Transmit Enable/ disable switch in the GCS is left in the disabled position, and an error mode in the ground modems has been observed where the modem can latch into a mode where it receives full downlink but does not uplink. **Action** **Cycle power on ground modem(s)** is a checklist item to correct this second potential fault. If the failure persists, use the *Comm Not Reacquired* checklist. If downlink is reacquired, use the *Comm Reacquired* checklist.
Electrical system – Failure	
Battery – low	**Action** Check the generator voltage and engine RPM, since a low battery may be due to degraded engine performance or a failing or failed generator. Ensure that the minimum throttle is not set too low for the aircraft electrical load. If one of the battery leads has opened (i.e. become disconnected), battery voltage of about 13 volts will be reported.
Generator – failure	**Primary concern** The battery is being drained since the generator is no longer providing electrical power. If the battery capacity is exhausted, the avionics will shut off and the aircraft will no longer be controlled. **Action** Unnecessary electrical loads should be secured to extend battery life, and the aircraft should be moved to a safe retrieval location as quickly as possible.

Emergency Procedures	
Flight control – Failure	
Autopilot – off: not intentional	**Primary concern** The aircraft will quickly lose control if the autopilot is turned off. **Action** The autopilot on/off switch on the pilot's console can be overridden by commanding the autopilot to SAFE.
DGPS – failure	DGPS failure is not necessarily an emergency, and in some scenarios, operating without DGPS for most of the flight is normal. However, DGPS is needed for a standard autonomous SkyHook approach.
Flight control – erratic	Erratic flight control may be due to hardware or software problems. **Action** Some forms of erratic flight control (e.g. pitch oscillations) may require immediate operator action to keep the aircraft from exiting the flight envelope.
GPS – failure: aircraft	**Primary concern** GPS failure is a critical failure for the aircraft. It affects the aircraft in two major ways: ▪ The aircraft navigation estimate will rapidly degrade. ▪ If GPS is lost for more than the **GPS timeout** period AND uplink is lost for more than the **link timeout** period, the aircraft will kill the ignition since the aircraft can no longer effectively navigate and is no longer receiving instruction from a ground-station. **Navigation estimate is unreliable**: When GPS is lost, the aircraft will continue to update the navigation estimate (position, velocity, etc.) if inertial navigation (dead-reckoning) is enabled. This information is reported to the ground (**source DR only)** and plotted on the I-MUSE and Groundbase maps. This is an estimate only and the accuracy rapidly degrades when GPS is lost, so this information may be misleading and cannot be regarded as truth. The operator should therefore not rely on the map display to “fly the aircraft home” when GPS has failed. **Increased chance of losing comm**: Because of the range safety logic (described above), once GPS is lost, the aircraft is then vulnerable to losing comm. Furthermore, there is an increased chance of losing comm because the aircraft position is no longer known, so the aircraft may exit the effective ground antenna RF cone (i.e. the main antenna lobe), or the tracking antenna may slew away from the actual aircraft as it continues to track the increasingly inaccurate, aircraft dead-reckoning estimate.

Emergency Procedures

Flight control – Failure (cont.)

GPS – failure: aircraft (cont.)

Action

Take prompt action: Since the navigation solution rapidly degrades, it is important to take prompt action if you want to command the aircraft to a new position (e.g. return to base, or clear of jamming, or clear of people and property).

Tracking antenna: Due to the increased chance of losing comm (described above), it is recommended to right-click on the I-MUSE map and select **Point Antenna Here** – if the aircraft position is known (from video or ground observation). Continue to right-click and select **Point Antenna Here** as the known aircraft position changes. If aircraft position is not known, the tracking antenna can be left in tracking mode since it will be tracking the best estimate of aircraft position (including drift due to last known wind). Video beam-width is about 5 degrees, and comm beam-width is about 10 degrees (15 degrees for 900 MHz systems), so if video reception starts to be lost, update the antenna position with **Point Antenna Here** before comm is also lost.

Omni antenna: The omni antenna should be used if the aircraft is within range (and can be kept within range).

Navigating by onboard video: It is generally best to point the camera ahead and slightly down, although it may be useful at times to look around to find landmarks, watch for traffic, etc.

Re-acquiring satellite lock: If GPS jamming or interference is suspected, it's worth remembering that the GPS can retain satellite lock in much harsher environment than it can acquire lock. Thus, if the GPS loses satellite lock it might be necessary to move much further away from the jammer in order to recover. With a strong jammer it might be more effective to move to a position where there is terrain between the aircraft and the jammer (if possible) rather than simply attempting to increase the distance between the aircraft and the jammer.

Potential jamming from video transmitters: One source of GPS jamming that has occurred is jamming from intermodulation from the winglet video transmitters. This occurs when strong interference from an external signal (at a certain frequency) combines with the video carrier signal to create a GPS jamming signal. The jamming can be removed by turning off the offending video transmitter. For any given video channel, there are certain external frequencies that the transmitter is vulnerable to, i.e. certain frequencies that can combine with the video carrier signal to jam one of the GPS bands. Therefore, if this type of jamming is encountered, in general, only one video transmitter will be affected. The transmitters should be turned off one at a time to see if the jamming is cleared. If jamming is due to this intermodulation issue, the offending video transmitter channel should not be used in that operational area.

Note: **Check the routing of the GPS hatch cable. Ensure that the GPS cable is not hooked under the serpentine bend in the wingflex of the aft JST connector to the spineboard.**

Landing procedure: If the aircraft GPS is successfully returned to the ground-station location but GPS never recovers, the aircraft can be recovered via a belly landing, using the decision height techniques described in the *Engine Failure: Recommended Landing Procedure* section. It is also possible to make a CWS retrieval into the SkyHook rope if an appropriate vantage point and trained person are available.

Emergency Procedures	
Flight control – Failure	**(cont.)**
GPS – failure: ground	**Primary concern** A ground GPS failure impacts operations in two ways: ▪ The aircraft will no longer have an DGPS solution and will be unable to make a standard autonomous SkyHook approach. ▪ The ground-station will no longer have updated position fixes. This is mainly of concern for a moving ground-station as the ground-station may move away from the last known position, with a corresponding error in tracking antenna pointing, potentially resulting in lost communications with the aircraft.
Helmsman – reset	A Helmsman (flight computer) reset may occur due to a bug in the flight software, a fault in the hardware, or an electrical problem or glitch, among other causes. **Primary concern** Following a Helmsman reset, the flight computer may remember some information. However, the aircraft may "forget" everything since power-on, including fuel weight, flightplans, and altimeter setting. Reset these from ground command. If Baro Altitude is computed from a "forgotten" base pressure, aircraft may descend quickly. **Action** It is important to download a full parameter report following a Helmsman reset, to ensure that you are not looking at old information in Groundbase and I-MUSE, e.g. you may see fuel weight is 4.12 lbs (1.87 kg) in Groundbase, when the aircraft really thinks there is 11.46 lbs (5.2 kg) of fuel onboard. Downloading a full parameter report synchronizes the ground-station software with the aircraft and keeps you from becoming confused by looking at inaccurate information. Furthermore, the ground software is not always immediately aware of a Helmsman reset. The reset will become apparent when the parameter report is downloaded.
Icing – airframe	**CAUTION: Per operating limitations, flight in icing conditions is not approved.** **Detection** Airframe icing may be detected by: an increase in engine power needed for level flight; and/or observation of ice accretion on the dome or leading edges (using the camera). There may also be "low engine power" alarms due to propeller icing (look for low RPM for a given throttle position) and occasional “rough engine running” alarms if the propeller sheds ice, suddenly increasing tach by a few hundred RPM. As flight control or pitot/static sensing degrade, there may be airspeed or other alarms. **Causes** Airframe icing occurs when the aircraft is in the right combination of cold temperatures and high humidity (or precipitation).

Emergency Procedures	
Flight control – Failure	**(cont.)**
Icing – airframe (cont.)	**Primary concerns** Icing is very dangerous as ice accumulation in any one of a number of areas can lead to loss of flight control. Accumulation on leading edges of the aircraft (wings, nose, winglets, etc.) can increase stall speed, increase drag, shift the center of gravity, etc. Icing of the propeller can reduce engine RPM for a given throttle position and reduce propeller efficiency/thrust. Icing of control surfaces can impair control. Icing on wing leading edges or wingtip hooks can impair hooking during SkyHook retrieval. One of the most severe dangers is icing of pitot or static pressure ports, which can lead to: airspeed or altitude sensing error; or failure and corresponding loss of control. In one case, pitot icing was the ultimate cause of a loss of control and crash of an aircraft. **Action** If at slow speed, increase commanded airspeed for margin against stall (approach speed may be increased by lowering Safe and Max CL to 0.5 if enough engine power for level flight at this speed is available). It may not be possible to greatly increase airspeed if engine power is also degraded by the conditions. Avoid steep bank angles and large angle-of-attack (steep banks can be avoided by lowering **bank angle** (**max yaw/(g/V)** in I-MUSE 5.0.X and earlier)). Adjust aircraft position/ altitude to avoid icing conditions (monitor OAT and humidity, if possible, as well as ice accumulation using camera). In one case, icing occurred during a freezing fog in a low-level temperature inversion. In this case, there was less icing at higher altitudes. Note that since the aircraft may lose control due to the icing, over-flight of people or property should be avoided. If ice accumulation can’t be stopped, quick SkyHook or runway retrieval should be conducted before icing causes loss of control.
Icing – carburetor	**Primary Concern** All carbureted engines are capable of experiencing carburetor icing under certain atmospheric conditions. Carburetor icing can partially or totally block the flow of the fuel/air mixture, resulting in engine failure. **Causes** As the aircraft carburetor vaporizes fuel, intake air is cooled by fuel evaporation. The carburetor venturi, throttle butterfly, or barrel valve further cools intake air by causing a pressure reduction (commonly known as intake manifold vacuum). If the air temperature drops below the dew point, moisture in the air condenses into water droplets. If the combination of these factors cools any part of the carburetor or intake below freezing and water is present, ice will form. Because lower throttle settings create greater levels of pressure reduction, lower throttle settings are more prone to carburetor icing. Carburetor temperature can drop below freezing when outside air temperature (OAT) is 15°C (59°F) or less. Carburetor ice is most likely to occur when the following parameters are met: ▪ OAT is -4° to 13°C (24.8° to 55.4°F); and ▪ Relative humidity is 70% or greater, or visible moisture is present, such as clouds, fog, rain or snow. **Note: Water can be present (high humidity) when flying in clear skies.** **CAUTION: The lower the throttle setting, the greater the pressure reduction across the carburetor, increasing the likelihood of carburetor icing.**

Emergency Procedures	
Flight control – Failure (cont.)	
Icing – carburetor (cont.)	**Detection** EO cameras can be used for icing detection by pointing the camera to the front of the dome. If icing is seen on the dome, the carburetor may have already developed a significant amount of ice. **Action** Refer to the emergency procedure *Degraded engine performance in carburetor icing conditions* in the *Pocket Handbook*. Additional avoidance and identification information is provided in *Troubleshooting*, later in this chapter.
Pilot's console – failure	**Primary concern** Failure of the pilot's console may make it impossible to turn the autopilot off, making preflight control surface checks difficult and manual control of the aircraft impossible. Failure of the pilot's console also makes CWS control impossible and limits control wheel tracking (CWT) control to keyboard inputs. It also might not be possible to use the pilot's console CTL switch in this situation. **Action** This problem is often related to the cabling – try unplugging and re-plugging.
Pitot (airspeed) – failure	Pitot failure may be the result of a plumbing blockage, constriction, disconnect, electrical sensor failure, or a problem with the static side of the pitot/static system. **Primary concern** Pitot failure is a critical failure because the autopilot relies on airspeed measurements for pitch control (and avoiding stall or over-speed, etc.). **Action** The autopilot detects large or total failures of the pitot system (high or low) and responds to the failure by holding estimated trim elevator (modulated by other terms such as pitch-rate). More subtle failures are more difficult to detect, but the operator can check for discrepancies between airspeed and groundspeed+wind or a discrepancy in altitude-rate, airspeed, and engine RPM. Dead-reckoning should be disabled when there is a pitot failure as wind-finding will be inaccurate, leading to dead-reckoning errors, and therefore, poor horizontal navigation.

Emergency Procedures	
Flight control – Failure	**(cont.)**
Stall / spin	**Action** The aircraft autopilot has automatic logic to recover from stall or spin. The operator may assist this logic somewhat, or stop an incipient stall by increasing commanded airspeed and commanding zero turn-rate (to keep the aircraft from stalling again as it continues tracking before completely regaining stability).
Static (altitude) – failure	**Primary concern** The most critical static failure is one that also affects airspeed sensing. For example, if the static ports were blocked, measured static pressure (and therefore altitude) would not change as the aircraft climbed or descended. Since total pressure from the pitot opening is compared against static pressure to determine airspeed (in this case with blocked static port), any increases in altitude would have corresponding decreases in indicated airspeed, and decreases in altitude would have corresponding increases in indicated airspeed (if actual airspeed were held constant). **Action** Therefore, in this failure case, current altitude should be maintained (using throttle commands) to minimize impact on airspeed sensing. Other static failure modes may only affect altitude sensing. In this case, it may be possible to safely continue flight by commanding throttle positions and closely monitoring GPS and DGPS heights. It may even be possible to complete autonomous SkyHook approaches if the failure is limited to the static channel. If the blockage is partial, you may be able to bring the aircraft home with slow, small changes in altitude command, and a long, shallow final.
Tracking – failure	This failure can be recognized by an inability of the aircraft to null (zero out) cross-track error and follow the active track as expected. **Action** ▪ Check wind solution. ▪ Disable (turn=0) and then re-enable track.
Ground control station – Restart	
FlightSim – restart	The *FlightSim Restart* checklist contains the procedure for setting up FlightSim if the program has been restarted.
If/C – restart	The *If/C Restart* checklist contains the procedure for setting up the If/C if it has been restarted/reset.
I-MUSE Client – restart	The *I-MUSE Client Restart* checklist contains the procedure for setting up an I-MUSE client if the program has been restarted.

Emergency Procedures	
Mobile ground station	
Note: **When operating with a mobile ground station, local terrain may change significantly, and emergency situations made more difficult to handle. The following paragraphs describe some differences that may not be obvious when handling emergencies with a mobile base, and these supplement the section on emergency procedures (EPs) elsewhere in this operator manual.**	
Centerline – error	Remember that control wheel tracking (CWT) allows for a centerline error that would normally trigger a wave-off. This might be appropriate for retrieval with high ground station movement. In this case, CWT could be used in hands-off mode, where no correction is applied with the console. The operator should remember that in this case, no misses will be called for centerline error, DGPS dropouts or high DGPS CEP. It is therefore critical to have an observer watching the approach, as this mode allows for navigation uncertainty, and the aircraft could come close to the ground station. An offset away from the boom is probably best used, which is safer but may result in some misses.
Comm – lost	Remember that in the event of lost comm, the aircraft will end up at its homecoming flightplan. The waypoint numbers cannot be changed, but they can be moved around. This flightplan should be moved as the ground station moves, if traveling a long distance. In the event of lost communications, it might be a good idea to point the antenna at a waypoint in the homecoming flightplan, as this is a known location where the aircraft will fly. Some ships have multiple directional antennas. Check to verify that the correct antenna is selected. It is possible that during a lost comm period the ground station software could crash, in which case, it would not know the updated flightplan. To plan around this, periodically it is a good idea to save the current flightplans to file, using the Plan Out feature. This file can then be read back in, and the antenna pointed and re-acquisition planned for. Without a reliable runway (for example at sea), it might be best to set the timeouts such that the aircraft does not ever try to land, and is in the air for as long as possible. If a runway is used, the operator must be certain that the path and area between the runway and home coming flightplan is free from obstructions and safe.
DGPS – no DGPS	Without DGPS, approaches may be done to the SkyHook in CWT mode, but it is likely that no proper bore-sight location is available (for example approaching parallel to a ship). Practice passes must be made, particularly to adjust the altitude errors (using rope touchdown point). When approaching the rope, small adjustments must be made, as anything significant could result in track being rotated in the wrong direction, possibly towards the ship. An observer should always be ready to wave off. Vehicle motion should be kept to a minimum through appropriate positioning. Users can also enter an estimated ground station position (**est GS)** if the ground station has moved significantly since the last DGPS update. As always, plenty of fuel allows for lots of time to practice for the retrieval attempt.
Engine out	Where possible, a safe landing area should be kept in mind. If over land, a good idea is to place a two waypoint flightplan over a flat area that is nearby, and can be tracked in the event of a stopped engine. When far out to sea, shore landing options should be planned for, but may not be reachable. In the event of ditching, try to make it towards home where recovery is an option, fly into the wind at minimum speed, and keep the wings level, always avoiding people and property. Some time floating is likely, depending on impact speed and how well the airframe stays together, and if the aircraft can be picked up, many components might be usable, although electronics are best not flown again. Any recovered non-electronic components should be cleaned with fresh water to remove salt.

<table>
<tr><th colspan="2">Emergency Procedures</th></tr>
<tr><th colspan="2">Mobile ground station (cont.)</th></tr>
<tr><td>GPS – no GPS</td><td>If in a new region or around new radiating sources (i.e. new ships), interference may cause GPS loss. Availability of ground references is potentially limited, both when out to sea, and also when in unfamiliar terrain if moving around a lot. Time should be spent learning the local landmarks; and be creative in the use of available heading references. For example, information can be gained from sun orientation, sea swells and waves, smoke drift and wind signals etc.</td></tr>
<tr><td>Helmsman – reset</td><td>It should be realized that in the event of Helmsman reset, the aircraft will revert back to its programmed flightplans, and any changes that have been made will be lost. If the ground station is moving a lot, the mission files should be updated often enough that with a reset, the aircraft will still remain in the area if it has lost communication.</td></tr>
<tr><th colspan="2">Powerplant – Failure</th></tr>
<tr><td>Engine – failure</td><td>Primary concern
Aircraft is losing altitude and will eventually impact the terrain.
Secondary concern
The battery is being drained since the generator is no longer providing electrical power (there is effectively a generator failure in addition to the engine failure). If the battery capacity is exhausted, the avionics will shut off and the aircraft will no longer be controlled, so it may be necessary to secure some electrical loads if flight time is likely to exceed battery capacity.
Action
Refer to Landing priorities, under the General Guidelines topic, earlier in this table.
This procedure can be used for landing without the engine, or in other situations where auto-approach can’t be used (even if the engine is healthy).
1 Create a two-waypoint flightplan (the engine-failure flightplan).
2 If time is sufficient, command the aircraft to an orbit at the downwind end of the flightplan. If there is not sufficient time for an orbit, command the aircraft to track the flightplan itself.
3 The aircraft can be held in an orbit downwind of the flightplan until reaching an appropriate altitude. Alternately, as the aircraft descends along the flightplan, the aircraft can be commanded to alternately track to the upwind and downwind waypoints, judging when to switch, in order to have the aircraft reach the desired landing point as it descends.
4 In simulations, an aircraft at medium gross weight and minimum speed loses approx. 115 feet (35 m) of altitude on a track reversal (180 deg), during engine failure, and ends up approximately 328 feet (100 m) down track from where the turn started. The same medium-weight, minimum-speed aircraft loses approx. 20 feet (6 m) of altitude every 328 feet (100 m) along track in calm wind.
Note: With a good engine, establish a decision height (such as 30 feet (9.14 m) off the ground). When the decision height is reached, make the decision whether to land. If landing, kill the engine; if not landing, command full-throttle, and the aircraft will climb. Another landing attempt can then be made.</td></tr>
</table>

Emergency Procedures	
Powerplant – Failure	**(cont.)**
Engine – failure (cont.)	**If the landing area is very narrow, GPS accuracy might not be sufficient. In this case, CWT can be used with either the nose camera or an outside observer. Commands such as “move the aircraft 5 feet to the left” can then be relayed and typed directly into the offset track field in the Advanced Autopilot Controls table.** **If the landing area is very short, place the waypoints beyond the ends of the landing area, then mark the actual landing area with Annotations. The waypoints are placed beyond the ends of the actual landing area to keep the aircraft from turning before reaching the end of the landing area (since the aircraft always turns before reaching a waypoint). Note the operator must command the aircraft to turn if the aircraft tries to fly beyond the landing area.**
Engine – degraded performance	There are a number of engine problems that may lead to the use of the *Degraded Engine Performance* checklist, such as: low RPM (due to cold engine, excessive load, poor performance, etc.); carburetor icing; low peak power (overheated engine, etc.); stuck throttle servo; fouled spark plug, etc. **Primary concern** An aircraft with degraded engine performance might not have enough power to maintain level flight or to power all electrical loads. As with engine failure, there could be eventual impact with the terrain and potential exhaustion of the battery. **Action** For some of these causes, immediate action by the operator may rectify the problem (low RPM, carburetor icing). If unable to maintain altitude, refer to the Landing Priorities and Recommended Landing Procedure.

6.11 Troubleshooting

In this section:

- Aircraft
- Antenna
- Launch systems
- Retrieval systems

If failures occur despite design and procedural defenses, then various automatic and operator responses are invoked. In many cases, appropriate action enables the operator to retrieve the aircraft without incident, or to be brought down safely. Use the *Emergency Procedure Checklists* whenever applicable.

Troubleshooting	
Aircraft	
Camera – splotches on image	When a camera is pointed into the sun, sensor pixels exposed to the direct sunlight may be super-heated and possibly annealed, biasing the signal and disrupting the calibration of the camera, and therefore the image. Over time, the effect may be reduced by repeated calibration cycles, however, the damage may be permanent. Therefore, it is important to remember: Don't point the camera into the sun.
Carburetor icing	Carburetor icing is best prevented by avoiding the conditions that lead to carburetor ice. Avoid operating when the OAT is 13°C (55.4°F) or less and: relative humidity is 70% or greater; or clouds or visible moisture are present. If climbs or descents through clouds are required, set throttle and speed as great as practicable to limit airframe and engine exposure to icing conditions. A combination of low to medium throttle settings (0.3 to 0.7) and high humidity result in the greatest risk of carburetor ice. Use C-10 fuel for year-round operations. C-10 has a low Reed Vapor Pressure (RVP), which equates to less fuel vaporizing in the carburetor venturi and intake, the most common locations for carburetor ice. MOGAS and Pump Gas have greater and broader RVP variations, making them more susceptible to and less predictable to the onset of carburetor icing. **Weather Forecast:** Prior to flight, obtain a complete weather briefing to include: ▪ Altimeter setting ▪ Temperatures at operating altitudes ▪ Winds at operating altitudes ▪ Dew point temperature ▪ Relative humidity ▪ Cloud altitudes Update weather forecast every three hours, or as needed during rapidly changing weather conditions. **Weather Observation During Flight:** Monitor the OAT during launch, climb, cruise, and descent. If icing conditions are encountered, seek an altitude with warmer air as noted during prior climbs and descents. EO equipped aircraft should note cloud formations. Watch for a temperature inversion (greater temperature at higher altitude). If carburetor icing is encountered in a temperature inversion, a climb to a higher altitude may be required.

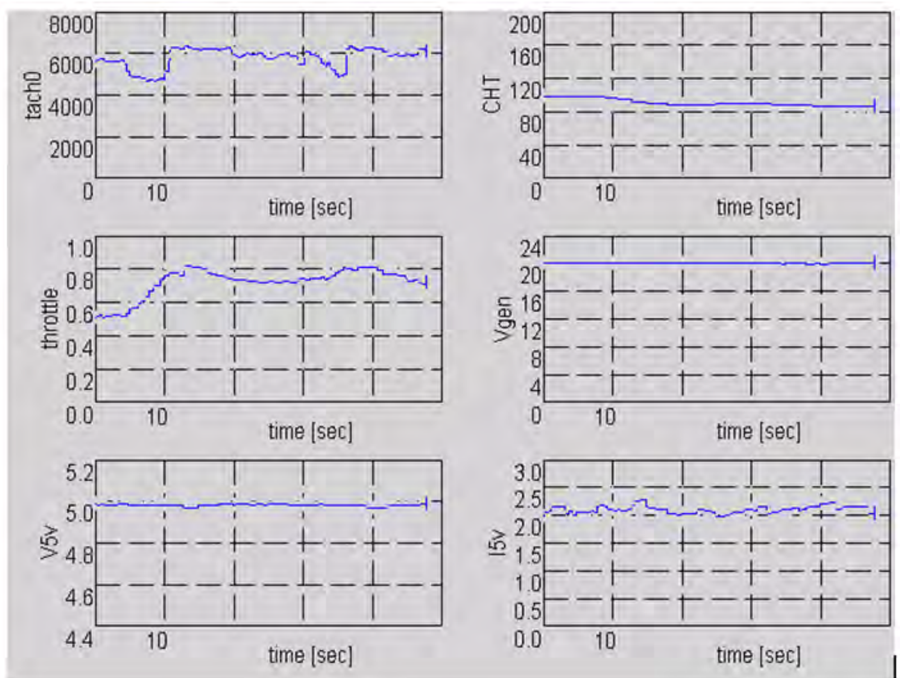
Troubleshooting

Aircraft (cont.)

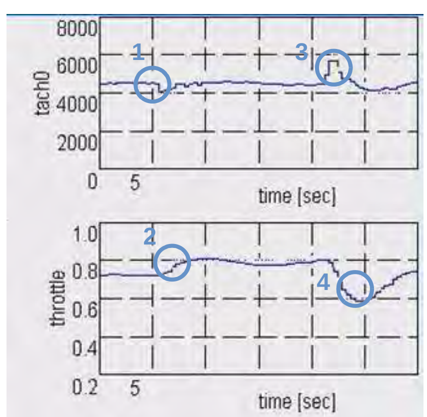
Carburetor icing (cont.)

Example carburetor icing telemetry

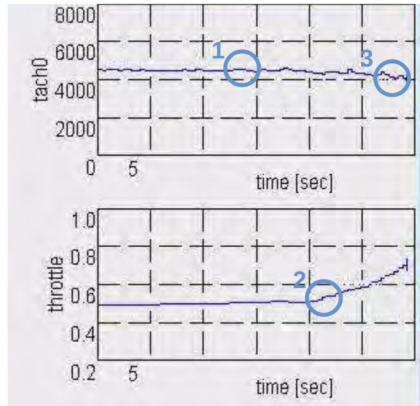
The following plots show telemetry from a suspected carburetor icing event. In this case, the engine later stalled. Notice the throttle setting and RPM correlation, and falling CHT.



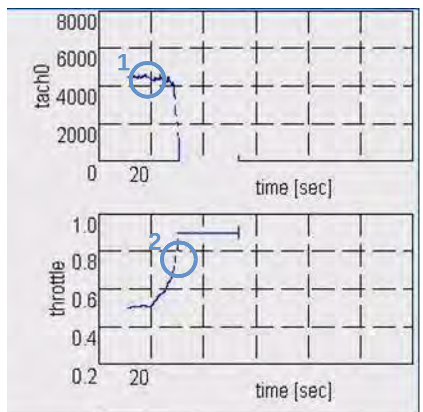
These plots were obtained from carburetor icing events on the ground, with an OAT of 2°C (35.6°F) and visible moisture in the form of drizzle and rain. The commanded throttle was 0.47 to 0.48 to maintain 4500 RPM.

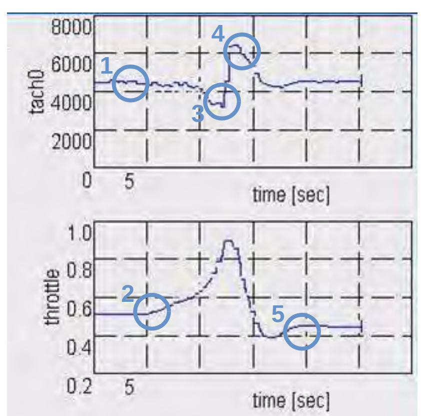


1. **Carburetor ice develops and RPM drops.**
2. **Helmsman increases throttle to prevent further drop in RPM.**
3. **The increase in RPM from Helmsman clears carburetor ice.**
4. **Helmsman reduces throttle once carburetor ice is clear.**

<table>
<tr><th colspan="3">Troubleshooting</th></tr>
<tr><th colspan="2">Aircraft</th><th>(cont.)</th></tr>
<tr>
<td>Carburetor icing (cont.)</td>
<td>These plots show an event where the engine spent a long time partially iced up, requiring low- to mid-throttle (0.5) to maintain 4500 RPM. It then degraded quickly and required full throttle.</td>
<td>

1 Carburetor ice starts to develop.
2 Helmsman slowly increases throttle to keep commanded RPM.
3 Carburetor continues to develop ice; RPM later decays to an unrecoverable level (not shown).

Note: Aggressive manual throttle commands could have prevented this engine stall.</td>
</tr>
<tr>
<td></td>
<td>These plots show an engine with a high level of carburetor icing. Autopilot commanded full throttle, resulting in an engine stall. Do not allow the autopilot to rapidly command full throttle when carburetor icing is possible.</td>
<td>

1 Carburetor has developed a high level of ice.
2 Helmsman commands a rapid throttle increase, resulting in engine stall.</td>
</tr>
<tr>
<td></td>
<td>These plots show the autopilot commanding full throttle and clearing ice from the carburetor. This behavior is not seen consistently.</td>
<td>

Note: Applying full throttle may cause engine stall. Advance throttle in 0.1 increments every two seconds.

1 Engine develops carburetor ice.
2 Helmsman starts a moderate increase in commanded throttle.
3 RPM decays to a near engine stall level.
4 Carburetor ice clears.
5 Helmsman reduces throttle to pre-carburetor ice level.</td>
</tr>
</table>

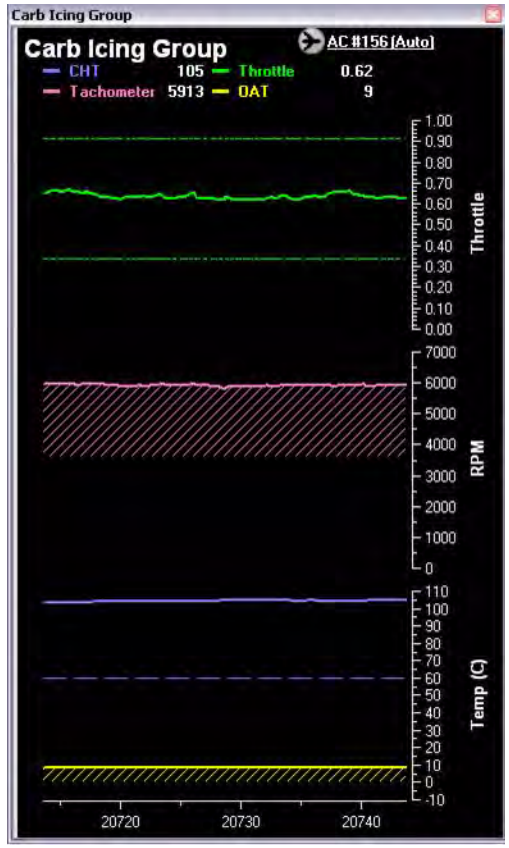
Troubleshooting

Aircraft (cont.)

Carburetor icing (cont.)

Operational procedures during potential icing conditions

The *Carb Icing Group* plot is used in conditions with a high potential for carburetor icing. When these conditions are met, be aware of engine performance – open the plot, titled *Carb Icing Group*.



Note: The *Carb Icing Group* plot is available on Insitu's Extranet or from Insitu's Operations Support Group. Add the following files to the I-MUSE Plots folder (C:\Program Files\InsituGroup 5\Imuse\DataFiles\ Plots):

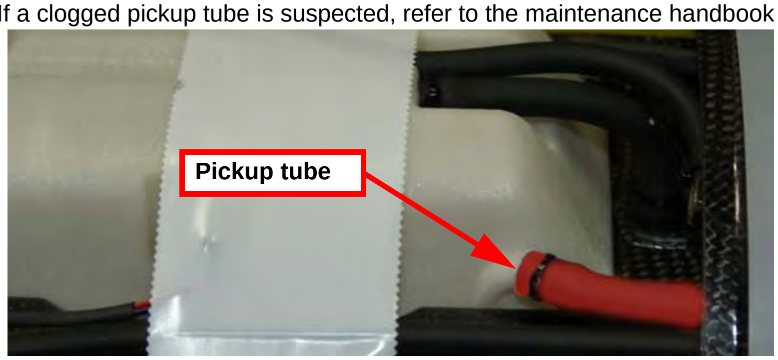
- **Carb Icing Group.xml**
- **Carb Icing Group.PlotProperties**

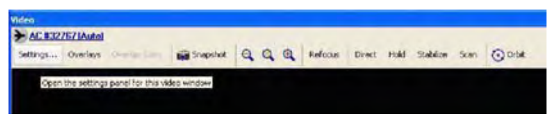
The *Carb Icing Group* plot will show up in the list of available plots.

Troubleshooting	
Aircraft	**(cont.)**
CHT with active intake	Beginning with Block D aircraft, cylinder head temperature (CHT) is actively controlled by the active CHT intake, which has a flap that opens and closes to maintain engine temperature between approximately 110°C and 130°C. When the aircraft is powered on, the flap in the engine cooling shroud opens for approximately 15 seconds, then slowly closes. If the flap doesn't open, the engine gets too hot. If the flap stays open for too long, the engine gets too cold. If CHT goes outside the limits, an alarm is heard. If the active CHT intake fails, the result may be a burned out engine. If the active CHT intake flap does not open and close properly, refer to the *Maintenance Handbook* for troubleshooting. 
CHT with cylinder cap	The CHT with the cylinder cap is inadequate in low temperatures. Resolve this problem as follows: In flight: ▪ Avoid CHT below 122 deg F (50 deg C). ▪ Increase power setting if possible. ▪ For long, cold descents, level off a few times and cruise at a higher power setting. Temporary fix: ▪ Block the cylinder head outlet with a metal sheet. ▪ Make sure the metal sheet is secure, does not rattle, and will not become loose.
Communica-tions – loss	Normally the ground station maintains a steady uplink stream to the aircraft (including a heartbeat message if no other traffic is needed). If this uplink traffic is not received for a specified length of time, then the aircraft starts its lost-comm protocol. This includes (unless uplink is regained at some point) the following: ▪ Commanding a safe speed (typically low-speed cruise); ▪ Climbing to altitude sufficient to re-establish line-of-sight with the ground station; ▪ Intercepting a designated route to a terminal circuit; ▪ Holding in the terminal circuit for a specified period (to allow the ground crew to reestablish communications, etc.); and ▪ Ultimately, landing on one of several designated runways (which might in fact be in the sea).

Troubleshooting	
Aircraft	**(cont.)**
Communications – loss (cont.)	The operator is alerted to loss of communication aurally, by a “no downlink” announcement, and visually, by the aircraft-state display switching to red background. Further visual indication is provided if any uplinked command is not acknowledged. The operator’s checklist procedures for lost-comm include various steps toward restoring link; notification of appropriate crew members and ATC (Air Traffic Control); and simulation based on last-reported aircraft data in order to establish the expected timeline for the lost-comm protocol. Various lost-comm situations are simulated as part of qualifying each revision of flight software, and each new mission plan to be stored on the aircraft. Hence the protocol is frequently tested in simulation.
Deadman monitor	The engine ignition is powered through a deadman switch that must be refreshed about once-per-second by the flight computer. Therefore, a software, processor, or power fault that interrupts normal execution of the onboard computer will cut the ignition immediately. This is exercised in simulation, but no actual failure to refresh, or failure of the deadman switch, has occurred in well over 10,000 hours of flight and simulation on A-15 and A-20 aircraft.
Electrical supply – loss	When the engine is running (except at low idle) the generator runs all aircraft busses and charges the battery. Normal procedure involves checking for a full battery charge before takeoff, so that full capacity is always available in the event of generator failure. If the generator fails then the load switches to the battery, and the operator is notified by visual and aural alerts (“discharge”).
Flight – terminated	If the aircraft is in its lost-comm protocol, and it is 1) lost, because of GPS failure; or 2) outside of a specified kill perimeter around its programmed track; then it cuts the ignition and continues navigating as before (which in the case of GPS failure, will be a tight turn to minimize drifting). In navigation failure (due to GPS loss), the turn rate is approximately 14 deg/s (0.25 rad/s), which amounts to one complete revolution in approximately 25 seconds. This value varies somewhat depending on a number of parameters, such as speed, weight, and ambient conditions. Flight termination has rarely been invoked in flight, but is routinely exercised in simulation as part of lost-comm testing. Unless the comm link has also failed, the operator has visual and aural indications of both navigation failure and kill-perimeter violation. The decision to cut ignition is then left to the ground station operator. Inadvertent ignition-kill is discouraged by requiring the operator to arm the ground station to accept the command, and to complete a two-keystroke query/confirmation protocol when command is issued.
Flight control – inner-loop flight control sensors, loss	The UAS relies on five sensors for inner-loop flight control, measuring pitot/static, roll, pitch, and yaw rates. With the GPS, these constitute the complete sensor suite for flight control (as opposed to those for systems monitoring). Under some circumstances, failure of the pitch- or roll-rate inputs is tolerated, under other circumstances, a rate-sensing failure causes loss of control. Failure of pitot/static sensing can be less serious: a subtle failure may cause loss of control, while a failure to an implausible value causes the aircraft to ignore pitot/static pressure, and set the elevator as calculated for trim at the commanded airspeed. Failure of static-pressure sensing (i.e. barometric altimetry) results in failure to regulate altitude. To intervene, command throttle directly while using GPS altitude, video, or visual contact for reference. If an input failure is such that the measured value is outside specified limits (e.g. a hard-over failure) an aural announcement (“too slow”, “roll rate”, “too high”, etc.) and a flashing-yellow display of the affected state variable alerts the operator. More subtle failures may be discerned from behavior (e.g. inappropriate pressure-altitude variation in response to engine-speed change).

Troubleshooting	
Aircraft	**(cont.)**
Flight controls – unresponsive	The aircraft utilizes six flight control surfaces: four elevons and two rudders. Servo failure is rare and when these failures occur airborne the autopilot compensates with little performance degradation. Fully autonomous Skyhook captures have been accomplished with a simultaneous single elevon and single rudder failure. Aircraft shall not be launched when any servo failure has been detected prior to flight.
Fuel-level sensor	The fuel-level sensor provides a continuous, direct measure of fuel in the main fuel tank.The fuel-level sensor is only accurate in straight and level flight. During climbs, decents, or sustained turns, or when the aircraft is on the launcher, the sensor may be inaccurate. A new alarm – fuel discrepancy – indicates at least 500 grams (1 pound) of disagreement between the fuel estimator and the fuel-level sensor. If there is a fuel discrepancy, fly straight and level, and set the estimator to agree with the sensor by entering the sensor value in the estimator field. **Note: The fuel-level sensor indicates fuel level at a specific point in the main fuel tank. If the main fuel tank is not level, the indication on the sensor will be incorrect.** **CAUTION: The fuel-level sensor is calibrated for certain fuel types. It is calibrated to function with all fuel types recommended in the *Maintenance Handbook* except Motorsport 109 (winter fuel).** **Note: Pre-Block D low-fuel alarms related to the fuel estimator have not been changed.**

Troubleshooting	
Aircraft	**(cont.)**
Header tank fuel sensor (bingo sensor)	The header tank fuel sensor (also known as the bingo sensor) indicates **full** or **low**, providing a discrete indication of fuel in the header tank. When the header tank fuel sensor indicates fuel is **low**, the header tank has 300 grams (10 ounces) of fuel remaining (approximately 75% of the header tank capacity). During defueling, the alarm indicates **low** when there are 300 g (10 oz.) of fuel left in the header tank. During fueling, the sensor won't return to **full** until there is approximately 1 kg (2.2 lbs.) of fuel in the aircraft – that is, approximately 400 g (14 oz.) in the header tank and 600 g (1.3 lbs.) in the main fuel tank. **Note: After the sensor switches to low, indicating there are only 300 g (10 oz.) of fuel remaining, it will not return to full until the aircraft has 1 kg of fuel. This is not a failure. The alarm was designed in consideration of sloshing, to prevent the alarm from continually switching between full and low when the header tank has very close to 300 g (10 oz.) of fuel.** If the header tank fuel sensor alarm goes off unexpectedly, there may be a clogged pickup tube, resulting in the lack of fuel transfer from the main tank to the header tank. If a clogged pickup tube is suspected, refer to the maintenance handbook 
Header tank – collapse	The fuel vent line must have some clearance from the top of the header tank to allow for proper air intake and exhaust. When the fuel vent line is not properly positioned, the header tank has been known to collapse; the pump may also slow and pull bubbles during de-fueling, beyond those typically seen when the aircraft is empty.

Troubleshooting	
Aircraft	**(cont.)**
I-MUSE – overlays not received or improperly displayed	When sending I-MUSE overlays, ensure that the proper settings are configured to allow overlays to be sent. In I-MUSE 5.0, the Video Output window allows for precise control over which overlay elements to display. In earlier versions of I-MUSE, the **Output** box must be checked in the settings window of the Video Overlays section. If the proper box is not checked, the I-MUSE overlay will not be sent. These setting apply only to video coming from I-MUSE. I-MUSE can receive input video from any source, including raw video from aircraft, stabilized video from specialized hardware, and video from ObjectTracker. If ObjectTracker video output is routed to I-MUSE video input, then I-MUSE video output will appear the same as ObjectTracker, including any overlays that ObjectTracker may burn into video image. In this scenario, when I-MUSE receives ObjectTracker video, ObjectTracker-generated overlays must be turned off, otherwise users will see both overlays. **In I-MUSE 5.0 and later:** 1 There are two ways to access video settings: a. Select I-MUSE menu items **Video -> Video Settings**… to open I-MUSE Settings panel with Video settings tab in focus:  b. Click **Setting…** toolbar button on the video window panel: 

Troubleshooting

Aircraft **(cont.)**

I-MUSE – overlays not received or improperly displayed (cont.)

2 On appropriate Video source Settings tab (there may be more than one video source defined) make sure:

a. Source field says: “FlashBus Spectrim VIDCAP Driver.” Only this type of video capture device supports video output (this device is standard for current GCS).

b. **Video Output** option is selected in Overlays section.

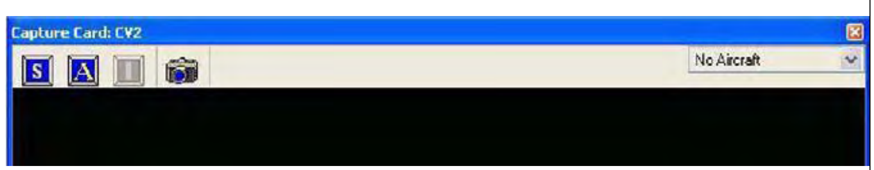
c. Video output overlay options are set as required.

3 Click **OK** or **Apply** button to commit the changes.

In I-MUSE 4.2X and earlier:

1 Click I-MUSE menu items **Video -> View Capture Card** to open video window panel:

2 On video window toolbar click **S** button to open Capture Card Video Settings panel:



3 On Capture Card Video Settings panel make sure:

a. **Live Video** option is selected in Video Output section;

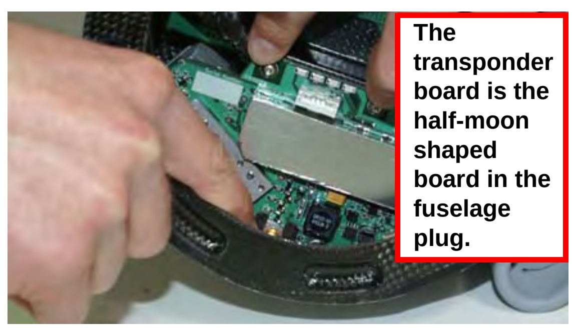
b. **Symbology Enabled** check box is checked;

c. **Output** check box in Symbology Options is checked.

4 Click **OK** or **Apply** button to commit the changes.

Flight 6

Troubleshooting	
Aircraft	**(cont.)**
Navigation – failure	The aircraft navigates at 10 Hz, with GPS corrections at 5 Hz. If the GPS position solution is lost due to some type of failure, then the aircraft will continue to navigate using its dead-reckoning sensors for the period of time specified in the communication parameters file. The default setting is 60 seconds. After this point the aircraft will stop navigating and command a tight radius turn. The aircraft may start drifting with the wind. The operator can issue steering commands, using visual contact or nose-camera video for guidance. The operator is alerted to loss of GPS aurally, by a “GPS failure” announcement, and visually by the navigation-state display switching to red background. If link is lost, then loss of GPS will invoke flight termination as discussed earlier.
ObjectTracker – target coordinate not displayed	After loading a new ACparam file, restart ObjectTracker as noted in the preflight Check. If ObjectTracker is not restarted, ObjectTracker will neither recognize the new aircraft configuration nor acquire the necessary ACparam file. As a result, target coordinates will not be displayed on ObjectTracker. If ObjectTracker was not restarted before the aircraft was powered on, to correct the problem during Video System Check: 1 Restart ObjectTracker. 2 Get a parameter report. 3 Download the A/C parameter file from the aircraft (ALT-F5 page); or, transfer the binary ACparam file via network or USB drive from another computer or folder (e.g. from the I-MUSE computer) to the ObjectTracker folder on the ObjectTracker computer. 4 Get a parameter report. 5 Check alarm settings.
Power – rapid, premature loss or malfunction	Use of 100 LL or petroleum-based oil additives will result in rapid, premature power losses and malfunctions. Only unleaded auto gasoline mixed with synthetic oil per 3W requirements may be used. Petroleum-based 2-stroke oil is only used during the initial 3 hours of engine break-in. (The abrasive in the oil helps seat the rings when used explicitly per 3W recommendations.) Use of petroleum-based additives beyond the 3-hour break-in period will lead to excessive wear of rings and cylinder walls, leading to premature failure.
Propulsion – loss	If the engine stops unexpectedly (as opposed to being commanded from the ground, or as part of the landing sequence), the operator is immediately notified by visual and aural alerts (“low RPM”). The battery assumes the electrical load, and has sufficient capacity for approximately 15 minutes of flight when all payloads are enabled. Turning off all payloads will extend battery life to approximately an hour. The operator’s checklist procedure involves first directing the aircraft by waypoints or turn commands, along an appropriate path, then shedding unnecessary electrical loads (e.g. video equipment). The ground station can generate performance charts to determine descent rate, glide ratio, and time/altitude at the commanded waypoint, which are calculated as functions of commanded speed for ambient wind and aircraft condition. (Upcoming software will add a projection of battery capacity to the existing display of downlinked voltages and currents.)

Troubleshooting	
Aircraft	**(cont.)**
Propulsion – loss (cont.	Carburetor ice occurs from fuel vaporization in the carburetor's low pressure throat area (venturi) causing a sharp temperature drop inside the carburetor throat. If the throat area is at or below freezing as a result of this temperature drop and there is water vapor in the air, ice could form on the internal surfaces of the carburetor throat, including the throttle valve. Conditions for carburetor ice formation are most favorable when outside air temperatures are at or below 70 degrees F (21 degrees C) and relative humidity is 80% or higher. When carburetor ice formation was suspected during ground run testing of the engine in an aircraft installation, a rapid throttle transient more often than not seemed to clear the condition. For more information, see *Carburetor icing*, earlier in this section. Fuel flow is estimated online by a carburetor model, which is rarely in error by more than 10%, and often is much better. Fuel weight is updated once per minute and downlinked to the ground station. **Note: If fuel vent line is not pointed away from the header tank, erroneous fuel readings have been known to occur due to fueling errors.**
Roll dynamics – when tracking to an orbit, unexpected	During an orbit, the aircraft attempts to hold a radius with respect to a center point. Incorrect aircraft wind estimates may affect the aircraft response and calculation of heading. Occasionally, this may cause the aircraft to enter a series of sharp roll dynamics when converging on a new orbit. The rolls are commanded by the autopilot. The problem can be corrected by sending the aircraft to a new waypoint, or tracking directly to a waypoint.
TAS – red	There is a standard preflight check of airspeed at rest (zero airspeed). Note that pitot and static pressure ports must be completely sheltered from wind to perform this test. **The aircraft is not cleared for flight if TAS is red during this test.** During the test, TAS ideally reads 0 (zero) m/s. The maximum error allowed is +/-19.68 feet/second (6 m/s). TAS must read between -6 and +6 m/s for the aircraft to be ready for flight. (Note that +/-6 m/s error at an actual TAS of 0 m/s corresponds to a +/-3.28 feet/second (1 m/s) error at an actual TAS of 65.62 feet/second (20 m/s) (20 Pa error in both cases).) TAS will be displayed in red if TAS is less than -6 m/s.
Transponder	 Block D aircraft and later are equipped with a transponder, which transmits an identification code and altitude to air traffic control. A red warning in I-MUSE informs the operator when the transponder has failed. The result of flying with a failed transponder is the same as flying with the transponder off – the aircraft will not send a signal indicating at what level it is flying. The transponder board is not field repairable. If the transponder board fails, remove it and return it to Insitu. Replace the transponder board with a new one. See the *Maintenance Handbook* for remove and replace instructions. **Note: The mission commander ultimately decides whether to fly with a failed transponder.**

Troubleshooting

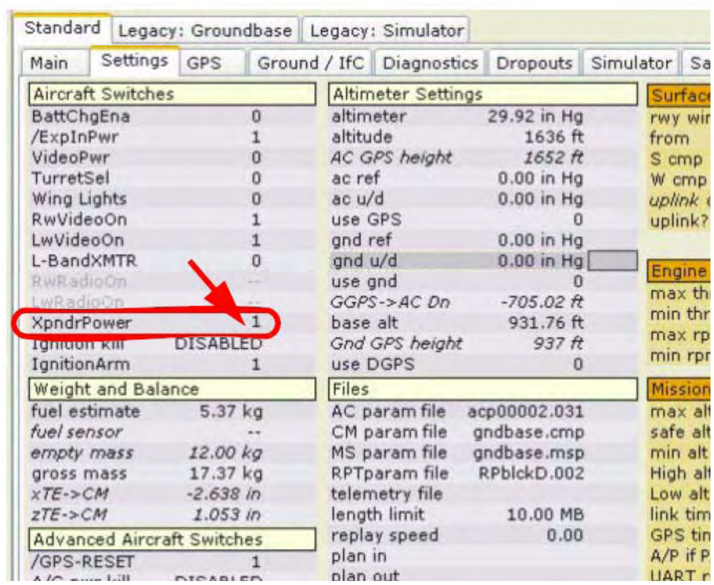
Aircraft	**(cont.)**
Transponder (cont.)	If the primary transponder display shows a healthy transponder (indicated by green font on the primary transponder display), but air traffic control reports no response, check that antenna cable is attached and check that antenna is properly installed, as described in the *Maintenane Handbook*. Ensure that transponder antenna is within line of site of receiving radar during test. Replace antenna if bent or broken. If the antenna is properly attached and the problem persists, replace the transponder board and return it to Insitu.

If the primary transponder display shows a failure (indicated by red font on the primary transponder display and a **fail** message in the diagnostics section of the transponder options panel), troubleshoot as follows:

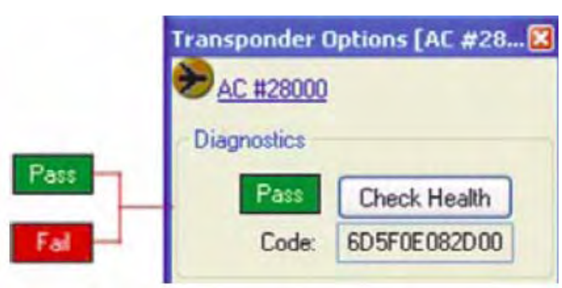
1 Transponder power:

Cycle the power to the transponder as follows:

- Change the power bit to 0 (default is 1).

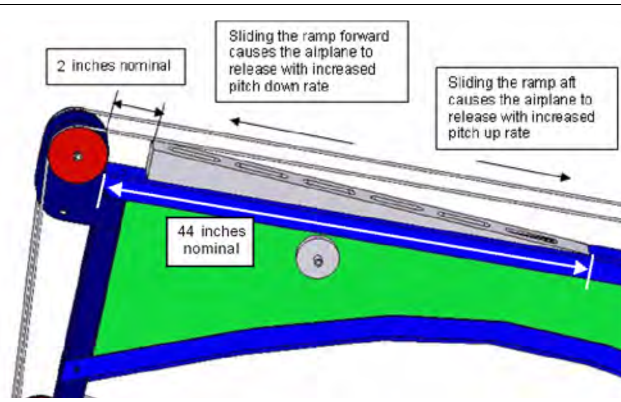


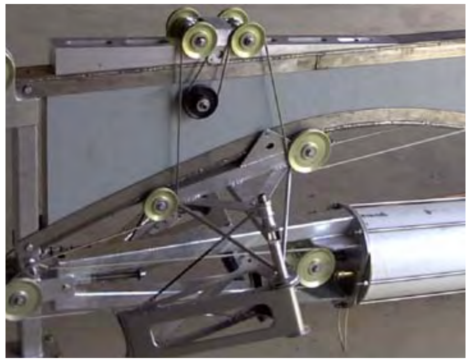
- Wait 20 seconds.
- Change the power bit back to 1.
- Wait 20 seconds.
- Check the health from the transponder options panel by clicking **Check Health** button.



- If the health indicated is passing, no further troubleshooting is required. If the health fails, refer to the *Maintenance Handbook.*

Troubleshooting	
Antenna	
Communica-tions – loss	If there is a communications loss at arbitrary times, without regard to direction: ▪ Consider possibility of 900 MHz jamming activity in that direction. Contact Insitu for workaround options if this is identified as a possible issue.
Range – inadequate	If the range is inadequate in all directions (less than 100 km): ▪ Check feed alignment and spacing with respect to parabolic dish; verify that tripod mount is level and that antenna backplate is vertical when tracking a target at the horizon. ▪ Check azimuth alignment. For example, if the antennas are more than 100 m apart: a) aim each antenna at the other antenna's GPS coordinates; b) while standing at each antenna in turn, verify that the feed assembly for the other antenna appears to be exactly centered with respect to its backplate. ▪ Examine dish for obvious distortions, bends, etc. ▪ Check for tight fit of cable connectors; check for damaged cables (spare cables are provided). If the range is inadequate in some directions: ▪ Look for possible sources of RF interference in the offending directions. These could be 900 MHz cell towers or 2.4 GHz systems. The command trailer uses a 900 MHz intercom system and could introduce downlink losses when the directional antenna is oriented within about 10 degrees of the trailer, particularly at long range. ▪ Look for terrain obstructions.
Sluggish	If the antenna is sluggish and lags the aircraft: ▪ Perform antenna calibration. If the antenna appears to lead the aircraft in some directions, and lag in others: ▪ Check azimuth adjustment and sign of adjustment (+/-) that was input to the If/C.

Troubleshooting	
Launch systems	
Gripper brake – adjustments	If one or both grippers opens too far, the gripper brake nuts may need to be adjusted. There should always be 6 inches minimum distance between the gripper halves. There should always be 4 inches minimum distance between the fixed diagonal brace and the swinging diagonal brace.   Gripper opening rotation The left gripper stops with a left-hand threaded rod, clamping axially down on a 3-inch abradable washer. The right gripper does the same with a right-hand threaded rod. To tighten the brake, simply remove the two #10 machine screws that lock the brass adjustment nuts in place, and tighten the brass nut, as needed, to prevent over-rotation. Replace the #10 machine screws. Generally these adjustments are made 1/12 turn at a time.   Tightening hinge post brakes
Pitch rate – adjustments	The aircraft should always release from the launcher with less than 1 rad/s pitch rate. A properly weighted dummy (with CG in proper fore/aft position) releases with the same pitch rate as the aircraft. If aircraft or dummy consistently release with unacceptably  great pitch rates (up or down), adjust the ski ramp for a cleaner release. The nominal setting for the ski ramp is with a 2 inch gap between the forward post and the ski ramp. The ski ramp can be adjusted by loosening screws and sliding the ramp. Tighten the screws with locktite 272 (blue).

Troubleshooting	
Transport – adjustments for C-130	Rig the launcher carriage for C-130 transport where head clearance is limited. Carriage is rigged in an inverted position.  1 Open the exhaust valve to vent air from the cylinder. 2 Remove the kickstand, but keep all washers and pulleys in place on the forward post. 3 Remove the safety pin and (using the winch) ease carriage forward until the transmission rope goes slack. 4 While a helper is balancing the upper carriage, remove bogey (lower carriage) first. Then, pull the release trigger and remove the upper carriage. 5 Place bogey on top track with forks facing down. The wheels should be rolling on the track surface. 6 Invert the carriage, open the grippers wide, and carefully feed it through the gap between the lower track and the cylinder cage. 7 Lace the rope through the pulleys like in the photo. Note the top forward pulleys are not used, but the wide arresting pulleys are used. 8 Keeping exhaust valve open, run the air compressor, until rope is pulled tight. 9 Check to make sure all wheels are centered on the track. Note the rear wheel may not be in contact with the track. 10 Close the exhaust valve and inflate to 5 psi for transport. Gently close the grippers until they touch. 11 Reverse the procedure to rig the carriage again for use.
Retrieval systems	
See the *Troubleshooting* section in Chapter 7: *Retrieval.*	

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Retrieval

Chapter Map			
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7.1 Approach Principles

In this section:

- Length and slope
- Hold position
- Misses – Parameters and types

This section provides general guidelines for loading an approach, starting the approach, and the sequence the aircraft goes through.

Note: As a prerequisite for understanding and using this material, you must have successfully completed Insitu's training for the setup and geometry of approaches.

Approach Principles

Length and slope

Approach length and slope must be chosen to ensure good clearance between the aircraft and the ground obstacles. For approach over obstacles (such as power lines), approach slope may be increased to give extra height. The limits for approach slope are:

- Min 3.1%
- Max 7.0% or so — this varies with weight and wind. Simulations will show the point at which the aircraft has trouble descending to keep on the approach path, and simulations are the best tool to design the approach parameters.

For operation near tall structures, it is recommended to increase final length. This makes the FAF higher, so it is safer. This also allows margin for convergence on centerline, as the aircraft will often start to descend as it turns onto the approach path, even if it is on the outer edge of its holding orbit.

Hold position

Offsetting hold position from FAF may help reduce issues with ground structures. **Important!** Hold in an offset position and trigger the approach only when aircraft is heading roughly in the direction of final approach fix. In any other direction, aircraft may enter sequence of maneuvers to converge on centerline, potentially reducing the distance to obstacle to an unsafe level.

Misses – Parameters and types

The SkyHook approach allows the operator two types of miss behavior: a wave-off or a go-around. Normal procedure is to use the wave-off, but go-arounds are used in some situations.

During a wave-off, the aircraft performs an immediate turn out from final approach and climbs back to the FAF, in a specified direction.

During a go-around, aircraft climbs straight out, offsetting its track if desired, and turns only once before reaching the miss point past TD length or approaching FAF height. This allows a long climb out before the turn. Take care, as this means the aircraft will stay longer in the low pass state. Furthermore, if the go-around is not manually triggered, the aircraft will not climb, but will stay at retrieval height for this distance. In the event of a missed rope or a practice attempt, the go-around must be triggered when the aircraft is past the SkyHook. If the aircraft decides to go-around, no triggering is needed, and behavior will be safe.

For information about disabling Approach Miss Reasons, refer to the *Approach Monitor* heading in the *Approach Settings* table, later in this chapter. The primary purpose of switching to go-arounds is obstacle avoidance. Situations where the approach area is constrained may include:

- trees at the side of the runway
- towers close to the approach path
- power lines and buildings in the wave-off path

Remember that the aircraft could decide to go missed at any moment during the approach. This means that all areas of the wave-off side must be clear of structures above a certain height. If this could be an issue, then go-arounds should be used.

In both a wave-off and a go-around, the aircraft will go directly to the FAF if the observer state is left as **OK**. This may not be desirable for obstruction proximity, as the direction of the aircraft's sharp turn cannot be controlled. A safer method is to leave the observer state in **Reject!** until the aircraft is established in the procedure turn. Then, allow the aircraft to go to FAF once in a safe position.

Note: In a go-around, there is little control over the direction the aircraft turns once reaching the upwind x length or approaching FAF height. The best means to guarantee a turn to the desired direction is to offset the hold orbit in the direction of the desired turn (i.e. left or right), and then ensure the observer state is left in Reject! as mentioned above.

7.2 Approach Procedures

In this section:

- Angle – Crab angle
- Control wheel tracking (CWT)
- Engine – Idle setting
- Observers
- Speed of retrieval

Approach Procedures
Angle – Crab angle
When approaching into a strong crosswind, the aircraft will crab or yaw into the wind. Occasionally this leads to a large crab angle. The aircraft senses the crosswind and offsets its position autonomously, but care should be taken for the direction it is offsetting. This may be towards the SkyHook or away. During normal operations, the crab angle should be checked once converged onto centerline of the approach path. I-MUSE automatically calculates the crab angle. The aircraft wing sweep is about 23°, so any crab exceeding 20° is very dangerous, as this may lead to an unsuccessful capture. Normal procedure is to offset half a meter away from the rope, but if there is a crosswind that the nose of the aircraft to point towards the SkyHook, it is safer to offset towards the SkyHook to catch the wing that is most forward. This is an inside catch, but can be safe when done with an observer.
Control wheel tracking (CWT)
Control Wheel Tracking allows the operator a method for an accurate SkyHook retrieval despite trouble with DGPS. This procedure corrects small errors in track position through input on the pilot's console rudder stick. Select **Standard Tables** from the **Tables** menu on the I-MUSE toolbar and enter **CWT** in the track field of the **Autopilot** table. This method requires the observer to be in a bore-sight position with the pilot's console. If this is not possible, the alternative – to give direction over a radio – is extremely difficult and not recommended. For any CWT attempt, first make many practice attempts using HiL, followed by many practice runs over top of boom before final approach. If approaching without DGPS, altitude may be incorrect due to GPS inaccuracy. If possible, verify altitude by passing to the side in practice attempts. Adjust the touchdown point if necessary.
Engine – Idle setting
The faster the aircraft flies, the faster the propeller spins (like a windmill). Hence when flying fast but descending (perhaps in procedure turn), engine RPM will appear higher than at loiter speed or on the launcher. Do not reduce minimum throttle setting at this point, as this would lead to RPM roll-back when the aircraft slows to approach speed, and the propeller slows. Therefore, only adjust the idle setting when flying at slow speeds. Always match throttle settings to the published minimum limitations for that engine. Only adjust the setting in small increments, and monitor the electrical state of the aircraft. To manually enter RPM values, select **Standard Tables** from the **Tables** menu on the **I-MUSE** toolbar and enter the desired RPM in the **AP thr/rpm** field of the Autopilot table. With reduced generator output and a high power draw, some drop may be seen in bus voltages. If this occurs, the operator may opt to turn a video transmitter off, or maybe even disable the video system to reduce electrical load. To make changes, select **Open Plot** from the **Plots** menu on the I-MUSE toolbar. Select **Electrical Group** and click **Open**.

Approach Procedures
Observers
Normal procedure is to have an observer watching approach. The operator has full readout of position through telemetry, but there may be a situation where the observer thinks that the situation is unsafe. Note the aircraft has no information on ground obstacles; it monitors its approach position and aircraft state, and will wave-off autonomously if needed. Ideally, an observer bore-sights the approach, standing a safe distance back from the SkyHook (100 m (328 feet)). Recording the approach is a good idea – in the event anything goes wrong, the video data can be analyzed for causal factors.
Speed of retrieval
When aircraft turns onto final approach path, check ground speed in Approach Monitor located under **Panel** in I-MUSE toolbar. Aircraft accelerates if above desired glide slope, or in presence of tailwind. When groundspeed reaches approx. 27 m/s (52 knots), airframe damage begins to occur. Always do approach into the wind, and monitor crab angle. Call a miss if the ground speed is too high, and check wind direction and engine idle setting (the aircraft will speed up to descend if the RPM is too fast).

7.3 Approach Settings

In this section:

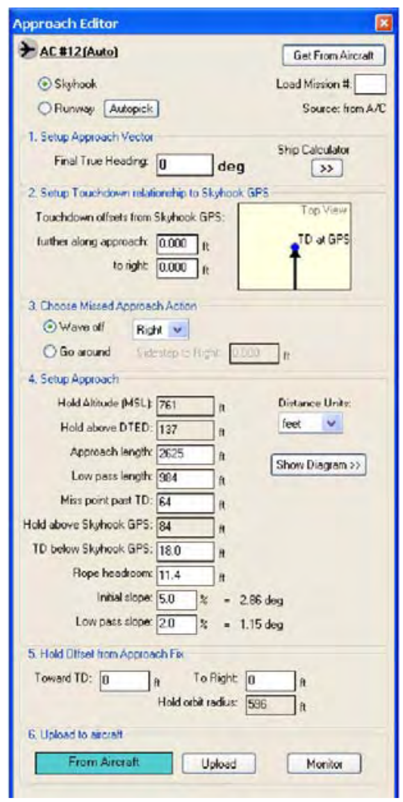
- Approach plan – Specifying
- Approach plan – SkyHook
- Approach plan – Runway
- Approach Monitor
- Miss reasons – Effect of disabling
- Data values
- Wind & pressure
- Auto retrieval

Note: All approach information is contained in the Approach Editor and Approach Monitor located in the Panel menu on the I-MUSE toolbar. Most GCS location information is located under Location in the Panel menu.

Approach Settings

Approach plan – Specifying

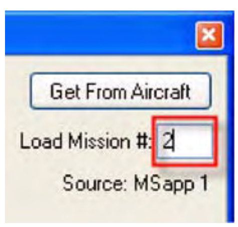
Using I-MUSE software Approach Editor, you're able to select an approach plan based on whether a SkyHook retrieval or runway landing is desired. The Approach Editor is located under **Panel** in the I-MUSE toolbar.



Predefined approaches are stored in the mission parameter file that is loaded on the aircraft. Approaches can be loaded from this file into the **Approach Editor** panel.

To load an approach from the Mission Parameter File:

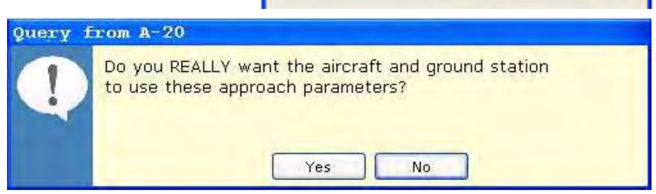
1 Enter the number of the approach to load in the **Load Mission #: field**.



2 Press **Enter** key.

3 Click the **Upload** button to load the approach into the aircraft.

4 Click **Yes** to confirm the dialog:



5 To get the approach currently uploaded into the aircraft, click the **Get From Aircraft** button on the **Approach Editor** panel.

Approach Settings

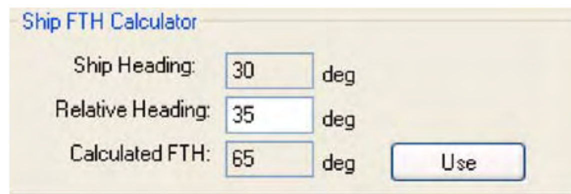
Approach plan – SkyHook

To create a new SkyHook approach, select the radio button indicating **SkyHook**. For a Standard SkyHook approach which will require only specification of Final True Heading, type **std** into the **Load Mission # field**.

Source: HDG RQD indicates that a heading must be provided for the SkyHook approach to be valid.

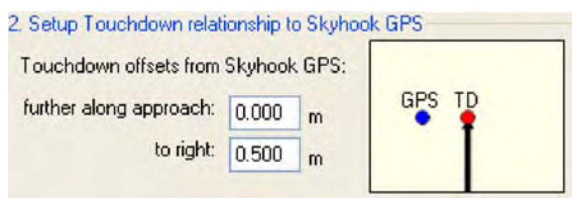
Specify the **Final True Heading** for the approach. This angle is measured relative to true north and should typically put the aircraft on a heading that will be into the wind for final approach. The field accepts positive numbers from 0 to 360 as valid input.

When the GCS is moving and AHRS data is available, the **Ship Calculator** can be used to specify **Final True Heading** for a SkyHook approach.



The **Relative Heading** field is specified with respect to the **Ship Heading** and Calculated FTH will display the actual **Final True Heading** with respect to true north.

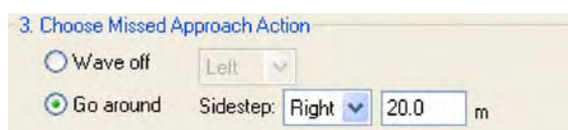
These offsets define the location of touchdown relative to the GPS unit located at the top of the SkyHook boom. Both fields accept either positive or negative numbers.



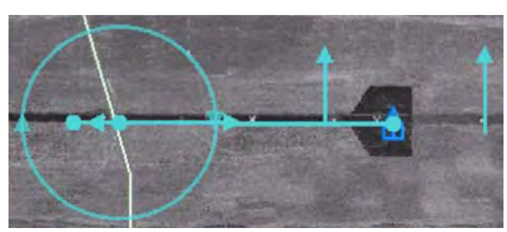
WARNING!

For ship-based operations, if the SkyHook is unable to be assembled and raised until just before recovery, a second GPS sensor is mounted to the ship. During recovery, make sure that the SkyHook GPS antenna is selected.

Selecting **Wave off** allows specification of the direction in which the aircraft will turn when a miss is called.

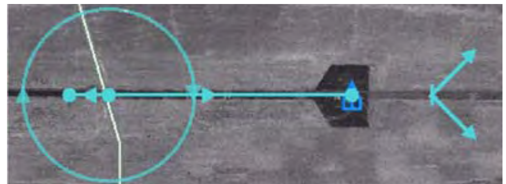


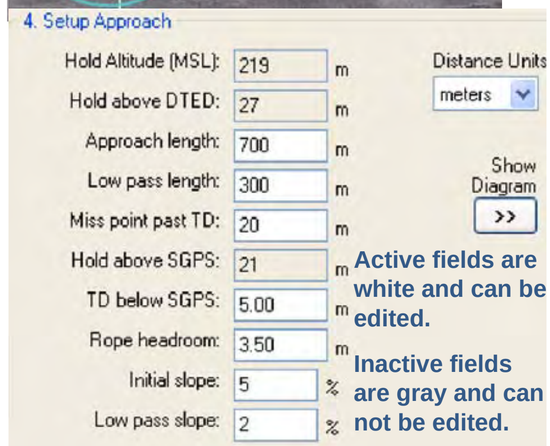
The turn will be executed anywhere along the approach path depending on when the miss is called. Arrows on the I-MUSE map indicate the direction of the wave off but provide no information about where the turn will occur.



Approach Settings

Approach plan – SkyHook (cont.)

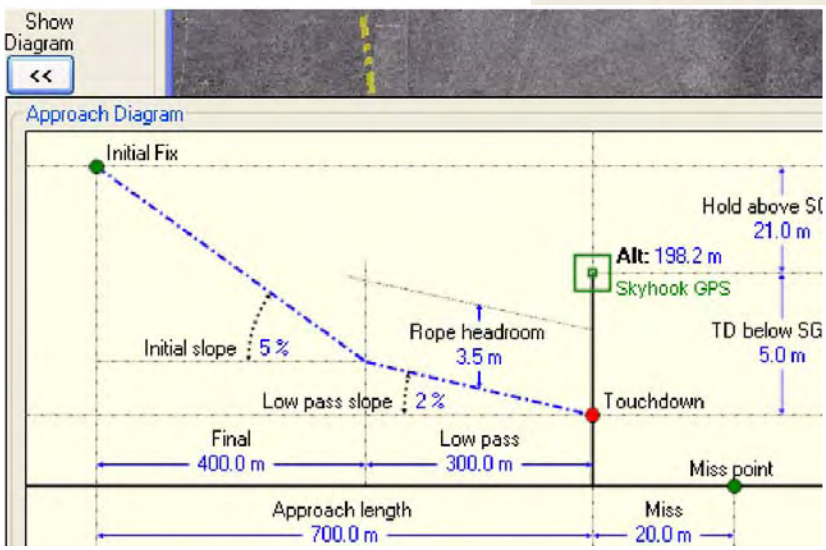




Selecting **Go around** allows specification of a sidestep to be executed when a miss is called. A go around does not allow specification of the direction in which the aircraft will turn back to the FAF or hold when it reaches **miss point past TD** or FAF altitude after the miss is called. The aircraft will make the decision about what direction to turn based on conditions at the time the miss is called. Arrows on the I-MUSE map indicate the **miss point past TD** location where the aircraft will have to turn regardless of altitude or whether a miss was already called.

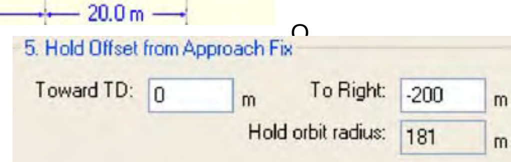
Numerical values are accepted if they constitute a valid approach. If the values don't meet minimum requirements for approach, a variety of prompts may be displayed.

Left-click on **Show Diagram** button for a display:



Note: The diagram is not to scale and is intended only as a quick reference to help visualize the approach.

Offsets define location of hold orbit relative to final approach fix. Both positive and negative numbers are valid. Hold orbit radius is calculated by the aircraft and its field cannot be edited directly.

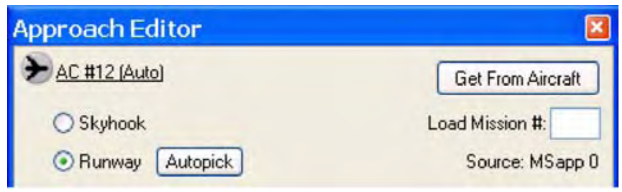


Note: The radius of the Final Hold Orbit cannot be calculated until the approach is commanded. Before the approach is commanded, the orbit is drawn as a band representing all possible radii. The final orbit will fall within the band drawn on the I-MUSE map.

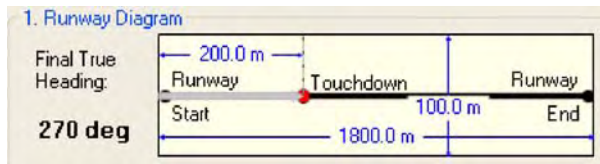
Approach Settings

Approach plan – Runway

In the **Approach Editor,** click **Autopick** to instruct the aircraft to select and load the best runway approach in the Mission Parameter File based on the current conditions. Or, to create a new runway approach, select the **Runway** radio button.



The **Runway Diagram** provides a top view of the runway. The diagram is not to scale and is only a quick reference to help visualize the approach. The final heading required to complete the approach also is provided. All fields are read-only.



The **Runway Start** provides the precise location of the beginning of the runway.

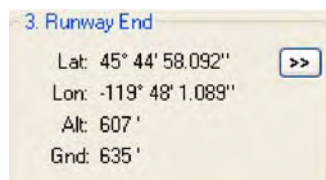
To edit this location:

1 Click the arrow button to open a **Coordinate Control**.

2 Use the **Coordinate Control** to enter specific location information to define the beginning of the runway.

Input will vary depending on the configuration of the **Coordinate Control**.

Runway End provides the precise location of the end of the runway.



To edit this location:

1 Click the **arrow** button to open a **Coordinate Control**.

2 Use the **Coordinate Control** to enter specific location information to define the end of the runway. Input will vary depending on the configuration of the Coordinate Control.

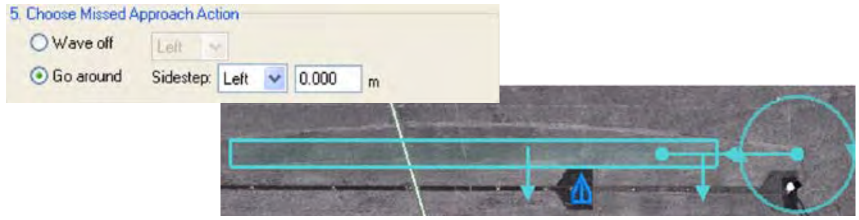
Touchdown provides the location of the touchdown point relative to the beginning of the runway. The touchdown point is the location at which the aircraft will attempt to make initial contact with the ground. Fields accept both positive and negative numbers as input. Negative numbers cause the aircraft to attempt touchdown before it reaches the specified runway. Positive numbers greater than the length of the runway cause the aircraft to attempt to touchdown beyond the end of the specified runway.

Selecting a **Wave off** allows specification of the direction in which the aircraft will turn when a miss is called. The turn will be executed at different points in the approach depending on when in the approach the miss is called. Arrows on the I-MUSE map indicate the direction of the **Wave off** but provide no information about where the turn will occur.

Approach Settings

Approach plan – Runway (cont.)

Selecting a **Go around** allows specification of a sidestep to be executed when a miss is called. A **Go around** does not allow specification of the direction in which the aircraft will turn when a miss is called. The aircraft will make the decision about what direction to turn based on conditions at the time the miss is called. Arrows on the I-MUSE map indicate where the turn will begin but provide no information about the direction in which the turn will be.

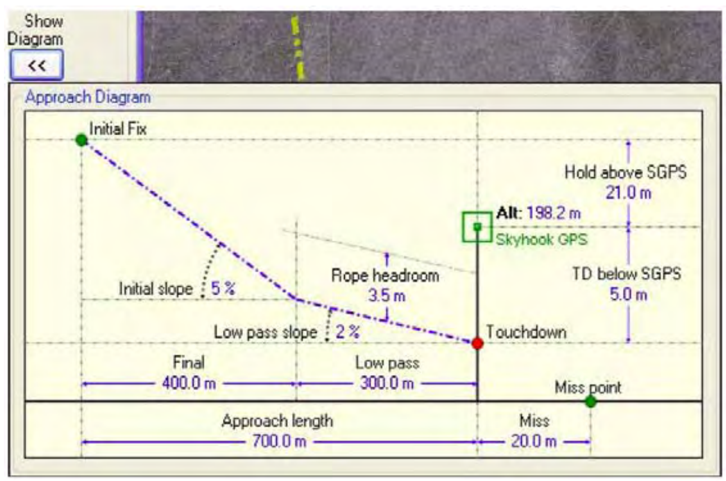


Either right or left may be selected from the Sidestep drop-down menu. The Sidestep field accepts both positive and negative numbers. A negative entry will automatically toggle the drop-down menu selection and display the numerical entry as positive.

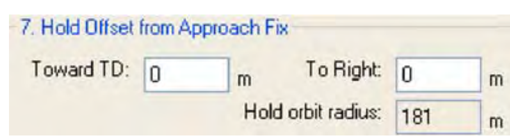
Numerical values are accepted if they constitute a valid approach. If the values don't meet minimum requirements for approach, a variety of prompts may be displayed.

Clicking **Show Diagram** opens a side view of the approach.

Note: The diagram is not to scale and is intended only as a quick reference to help visualize the approach.



Offsets define the location of the hold orbit relative to the final approach fix. Both fields accept positive and negative numbers as valid. Hold orbit radius is calculated by the aircraft and cannot be edited directly.



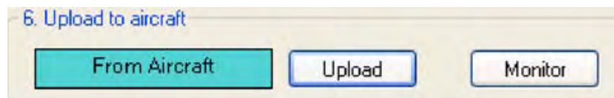
After an approach has been edited, its status is displayed in the Upload to aircraft control as **Not Uploaded**. This means that the approach exists only on the local I-MUSE client.

Approach Settings

Approach plan – Runway (cont.)

To load an approach in the aircraft, left-click **Upload** and select **Yes** to confirm the dialog.

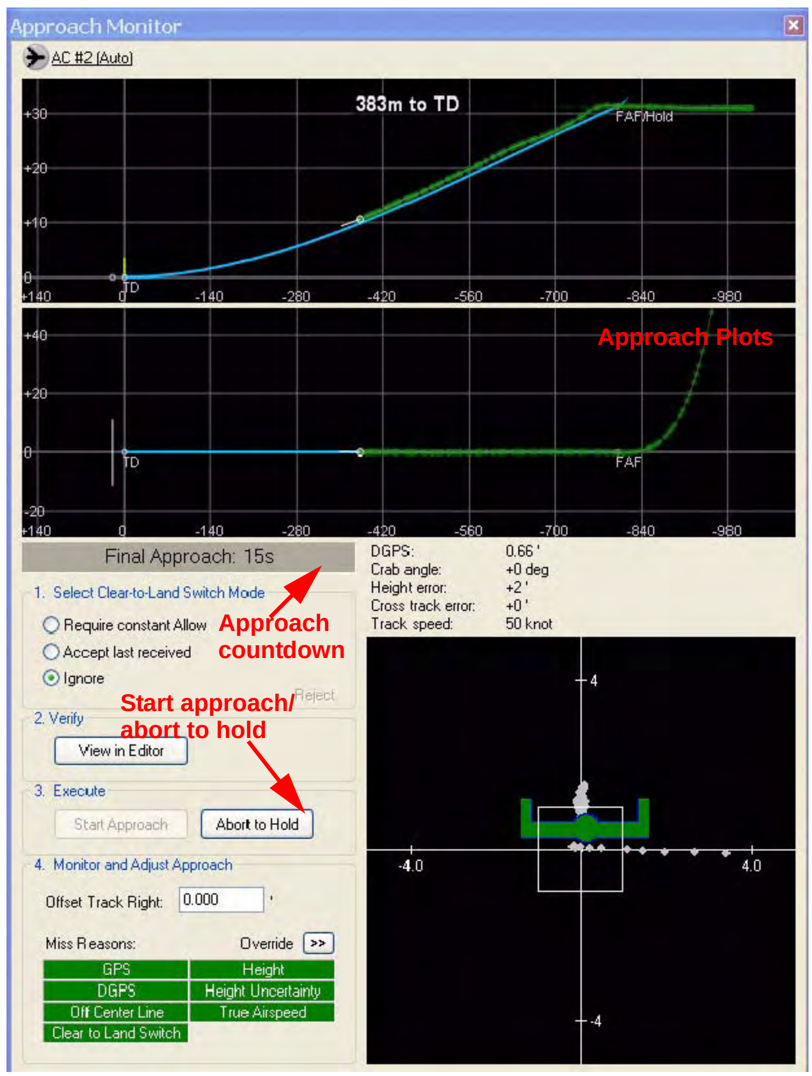
Once the upload is complete, the Upload to aircraft control window should look like this:



It should now be possible to execute the approach as programmed.

Approach Monitor

The approach can then be observed using the **Approach Monitor** located under **Panel** in the I-MUSE toolbar. The Approach Monitor provides the interface to command an approach and to call a missed approach. It provides additional functions to monitor, modify, and execute an approach. It is used in conjunction with the Approach Editor to specify and execute both SkyHook and Runway approaches. The Approach Monitor Plots provide the ability to monitor the aircraft before and during an approach.



The upper plot provides a side view of the aircraft in relation to the approach while the lower plot provides a top view. The white data values at the top indicate:

- Aircraft altitude MSL according to available DTED data.
- Aircraft altitude above final approach fix.

Approach Settings

Approach Monitor (cont.)

The bread crumbs behind the aircraft are an indication of the general health of the aircraft and its subsystems. The color corresponds to that of the aircraft on the I-MUSE map. The aircraft is indicated by a white vector that provides a reference of speed and direction. The plots can be rescaled by double left-clicking on each plot window. They will auto-scale during an actual approach.

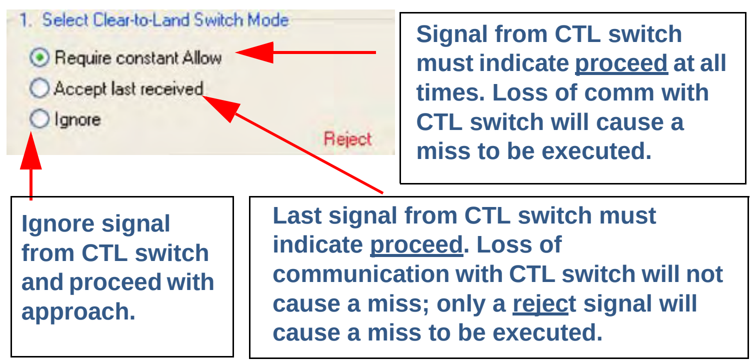
The **Approach Monitor** will plot the current approach phase.

The possible phases of approach are:

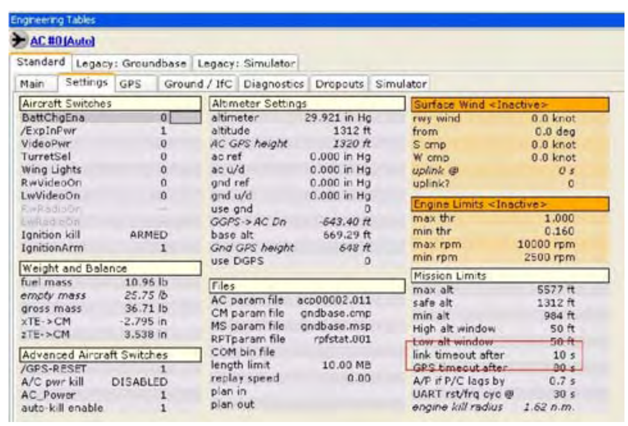
- Off
- To Hold
- Procedure Turn
- Slow to Final Approach
- Final Approach
- Lowpass (SkyHook only)
- Go Around
- Wave off

Note: During the final approach and low pass phases, the estimated time to touchdown is also displayed.

The Clear-to-land switch is a safety precaution that allows an observer on the ground to call a miss during approach. There are three options for configuration in this control. If the Clear-to-land status is reject, the word will appear in red at the lower right.

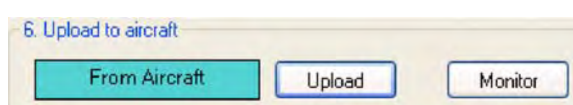


CAUTION: If Accept last received or Ignore is used and uplink (comm) is lost, aircraft won't execute a miss due to reason "Clear-to-land switch." To avoid this situation when using either of these two modes, it is recommended that link timeout after be set to a short value for approach, e.g. 5 seconds or shorter. This will limit the length of time that the aircraft will continue an approach without uplink.



To verify the correct approach is loaded on the aircraft:

1. Click the **View in Editor** button in **Approach Monitor** to open **Approach Editor**.
2. Click the **Get From Aircraft** button in **Approach Editor.**



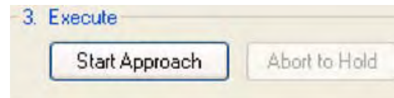
Approach Settings

Approach Monitor (cont.)

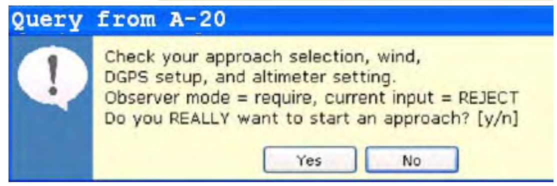
3 Verify that **Upload to Aircraft** indicates that the approach is **From Aircraft.**

4 Verify that the approach in the editor is the correct approach to command.

The Execute control provides the interface to command an approach or to command a miss. Only one of the two options will be available at any given time.



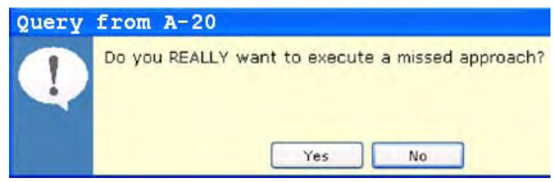
When an approach is commanded, confirm the dialog to continue:



The aircraft then executes an approach, begins a procedure turn and descend to its final approach fix.

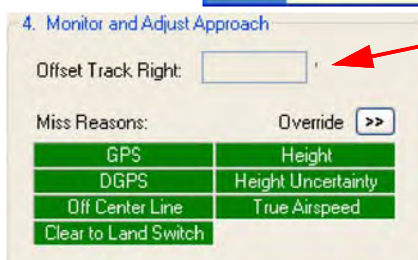
When a miss is called, confirm the dialog to continue with the miss and abort to hold.

The aircraft then executes a missed approach, climbs to a safe altitude, and proceeds to its hold orbit.



Monitor and Adjust Approach enables:

- Offsetting the aircraft to the left or right during specific phases of approach.
- Disabling/Enabling Miss Reasons.
- Reporting of Miss Reasons.



The track of the aircraft can be offset at different points during the approach. Positive values offset to the right while negative values offset to the left.

WARNING!

Although I-MUSE allows disabling the approach miss reasons, doing so can result in injury/damage to personnel or aircraft and equipment. Before disabling an approach miss reason, read *Miss reasons – effect of disabling*, later in this table. Removing a miss reason reduces safety margin, and missing a few approaches for the same reason is not always grounds for disabling a miss reason. It is often better to fix the cause of the miss. An observer should be used when disabling an approach miss reason.

To disable/enable **Miss Reasons** in I-MUSE:

1 Click the arrow button under **Monitor and Adjust Approach** in **Approach Monitor**.

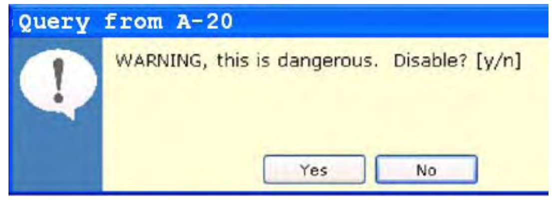
2 Click **Enable** or **Disable** as appropriate for corresponding fields.

Approach Settings

Approach Monitor (cont.)

3 When disabling **Miss Reasons** the aircraft will query:

4 Confirm the dialog to disable the **Miss Reason**.



Note: Approach miss reasons can't be disabled when the approach is off. Any approach miss reasons that were disabled will be enabled again if the approach is turned off.

Disabled Miss Reasons display red with a line through text.

Enabled Miss Reasons display green.

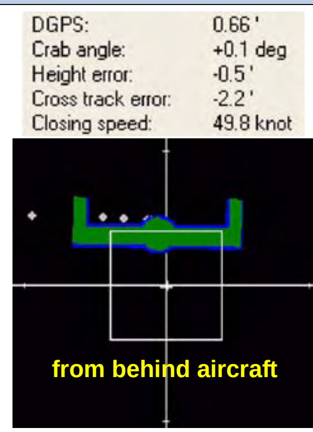
Reasons for a miss display in yellow in the **Monitor and Adjust Approach**.

Miss reasons – Effect of disabling

DGPS	▪ For SkyHook approach, there will not be a miss because of no DGPS. ▪ For SkyHook approach, there will not be a miss for DGPS uncertainty greater than half a wingspan. **<u>CAUTION</u>: One of the many possible dangers of disabling this would be that the aircraft would continue down final without good DGPS and crash into the SkyHook, ground, or personnel because it was too low/high or wide, even if the aircraft thought it was tracking the approach path perfectly.**
GPS	▪ There will not be a miss because of no GPS ▪ For Runway approach, there will not be a miss at the decision point because GPS uncertainty is greater than 6 m (19.6 feet). **<u>CAUTION</u>: One of the many possible dangers of disabling this would be that the aircraft would continue down final after completely losing GPS, possibly crashing into property or personnel even if the aircraft thought it was tracking the approach path perfectly. Another of the many possible dangers is that after losing GPS, the aircraft would circle at low altitude, drifting with the wind, after turning after <u>nav by DR only for</u> time.**
Height	▪ During LOW_PASS, there will not be a miss if the aircraft is more than rope headroom above the glide-slope. ▪ For Runway approach, there will not be a miss at the decision point because the projected touchdown position is beyond the touchdown limit. **<u>CAUTION</u>: One of the many possible dangers of disabling this would be that the aircraft would crash into the SkyHook boom, or overshoot the runway entirely, crashing into personnel and property.**
Height Uncertainty	▪ There will not be a miss because of a height discrepancy, e.g. a discrepancy between DGPS and barometric pressure altitude because of an error in one or both sensors or because of vertical ground-station (SkyHook) motion. **<u>CAUTION</u>: One of the many possible dangers of disabling this would be that the aircraft would be too high or low, or suddenly climb or descend, even if it thought it was tracking the approach path perfectly.**

Approach Settings	
Miss reasons – Effect of disabling (cont.)	
Off Center Line	▪ During LOW_PASS (SkyHook approach only), there will not be a miss if the aircraft is more than a wingspan towards the SkyHook. ▪ For Runway approach, there will not be a miss at the decision point because the aircraft is outside the runway width. **CAUTION: One of the many possible dangers of disabling this would be that the aircraft would crash into the SkyHook mast or personnel/ property along the side of the runway.**
True Air Speed (TAS)	▪ For Runway approach, there will not be a miss at the decision point because TAS differs from commanded TAS by more than 10%. **CAUTION: One of the many possible dangers of disabling this would be that the aircraft would suffer considerable damage from impact at high speed or under- or over-shoot the runway because of unexpectedly high or low speed.**

Data values



The five data values considered to be most important during an approach are displayed on the **Approach Monitor** panel.

Specific values are available during various approach phases.

When key values get out of range they are highlighted. Caution values are highlighted in yellow. Warning values are highlighted in red.

The ranges are based on alarm definitions and can be viewed and edited in the **Alarm Editor**.

The Wingman display on the **Approach Monitor** panel provides a glide-slope centric view of aircraft location. The glide-slope point for the approach is located at the center of the cross-hairs. An ideal approach will show the aircraft centered on the plot during final approach.

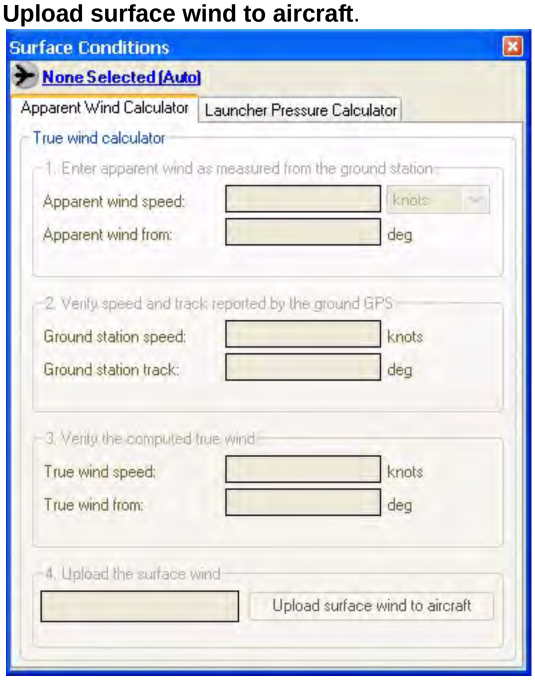
The coloration of the aircraft in the Wingman display is an indication of its general health and the health of its subsystems. The coloration is the same as it is for the aircraft icon on the I-MUSE map.

Approach Settings

Wind & pressure – Surface wind and base pressure

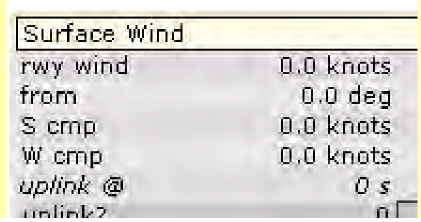
Note: There is a 15-minute time limit from the time surface wind is uploaded to the time that an approach is executed. (In I-MUSE 5.0.X and earlier, the time limit is 5 minutes.) If this time limit is exceeded, you must recheck and reenter surface wind before you can proceed with the approach.

To enter surface wind values, enter the **Panel** menu on the I-MUSE toolbar, and select **Surface Conditions**. In the **Apparent Wind Calculator**, enter and verify the data in all fields, then click **Upload surface wind to aircraft**.



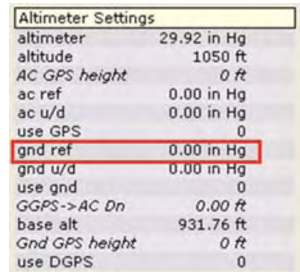
In I-MUSE 5.1.X and earlier:

In the **Surface Wind** table, select **Standard Tables** from the **Tables** menu on the I-MUSE toolbar. Go to **Standard** then **Settings**. After values are correct, enter **1** in the **uplink?** field and press the **Enter** key on the keyboard. After the information is entered and successfully uploaded to the aircraft, the entire table appears gray.



Approach Settings	
Wind & pressure – Surface wind and base pressure	**(cont.)**

During the Pre-Takeoff tasks of the System Check, the ground reference pressure was measured using the optional weather station (handheld GPS if weather station is not available) or obtained from an onsite authority, and then recorded in the **gnd ref** field in the **Altimeter Settings** table located under **Settings** in the **Tables** menu on the I-MUSE toolbar.



You may need to update barometric altitude before starting an approach. The ambient barometric pressure may have changed over the course of the flight and updating the aircraft's reference for the ground will correct any errors in its barometric altitude from GPS height. Generally, if GPS height and aircraft barometric altitude are within 5 m (16 feet) of each other (with low GPS uncertainty) it is unnecessary to update the aircraft's barometric altitude. This is done generally at lower altitudes before proceeding with the approach.

Use one of the following methods to update the altitude in the **Altimeter Settings** table:

- Using the same handheld GPS or other device, read the pressure on the ground, and record the ground update pressure in the **gnd u/d** field. Then type **1** in the **use gnd** field. The base pressure on the aircraft is updated by comparing the original pressure at the beginning of the flight to the updated pressure prior to the approach. This corrects for any changes in weather since takeoff, while not requiring the exact altitude of the aircraft.
- If the reference pressure update does not correct the split between barometric and GPS altitude, or if there was a reset on the aircraft, you can type **1** in the **use DGPS** field. The base altitude (which should be set to the ground station altitude), plus the differential down measurement, is used to update the aircraft altitude. This will be more accurate than using the GPS reported height because you can survey the ground station over a longer period of time to average out the GPS noise.

Note: During lost comm, with I-MUSE 5.2 and later, if GPS uncertainty is sufficiently small, the altimeter automatically resets on procedure turn and FAF. This is the equivalent of typing <u>1</u> in the <u>use GPS</u> field.

Approach Settings
Auto retrieval
Auto retrieval information can be found in the I-MUSE software. 1 Select **Checklists and Procedures** from the **Panel** menu on the I-MUSE toolbar. 2 Select **Start New**. 3 Select **Auto-Retrieval** and click **Start.**

7.4 Retrieval Operations

In this section:

- SkyHook operation
- Land-based retrieval
- Maritime retrieval
- Troubleshooting

Prior to operation, it is the responsibility of the operator to:

- Learn and practice the principles of safe machine operation
- Perform the required inspections and tests
- Perform routine maintenance

WARNING!

Do not operate the equipment unless you have been trained and certified by an authorized Insitu representative. Failure to operate the equipment properly may result in serious injury or death.

SkyHook Inspections

Complete the SkyHook Inspection Checklist using the latest approved checklist found:

- On Insitu's Extranet
- In the *Pocket Handbook*

SkyHook Operation Checklist

To ensure that all vital steps are performed in the correct order:

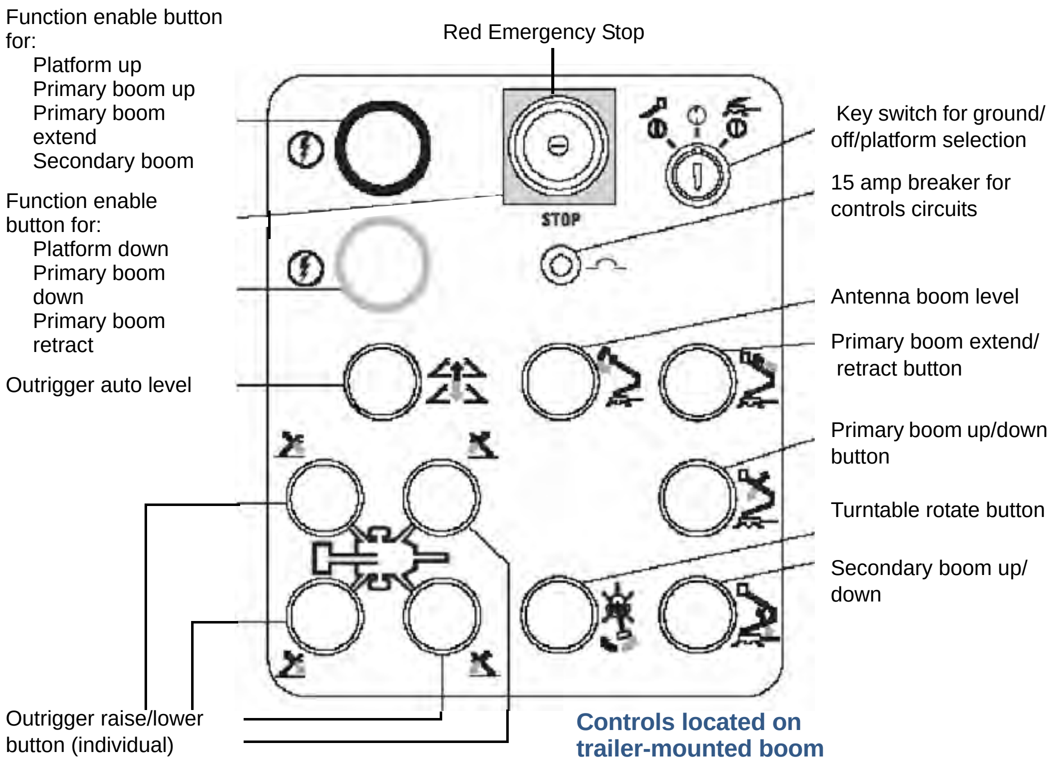
- [ ] **Complete the SkyHook Operation Checklist using the latest approved checklist in the I-MUSE online help reference documentation.**

Retrieval Operations

SkyHook operation

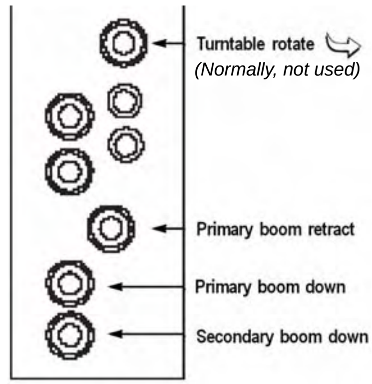
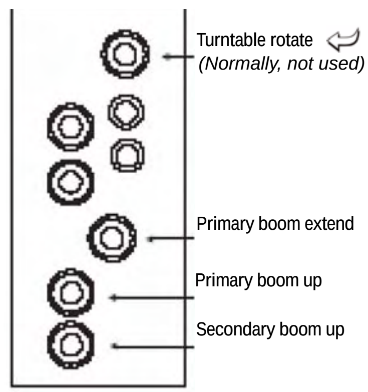
Note: These instructions are for the trailer-mounted boom, which is the most common SkyHook design. If these instructions do not match your SkyHook configuration, contact Insitu for more specific information.

Controls



Controls located on trailer-mounted boom

Emergency stop	Push in the red emergency stop button to the off position at the ground or platform controls to stop all machine functions. Repair any function that operates when the red emergency stop button is pushed in. Selecting and operating the ground controls will override the platform red emergency stop button.
Operation – Automatic	1 Turn the key switch to ground control. 2 Pull out the red Emergency Stop button to the on position. 3 Press and hold the yellow function enable button. Press and hold the auto level button or the individual outrigger buttons to lower the outriggers and level the machine.  4 Check the bubble level to make sure the machine is level.

Retrieval Operations	
SkyHook operation	**(cont.)**
Operation – Manual	All boom functions can be operated with the hand pump located on top of the power unit cover. Manifold valves are located under the manifold cover on both sides of the machine.
Boom – Lower / Retract	1 At the ground controls side of the machine, open the manifold cover. 2 Open the valve completely by turning it clockwise. 3 Operate the hand pump. 4 Close the valve completely by turning counterclockwise. **Note: The machine will not operate unless the valves are closed.** 
Boom – Raise / Extend	1 At the side of the machine opposite the ground controls, open the manifold cover. 2 Open the valve completely by turning it clockwise. 3 Operate the hand pump. 4 Close the valve completely by turning counterclockwise. **Note: The machine will not operate unless the valves are closed.** 
Beacons (Optional)	The IR beacon has a range of visibility in excess of one nautical mile.The switch for the IR beacon is located on the forward right battery cover of the SkyHook unit. Each beacon has a dedicated toggle switch to power-on or power-off the beacon. "OFF" and "ON" directions are indicated on the switches. If the desired beacon is not illuminated, ensure that the corresponding toggle switch is flipped to the "ON" position. If problems persist, troubleshoot fuses and connections as described in the *Maintenance Handbook*.   

Retrieval Operations

Land-based retrieval

WARNING!

In strong winds, use caution when retrieving the aircraft because it can swing wildly and cause injury; hard-hats must be worn!

Retrieval with land-based SkyHook requires at least **two operators**.

Note: In high wind, SkyHook retrievals require a third operator to pull on the capture rope as soon as possible and continue holding the rope while the aircraft is lowered.

1 Operator #1 lowers the telescoping boom carefully.

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Retrieval Operations

Land-based retrieval (cont.)

2. Operator #2 holds the lower rope to stabilize the aircraft.
3. Operator unhooks the aircraft.

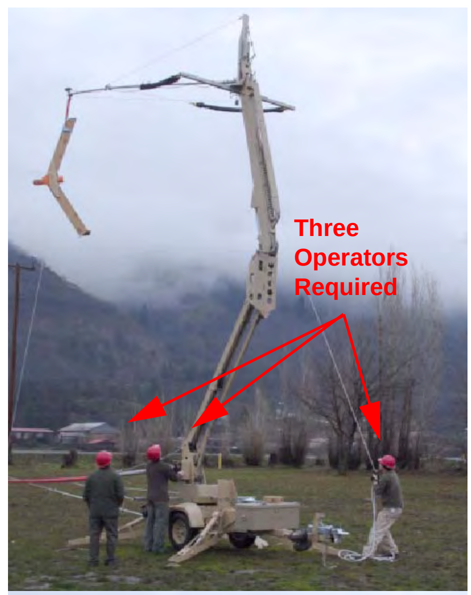
Maritime retrieval

WARNING!

In strong winds, use caution when retrieving the aircraft because it can swing wildly and cause injury; hard-hats must be worn!

A **minimum of 3 operators** are required to retrieve an aircraft from a maritime SkyHook.

1. Operator #1, retract the telescoping boom until Operator #2 has a good hold on the aircraft.



Note: **Maritime SkyHook retrievals require a third operator to pull on the capture rope, raising the aircraft to the anti-spin device (red tube) as soon as possible. The third operator continues holding the rope while the aircraft is lowered.**

2. Continue lowering the boom down, or telescoping in, until the full weight of the aircraft is supported by operators.

Retrieval Operations	
Maritime retrieval	**(cont.)**
	3 Unhook the rope from the aircraft wingtip. **Note: Stabilizing a wild aircraft can be achieved by pulling tension from the lower capture bungee.** 4 Retract all hydraulic cylinders until resting in cradles.  

Retrieval Operations

Maritime retrieval (cont.)

Retrieval parameters

A benefit of a mobile ground station is that it can maneuver to give the best conditions for retrieval. The main factor here is wind, and normal procedure is to align the ground station so that retrieval will take place directly into it. Once the course has been set with this in mind, an approach can be set up using a heading close to that of the ground station (read from the AHRS). For ship-based retrieval, the SkyHook is normally situated off to one side of the ship, over water; and final approach is in line with the beam from the stern.

WARNING!

If ship motion causes the SkyHook to rotate, secure the SkyHook.

The approach direction is normally adjusted up to 10 degrees from inboard to outboard, so that in a missed approach the aircraft is already flying away from the ship structure. For example, if the SkyHook is on the starboard side and the AHRS reads 270 degrees, the **final true heading** might be set to 280 degrees. Wave-offs are the normal miss type. During an approach, ensure that the ship heading does not change significantly, as this could result in the aircraft flying toward the ship.

For operation on a mobile ground station, it has been general practice to uplink the ground station velocity and acceleration to the aircraft. This is done on the GPS tab in the I-MUSE table page, and standard procedure is to uplink these at a 0.2 second period (set **uplink V/acc** to **0.2**). The three components of SkyHook velocity are averaged, with a time constant of 0.5 seconds. This rejects anomalous GPS reports, but induces some lag to the system (set **Vgnd filt wid** to **0.5**). Accelerations are calculated based on these averaged velocities.

Approach geometry is standard, but an offset hold is often used, so that the hold orbit does not infringe on the antenna unwind azimuth. With retrieval to the starboard side of a ship, the hold is offset to the right by 650 feet (200 m) or so. The opposite would apply for a system on the port side (assuming the antenna unwind direction is aft).

The mission file should be set up so that the relocatable approach template (**std** approach) reflects the parameters expected for the normal retrieval.

Aerodynamic effects near retrieval point

In certain situations, such as flying close to a large ship, the standard approach pattern puts the aircraft in potentially dangerous turbulence. Where possible, aerodynamic models of the ship can help in determining the standard retrieval procedure.

Retrieval Operations

Maritime operations (cont.)

Rope dismount procedure

A mobile ground station such as a ship allows retrievals with a low impact speed, as the ship can steam into the wind for recovery. Experiments are best run to find a "sweet spot" for this speed, which will vary depending on current wind, the ship size (tendency to pitch/roll), and SkyHook characteristics. Before any flights are made, it is advised that all persons involved in dismounting the aircraft from the SkyHook practice with a winged dummy. This is best done initially in dock with no motion, but then practiced again before a flight when significant motion is expected. Each installation aboard a ship is likely to be different. Practice reduces the chances of mistakes being made, such as dunking an aircraft in salt water, and it may even set limits on flying due to the difficulties found.

After capture, pull the aircraft up to the anti-spin device while the extension boom is retracted. Lower the secondary boom until the aircraft is 3-5 feet (1-1.5 m) above the deck. Pull the turret lock pin and rotate the turret to bring the aircraft over the deck. Lower the main boom as needed to hand the aircraft to the operator.

Recovery area envelope

As in launch, the recovery area envelope needs to be discussed and approved. As mentioned, the standard approach is from the rear, into the wind. This may affect or be affected by other operations aboard (such as helicopters, other boats, etc.). Where possible, all conflicts should be removed, over-flights kept to a minimum, and as much cooperation with the recovery procedure as possible is best (i.e. with the ship captain, and the options for changing the ship heading, speed, etc.). Depending upon SkyHook location, a sizeable area is needed for the procedure turn, final approach, miss and wave-off stages. Typical space requirements are 3,000 feet (1,000 m) behind the SkyHook, 650 feet (200 m) forward and 2,000 feet (600 m) to the side. As always, flying near populated areas and other ships is best avoided during recovery.

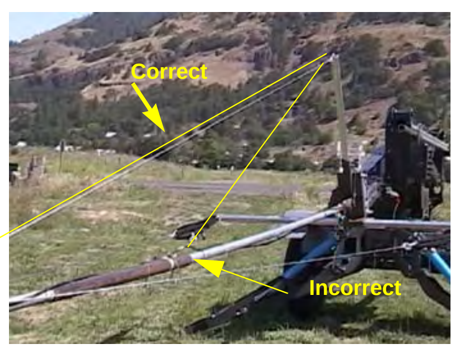
Note: **For ship-based retrieval, if space is limited, use a heading offset to deconflict with the ship's superstructure.**

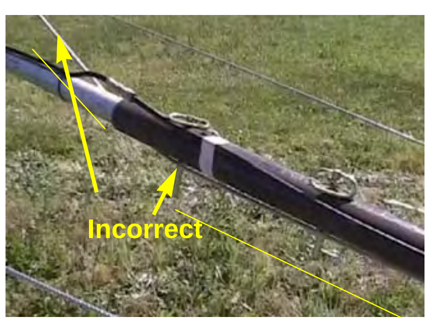
Troubleshooting – SkyHook

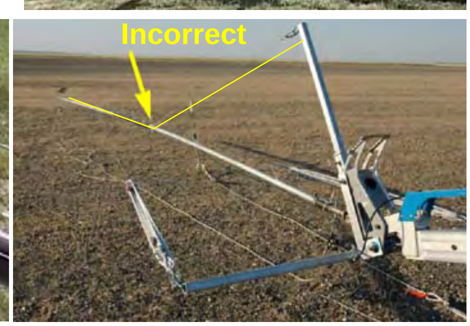
Cable rigging – upper support

It is very important to ensure that the upper support cable does not get hooked up on any part of the boom section assemblies.

CAUTION: Failure to rig the upper support cable correctly will damage the aircraft and the SkyHook.







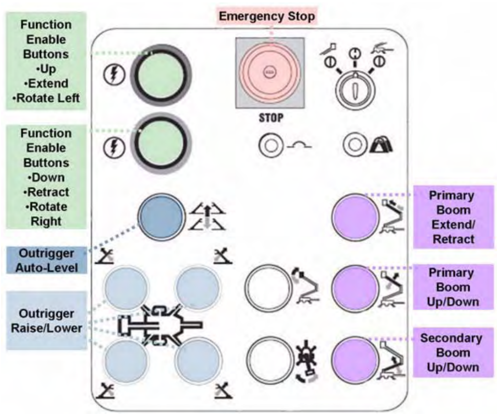
Retrieval Operations

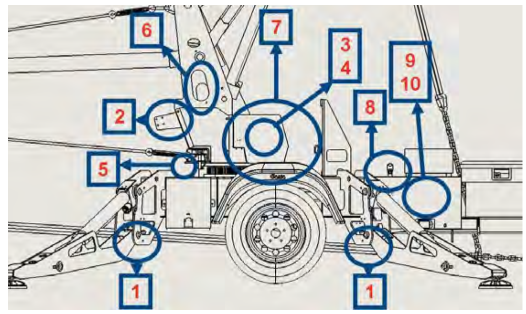
Troubleshooting (cont.)

INSITU

SkyHook – Troubleshooting

Note: **This card supplements information provided in Insitu's *Operator's Handbook*, *Maintenance Handbook*, and *Pocket Handbook*, as well as the Genie TZ 34/20 manufacturer's manuals. Before troubleshooting, ensure that the key is in and the red emergency stop button is pulled out.**





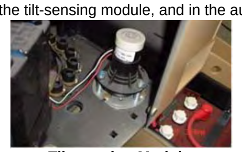
1	Outrigger limit switch	6	Boom limit switch (opposite side)
2	Manual hold-down latch	7	Manual control valves (under cover)
3	Auto-level module (under cover)	8	Hand pump
4	Tilt-sensing module (opposite side)	9	Hydraulic tank (under cover)
5	Visual level	10	Hydraulic valve (under cover)

Booms Don't Work

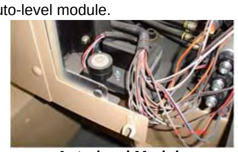
Function enable button was not pressed.
It is necessary to press a function enable button before pressing a boom control button. The function enable button tells the SkyHook in which direction to perform a function (e.g. up or down). Without this information, booms won't work.

Mechanical hold-down latch for the primary boom is latched.
Release the manual hold-down latch located near the control station.

The machine is not level.
If the SkyHook is not level, booms won't raise. Manual leveling may be needed. The SkyHook is equipped with levels on the rear of the unit, in the tilt-sensing module, and in the auto-level module.



Tilt-sensing Module



Auto-level Module

If the tilt-sensing module is not level, booms won't raise. Manually level the SkyHook using the tilt-sensing module as a guide. From time to time, recalibration may be required for tilt-sensing module and auto-level module agreement.

To recalibrate levels:

1. Manually level the SkyHook using the visual level on the rear of the machine as a guide.
2. Use 7/16-inch adjustment nuts to adjust the tilt-sensing module and the auto-level module to agree with the visual level.

Booms Don't Work

There is an outrigger load malfunction.
Check that outriggers are loaded. Outrigger limit switches are activated by outrigger movement once outriggers are loaded. On newer systems, all four outrigger limit switches must be on (illuminated) for the boom to function. On older models, or if a light is not on, ensure that the corresponding outrigger limit switch is engaged and auto-level the SkyHook as directed in the *Operator's Handbook*. If problems persist, see next topic on this card: *An outrigger limit switch is not working*.

An outrigger limit switch is not working.
If one of the outrigger limit switches is not working or not engaged, the SkyHook thinks one of the outriggers is not down, and boom functions will not operate. If the outrigger limit switch is not working, jump the limit switch to tell the SkyHook the outrigger is down. To jump the outrigger limit switch, unplug it and use wires to complete the circuit.

WARNING!

Ensure outriggers are loaded. The SkyHook may tip over if the limit switch is jumped when outriggers are not loaded.

Note: **Insitu is troubleshooting a problem with telescoping booms. Icing is suspected as the cause. The manlift is tested to -6°C. If the telescoping boom is not working and the temperature is below -6°C, try wrapping the boom in a heating blanket. Please report any related problems or findings to Insitu.**

King Post Is Not Vertical When SkyHook Is Erect

The slave cylinder is not properly operating the tilt function.
Lower primary boom. About halfway down, the slave cylinder will resume functioning properly. Tilt the king post to vertical, or slightly past vertical.

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SkyHook MAR07

Retrieval Operations

Troubleshooting (cont.)

INSITU

SkyHook – Troubleshooting

Motor Is Spinning / Extensions Are Jerky or Erratic

Check the hydraulic oil level.

Note: If performing scheduled maintenance, as described in the *Maintenance Handbook*, this should already have been done.

1. Ensure boom is stowed and outriggers are raised.

CAUTION: If fluid level is read in any other configuration, it will read low, and adding fluid will result in overfill. Improper hydraulic oil levels can damage hydraulic components.

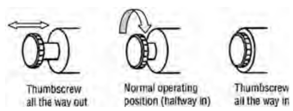
2. Remove the cap from the hydraulic tank and check the dipstick. The hydraulic oil level should be at the mark on the dipstick.

Motor Doesn't Turn On / Motor Doesn't Have Enough Power

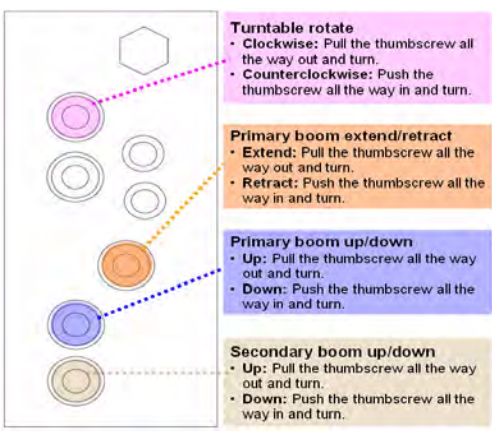
Batteries are not charged or are dead; power is not being received.

With the exception of outriggers, all SkyHook functions can be operated manually. Manual control valves are under the control-side panel.

Each valve has three locked positions – out, halfway in, and in.



1. Push/Pull the thumbscrew for the desired function, then turn to lock in position.



2. Operate the hand pump.
3. Turn the thumbscrew to release.
4. Push the thumbscrew halfway in and turn clockwise to lock into position for normal machine operation.

Note: If valves are not properly reset, the machine will not operate.

Rope Is Freezing

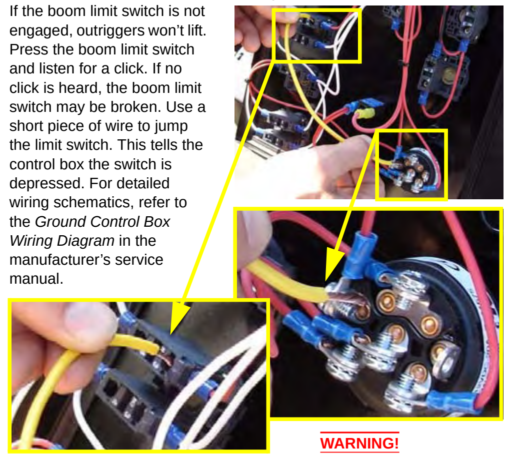
Sea spray at low temperatures causes rope freezing, eliminating bungee effect.

Soak rope in antifreeze.

Outriggers Only Operate in One Direction

The boom limit switch is not working.

If the boom limit switch is not engaged, outriggers won't lift. Press the boom limit switch and listen for a click. If no click is heard, the boom limit switch may be broken. Use a short piece of wire to jump the limit switch. This tells the control box the switch is depressed. For detailed wiring schematics, refer to the *Ground Control Box Wiring Diagram* in the manufacturer's service manual.

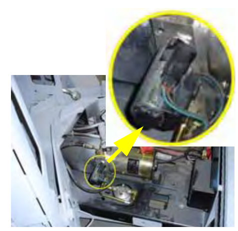


WARNING!

Outriggers move as soon as switch is jumped. Beware of moving SkyHook, and do not touch any other connections.

Power is not transferred properly through the coils.

Jiggle the coils. If this does not correct the problem, test power connections to outriggers:



1. Remove the motor cover and locate the two 24V DC coils mounted on the control panel side of the hydraulic manifold. The inner coil (closest to the manifold) controls outrigger extension. The outer coil controls outrigger retraction.
2. Note which connector goes to which coil, then unplug the connectors and use a DC volt meter to measure the voltage going to the coils when the **function enable button** and **outrigger auto-level button** are pushed to activate the outriggers. When associated functions are engaged, the coil should receive ~20-24V DC; when not engaged, 0V DC.

Note: The motor will run when buttons are pushed, but outriggers will not move when wiring to coils is disconnected.

- If both coils receive ~20-24V DC when attempting function activation, there is a malfunction. To raise/lower outriggers, unplug the opposite coil and reattempt function activation.
- If both coils receive voltage (one at a time) with the appropriate functions pushed, the hydraulic valve is not opening, likely due to contamination. Remove, clean out debris, reinstall, and retry.
- If only one connector receives voltage, to raise/lower outriggers, plug in the active connector to the appropriate coil.
- If neither coil receives voltage, the problem is electrical. More diagnosis and schematics are needed.

No GPS

See *SkyHook GEM – Troubleshooting*.

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Retrieval Operations

Troubleshooting (cont.)

INSITU

SkyHook GEM – Troubleshooting

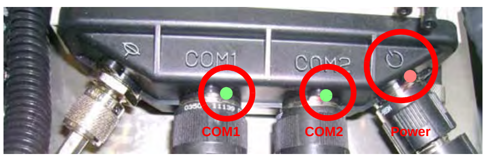
Note: If the SkyHook is not receiving GPS signal, there may be a problem with the SkyHook GEM. This quick reference card provides basic SkyHook GEM troubleshooting instructions and supplements information provided in the *Operator's Handbook: Setup.* If problems persist after troubleshooting, return GEM to Insitu for repair. Contact insitu's Operations Support Group:

- **Inside the United States 866-637-4691**
- **Outside the United States 509-637-4691**

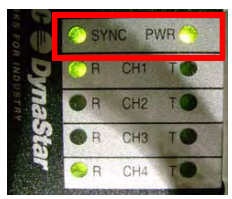
No GPS

GEM is not functioning.
Verify that GEM appears functional:

1. On the inside of the GEM verify that:
   - COM 1 flashes 10 times per second.
   - COM 2 flashes once per second.
   - Power light is solid red.



2. SYNC and PWR are illuminated on the DYMEC.



If any light is not illuminated as described here, run through all GEM troubleshooting items, ending with *GPS is not operating through I-MUSE,* then recheck lights. If they are still not properly illuminated, return GEM to Insitu for repair.

GEM selection switch is not set to SkyHook.
Set the GEM selection switch to **SkyHook** when the SkyHook is erect.
Set the GEM selection switch to **BOG** when the SkyHook is stowed.

GEM is not receiving power.
Connect the power from the GEM to the power source.
Note: 12V DC power is used for the SkyHook GEM - not 24V. Turn on switch on the outside of the GEM. The red LED power indicator lamp illuminates, verifying that power is on.

Coax is not connected.
Connect the coax from the GEM to the NovAtel pinwheel antenna.

No GPS

Fiber is not connected or is not clean.

Note: If the SYNC light on the DYMEC is illuminated, fiber connections are good.

1. Verify fiber is connected from the GEM to the GCS.

Note: The only colors seen on the connector should be yellow and blue; this indicates a good connection.

2. If necessary, clean connectors with isopropyl alcohol (99% or greater) to keep them free from dust and small debris.

WARNING!

Do not stare directly at the light from the fiber optics.

Do not touch the end of the fiber, as this will affect the function of the fiber. Do not scratch the end of the fiber by allowing the face of the fiber to touch hard objects.

View of sky is obstructed.
Ensure that NovAtel pinwheel antenna has an unobstructed view of the sky.

GPS is not operating through I-MUSE.
Verify GPS is operating through I-MUSE and note any values that do not match those noted below. To troubleshoot value discrepancies, complete all troubleshooting items for SkyHook GEM, and conduct this procedure again. If value discrepancies persist, contact Insitu.

1. Start I-MUSE.
2. Power on the If/C.
3. Start I-MUSE server.
4. Go to Engineering Tables, GPS tab, Ground GPS Satellites.
5. Verify GPS (4 or more satellites locked).
6. Go to Engineering Tables, GPS tab, Ground GPS Settings and Status.
7. Verify PPS (OK).
8. Verify COM 1 and COM 2 (OK).

Note: To get COM 2, enter 1 in Moving GS in Groundbase.

9. Clock Model (Valid).
10. Almanac (Valid).
11. Position (Pos. Fixed).

026-010115 v1.0
SkyHook MAR07

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8

Post-flight

To ensure that all critical tasks have been performed, complete the Post-flight Checklist using the latest approved checklist found:

- On Insitu's Extranet.
- In software installed with I-MUSE 5.0 and later.

8.1 Aircraft Storage

In this section:

- Wing removal
- Stowing
- Maritime operations

Aircraft Storage

Wing removal

1 Use a flat-head screwdriver to open the fuselage hatch cover.

2 Remove the wing pin.

3 Firmly grasp wing and remove it from socket.

Note: Don’t handle by the control surfaces since this could damage the servos.

It may be necessary to gently rock the wing fore and aft while removing it from the fuselage wing root. Depress the flex tension lever to maintain tension on the flex.

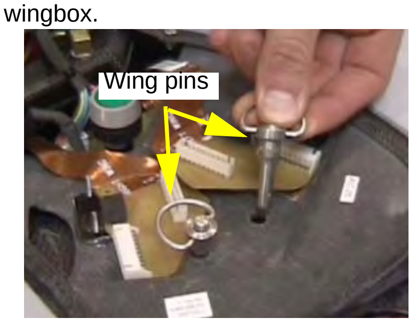
4 Continue depressing the flex tension lever while extending the flex strip out to the STOP line marked on the flex.

5 Grasp the flex strip against the wing to maintain tension. Position and hold the flex strip alongside the wing while carefully inserting both back into the stand (as shown).

Note: Be careful not to kink or twist the wing flex wiring.

Remove the second wing as described in the previous steps.

6 Replace the wing pins in the fuselage wingbox.



7 Replace the orange elevon protection strips. These strips protect the gears and servos from being damaged during shipping and unloading.

Aircraft Storage

Stowing

1 Prior to stowing the aircraft, replace any shipping straps, clips, or foam plugs.

2 Grasp the stand (as shown) and firmly and slowly push it down into the storage case. Do not allow the stand and the aircraft to fall sharply.

3 Close the lid and secure all latches on the storage case.



Maritime operations

Humidity	It is recommended that aircraft that are operated in humid conditions and stored in cool areas be fully fueled during storage. This reduces potential for condensation build-up inside the tank from venting humid air.
Air-conditioning	Aircraft are not required to be in air-conditioned storage in hot environments. Store aircraft near the temperature and humidity of the environment the aircraft will operate in. For long term storage it is recommended that the aircraft be stored in a relative humidity of 50%-70%, and a max temperature of not greater then 50º C (122º F). Aircraft that have been stored in air-conditioned environments, and then operated in high temperature and high humidity have a tendency for condensation to form on the inside of the camera dome, impacting camera clarity. Use of desiccant packs is required in humid environments. **CAUTION: The aircraft should not be flown with an accumulation of dust or dirt on any surface. Dust or dirt on the aircraft can impair its aerodynamic performance. Clean the aircraft before takeoff.**

8.2 Launcher Storage

Launcher Storage
Stowing

1 Use caution. Two people are necessary. Fold the kickstand back up over the machine. The kickstand can be positioned straight or folded. To fit into the zippered cover, the kickstand must be folded.

2 Put cover on the launcher and secure belly straps.

3 Take inventory of the following equipment any time the launcher is moved

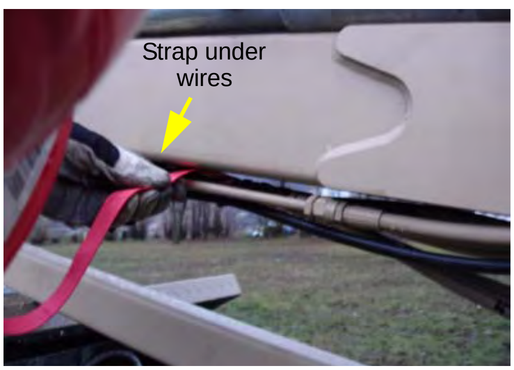
Desert Launcher

- Launcher log book
- Upper carriage
- Lower carriage
- Prop guard
- Trigger rope
- Safety pin and rope
- Outriggers (quantity: 2)
- Compressor cover
- Cover
- Dummies
- Desert spares kit

Maritime Launcher

- Launcher log book
- Upper carriage
- Lower carriage
- A-frame kickstand
- Prop guard
- Trigger rope
- Safety pin and rope
- 100-ft. extension cord (quantity: 2)
- Cover
- Dummies
- Marine spares kit

8.3 SkyHook Storage

SkyHook Storage
Stowing
1 Store all loose parts in the aluminum storage box on the SkyHook trailer. 
2 Attach booms/cables using brackets or straps, as delivered.
Note: Land-based SkyHook – Be sure that the strap is under the wires.   **Note: Maritime SkyHook – Be sure that the strap is under the wires, and that the buckle is not touching the carbon.** 
 
3 Store the SkyHook covered if harsh conditions exist or if prolonged storage is expected.

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Appendix

Chapter Map			
A.1 Planner – Programming Software			
Note: This section includes detailed programming and file management instructions. Once familiarized with the processes described here, a simplified programming guide in the *Pocket Handbook* is available for quick reference.			
Parameters	A-3	Modem settings	A-12
Bootloader	A-11	If/C	A-16
Helmsman	A-11		

A.1 Planner

Note: I-MUSE 5.2 includes the Programmer application (programmer.exe) for programming aircraft and ground control station software. I-MUSE 5.1 and earlier uses Planner (planner.exe). The instructions in this appendix apply to programming using Planner with I-MUSE 5.1 and earlier. These instructions replace the *Programming Aircraft Software* topic in *Chapter 3: Programming*. If operating with I-MUSE 5.2 or later, refer to the *Programming Aircraft Software* topic in *Chapter 3: Programming*.

In this section:

- Parameters
- Bootloader
- Helmsman
- Modem settings
- Field pitot offset correction
- If/C

Use Planner to build an aqall.s19 file with the verified aircraft parameter file and the appropriate communications, mission, and reporting parameter files. Planner can be found in a folder in the same directory as the aircraft simulator (Groundbase/FlightSim). The link is generally C:\Program Files\InsituGroup X.XX\Groundbase\Parameters\ParamsBuilding (where X.XX equals the current code version). In this folder, there is an executable file called Planner that will create a .s19 file containing all the parameter files to be flashed into the aircraft memory. Double-click on the icon to start Planner and input the .prns of the parameter files to be used. There are four types of parameter files: aircraft, reporting, mission, and communication. Each file can be created by saving the Excel version of a file as a text document, or by using the program MakeFlightParams to convert the binary files from the aircraft to .prn text files. Then, select a directory to which the .s19 file will be written once the file is created, and run Planner. Carefully inspect the Planner output to check for errors (particularly at the start when MakeFlightParams reads the parameter files).

Note: This section includes detailed programming and file management instructions. Once familiarized with the processes described here, a simplified programming guide in *The Pocket Handbook* is available for quick reference.

Note: These instructions are included on the CD received with each I-MUSE release. Review those instructions to ensure that the correct values are entered for each device programmed.

Planner

Parameters **(cont.)**

Create and load aircraft flash record (.s19) file

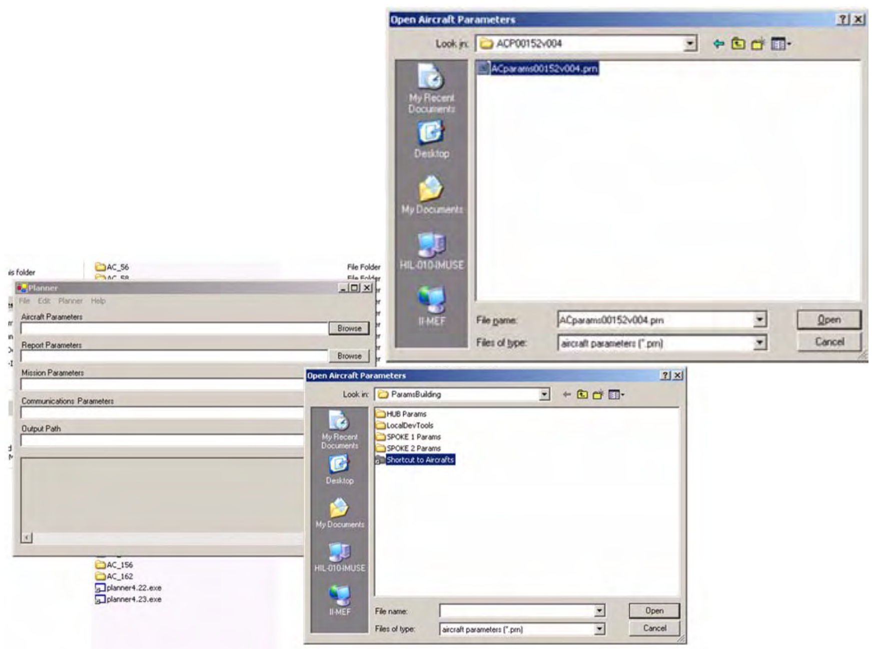
Before beginning this step, create a desktop folder to store the newly created flash record (.s19) file. Name the folder after the aircraft (e.g. AC152).

The flash record (.s19) file is the file that is loaded onto the aircraft. It is created from four .prn files:

- Aircraft File (e.g. ACparams00152v003)
- Reporting File (e.g. RPblckDv002)
- Mission File (e.g. MSbrdmnv010)
- Communications File (e.g. CMelsnrv004)

Planner takes these four .prn files and outputs a single flash record (.s19) file that is readable only by the aircraft that contains the parameter information.

1 Browse to Program Files\InsituGroup 5\Groundbase\Parameters\ParamsBuilding\planner.exe



2 A window opens; browse to the aircraft file being updated – latest version.

Select the aircraft .prn file; click **Open**.

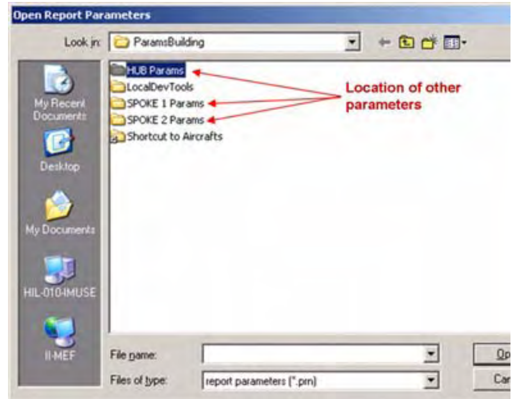
Appendix

Planner

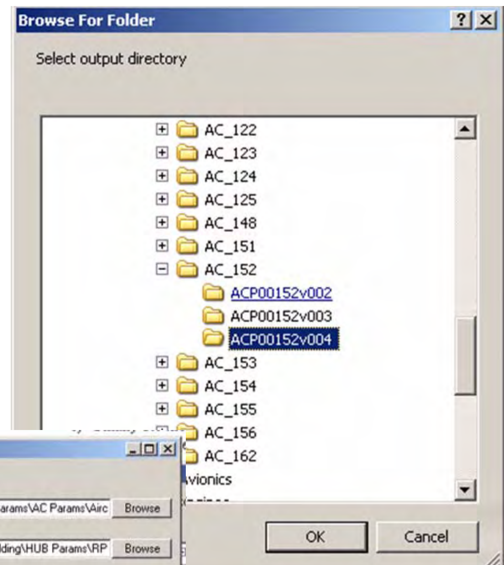
Parameters **(cont.)**

Create and load aircraft flash record (.s19) file (cont.)

Select the reporting, mission, and communications files by selecting **Browse** for each one in the Planner utility. Determine the location you will be flying the aircraft, as this will establish which mission file you will need. Browse in the appropriate folders to find these files.

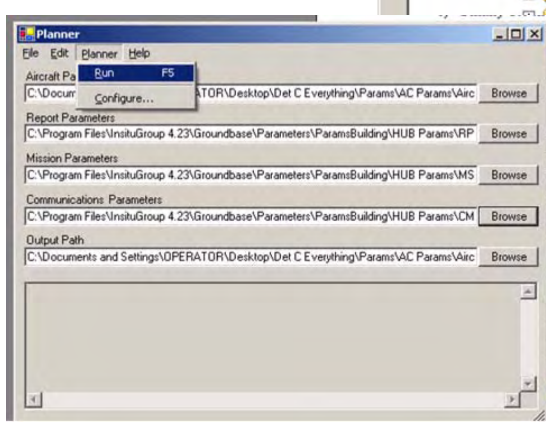


Finally, for the Output path, browse to the location of the new folder for new aircraft parameters; select **OK**.



3 Before running the program, verify the reference of each file path for the Aircraft File, Comm File, Mission File, and Reporting File.

4 **Run** the program from the Planner menu.



5 Verify that “Binary Written Successfully” is printed on the bottom of the printout.

6 Scroll up the printed output page to verify that the printout appears normal, without errors or tabulated numbers indicating errors.

7 If all appears normal, close the Planner utility.

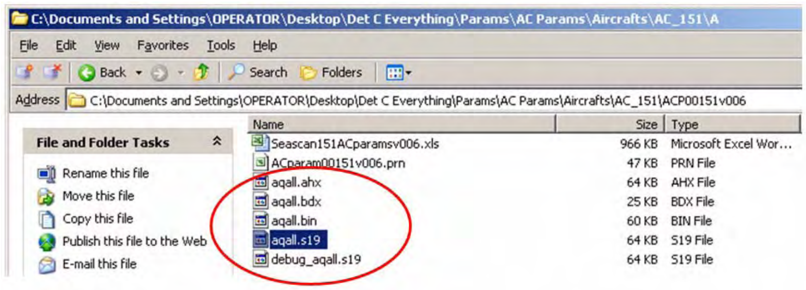
Planner

Parameters **(cont.)**

Create and load aircraft flash record (.s19) file

Create and load aircraft flash record (.s19) file **(cont.)**

8 The flash record (aqall.s19) file is now in the aircraft folder.



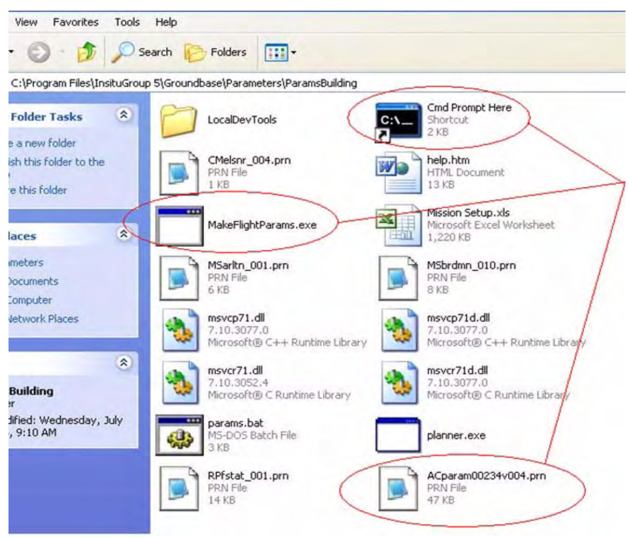
9 Copy the folder containing the new binary file to a USB drive, and use your laptop to program the file onto the aircraft.

10 Update the logbooks regarding the new file changes on the aircraft. Verify that the module change was logged correctly.

Text (.prn)-to-binary (.00#) file conversion

Note: Occasionally, only the binary version of a parameter file (ACP00152.003) is available, and the .prn file must be created. The software program MakeFlightParams converts these files from binary (.001) to text (.prn) and from text (.prn) to binary (.001).

1 Place a copy of the text (.prn) file to be converted in a folder that contains a command prompt and a copy of MakeFlightParams.exe (e.g. ProgramFiles\InsituGroup 5\Groundbase\Parameters\ParamsBuilding).



2 Open the command prompt and type **makeflightparams**.

3 This program requires arguments to affect software behavior. Such arguments are:

- -a for text file of aircraft parameters
- -c for text file of communication parameters
- -m for text file of mission parameters
- -r for text file of reporting parameters

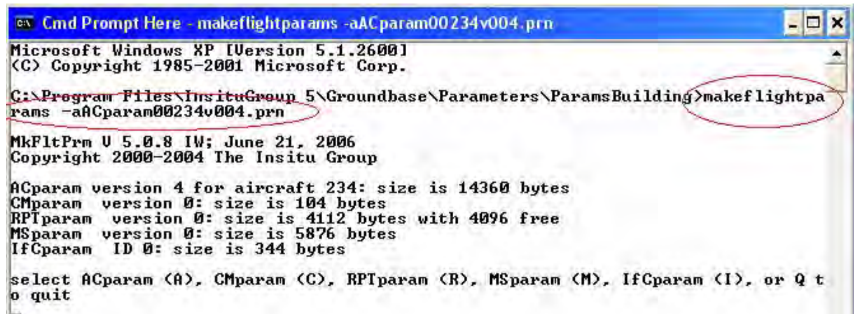
Planner

Parameters **(cont.)**

Converting parameter (.prn) files to flash record (.s19) files (cont.)

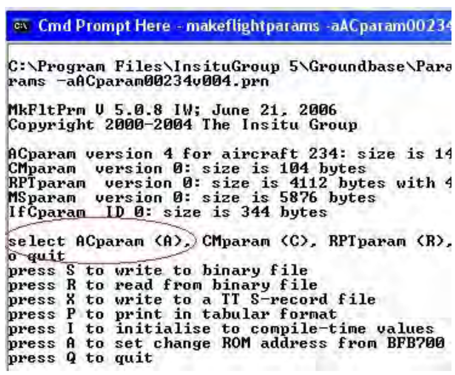
Text (.prn)-to-binary (.00#) file conversion **(cont.)**

4 To convert the text version (.prn) of an aircraft parameter file, use the “-a” argument, providing the name of the file directly after the "-a” (e.g. -aacparam00234v004.prn), and press **Enter**.

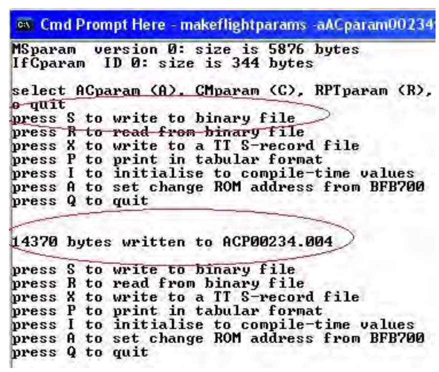


5 When prompted to select a parameter file, press **A** to select the aircraft parameter file.

6 To convert the file to a binary version, press **S**.



A for aircraft parameters



S to convert to binary version

7 The window says data was written to ACP00234.004. This file is located at C:\Program Files\InsituGroup 5\Groundbase\Parameters\ParamsBuilding. Press **QQ** to exit the program.

Appendix

Planner

Parameters **(cont.)**

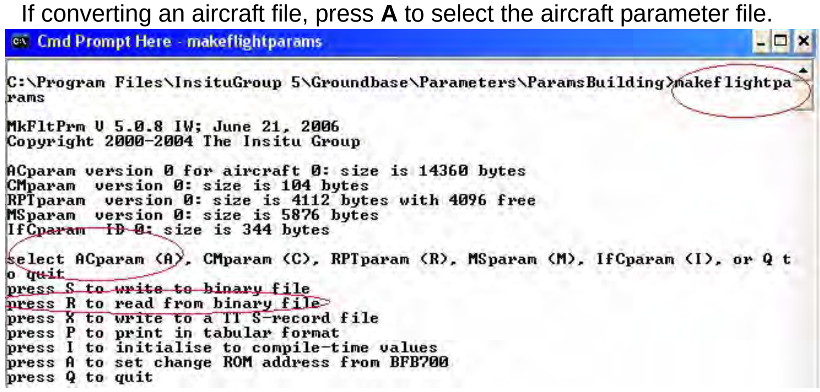
Converting parameter (.prn) files to flash record (.s19) files (cont.)

Binary (.00#)-to-text (.prn) file conversion

1 Place the binary (.00#) file to be converted in the same folder as before. This is the folder that contains both a command prompt and a copy of MakeFlightParams.exe.

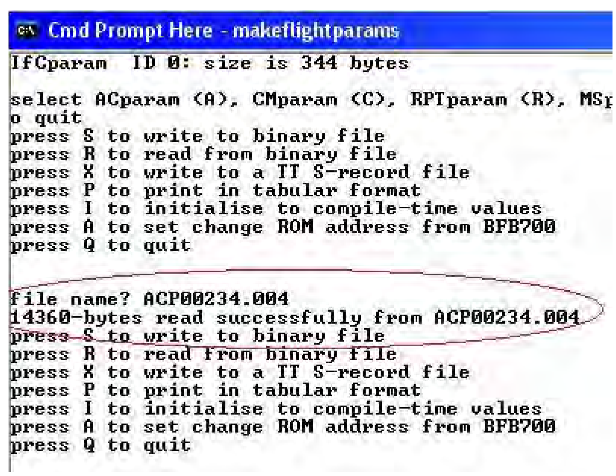
2 Open the command prompt, type **makeflightparams** and press **Enter**. If converting an aircraft, communication, or mission file, arguments are not needed.

3 If converting an aircraft file, press **A** to select the aircraft parameter file.



4 Press **R** to select **read from binary file**. At the prompt, enter the name of the binary file to be converted and press **Enter**. (Enter the name exactly, using the correct number of zeros with a period in the specified location.)

5 A message states that a certain number of bytes were successfully read from the specified file. Now, write that data into a text file.



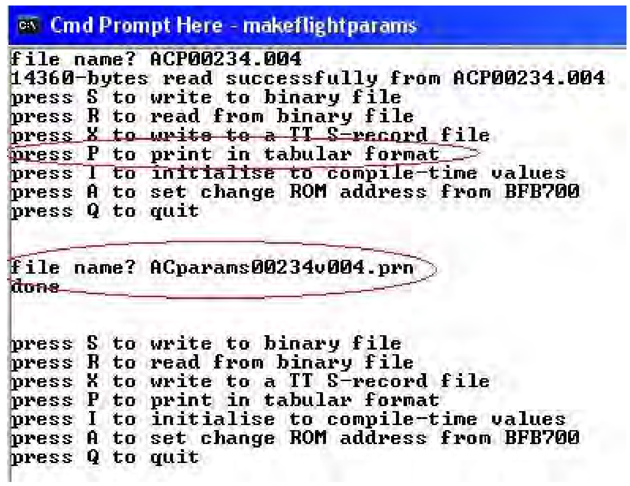
Planner

Parameters **(cont.)**

Converting parameter (.prn) files to flash record (.s19) files (cont.)

Binary (.00#)-to-text (.prn) file conversion **(cont.)**

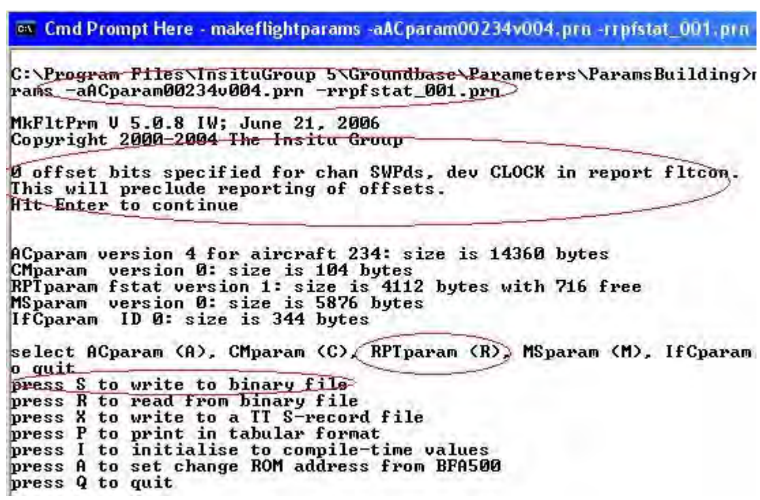
6 Press **P** to print the data in tabular format. When prompted, specify a new file name. Use the standard naming convention (e.g. ACparams00234v004.prn).



7 The text file you created now appears in the specified folder.

8 Press **QQ** to exit the program, close the window, and use the newly converted text file.

Note: **When converting reporting files an aircraft parameter file must be specified when first entering <u>MakeFlightParams</u>. To continue through the offset warning message, which is normal, press <u>Enter</u>. The remaining steps to convert the file are the same as for the other files from then on.**



Planner

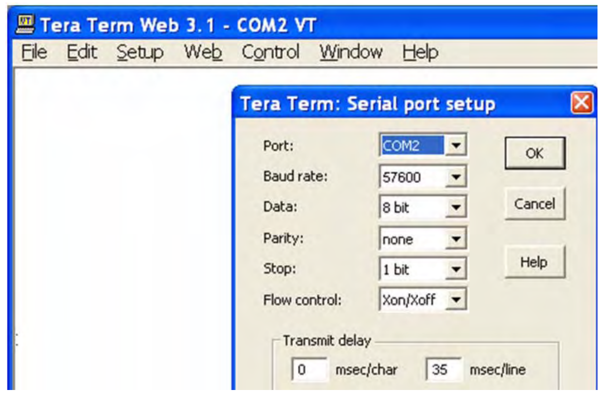
Parameters **(cont.)**

Flashing.s19 file to aircraft

Note: **These instructions are included on the CD received with each I-MUSE release. Review those instructions to ensure that the correct values are entered for each device programmed.**

To start program (Version 1.1 - 16 Aug. 2004):

1 Start Hyperterm or Tera Term Pro: 57600, 8, N, 1. xon/xoff, 35 ms line delay.



Note: **Tera Term Pro is ten times faster than Hyperterm.**

2 Connect the serial cable on the PC to debug/programming connector the on aircraft.

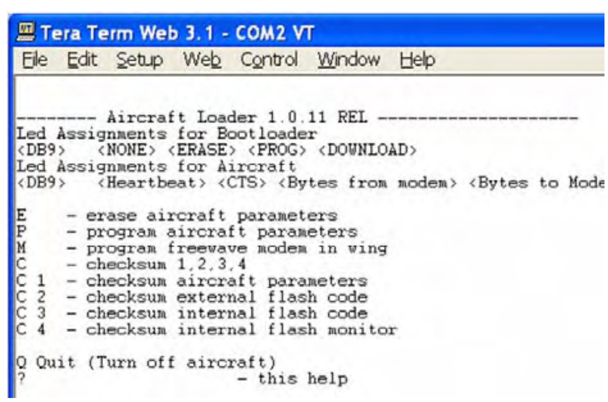
3 Press and hold the **b** key.

4 Power on the aircraft. The bootloader help screen appears.

5 Release the **b** key.

6 Type **?**.

7 Verify simple help screen prints.



Note: **Press <u>Enter</u> after typing the desired letter or number command.**

8 To go to advanced mode, type **I**; press **Enter**.

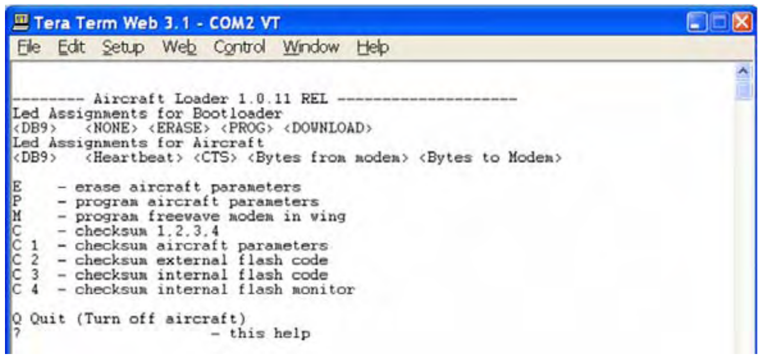
9 To return to simple mode, type **I**; press **Enter**.

Planner

Parameters **(cont.)**

Program aircraft parameters (simple mode to update aqall.s19 file <30 secs)

1 Erase current parameter: select **E**; press **Enter**.



2 Verify checksum is zero.

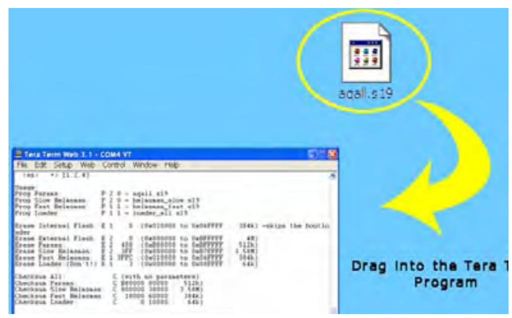
3 Open folder containing aqall.s19 file for the aircraft being programmed.

4 Program parameters: press **P** and **Enter**; drag aqall.s19 file to Tera Term window.

5 Verify checksums are not zero: press **C** and **Enter**.

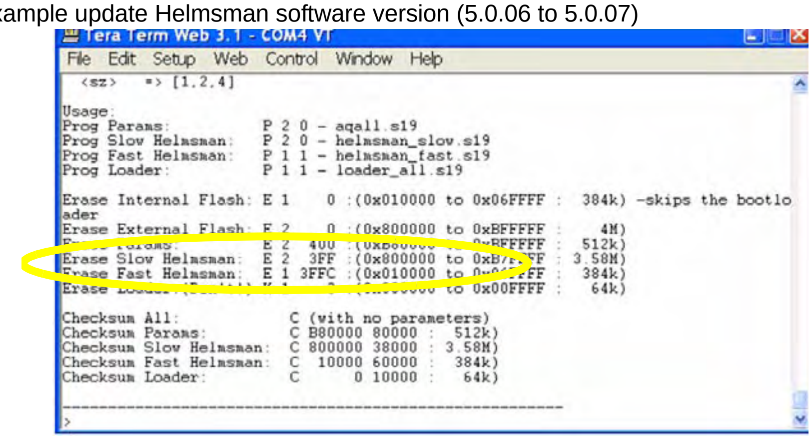
6 Return to simple mode: press **I** then **Enter**.

7 Press **QQQ** to quit.



Program aircraft parameters (advanced mode)

Example update Helmsman software version (5.0.06 to 5.0.07)



1 Erase external flash code (Helmsman Slow): Type the values displayed in the bootloader menu (e.g. **E 2 3FF**), then press **Enter** < 30 sec.

2 Erase internal flash code: (Helmsman Fast): Type the values displayed in the bootloader menu(e.g. **E 1 3FFC**), then press **Enter**< 5 sec.

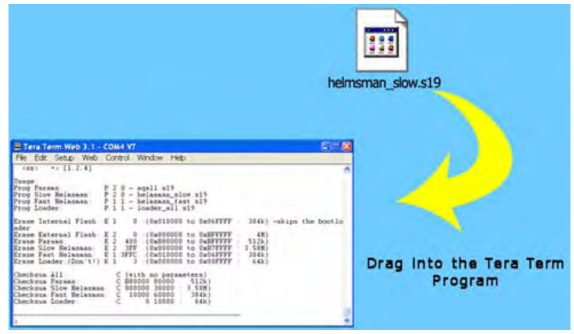
3 Verify checksums are zero.

Planner

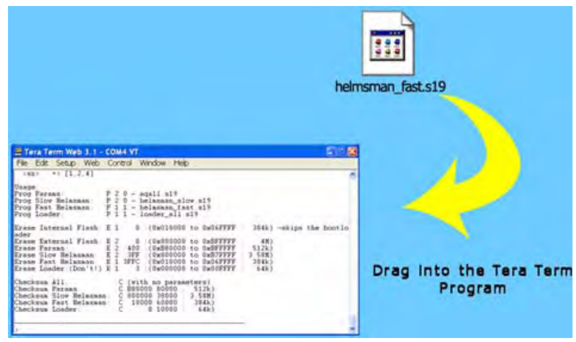
Parameters (cont.)

Program aircraft parameters (advanced mode) (cont.)

4 Program external flash code: **P 2 0** then **Enter**. (Click and drag Helmsman_slow.s19) < 65 sec. EXAMPLE: Program Files\InsituGroup 5\EmbeddedSW\Helmsman_slow.s19.



5 Program Fast Helmsman code: **P 1 1** then **Enter**. (Click and drag Helmsman_fast. s19) < 15 min EXAMPLE: Program Files\InsituGroup 5\EmbeddedSW\Helmsman_fast.s19.



Bootloader

Program Aircraft bootloader (advanced mode < 2 minutes)

Note: Only program the bootloader if you receive Insitu release notes specifically instructing you to do so.

1 Erase internal flash bootloader code: **K 1 3**.

Note: Values are subject to change with each software release. To verify that these are the correct values, see the bootloader menu.

2 Verify checksum is zero.

3 Program internal flash bootloader code: **P 1 1** (download loader_all.s19).

Helmsman

Verify checksums (simple mode)

1 Checksum all memory sections: **c 0**

2 Compare checksums to the Readme.txt file located in the same folder as the Helmsman Fast and Slow .s19 files (e.g. C:\Program Files\InsituGroup 5\EmbeddedSW):

- Ext Code equals Helmsman_Slow.s19
- Int Code equals Helmsman_Fast.s19
- Int Loader equals loader_all.s19
- Params are different for each aircraft

Note: Aircraft with corrupted or empty params or code will not boot to Helmsman but will boot to the bootloader/serial programmer. Aircraft with corrupted or empty bootloader code may not boot at all, and must be returned for service.

Appendix

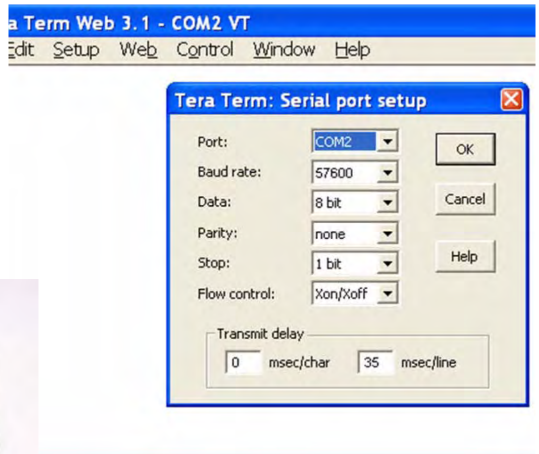
Planner

Modem settings

Note: **If/C modem programming instructions are provided in the next section, *Ground Control Station Software*.**

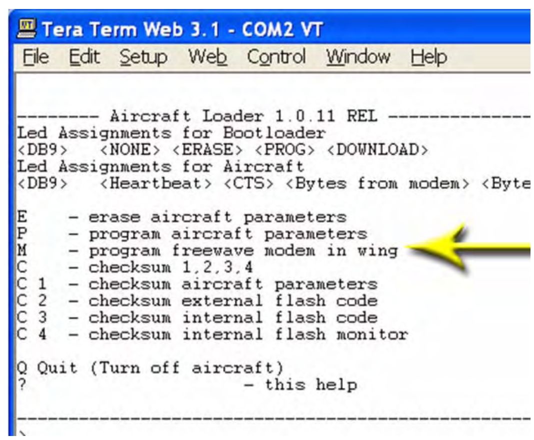
Aircraft

1. Start Hyperterm or Tera Term Pro: 57600, 8, N, 1. xon/xoff, 35ms line delay.



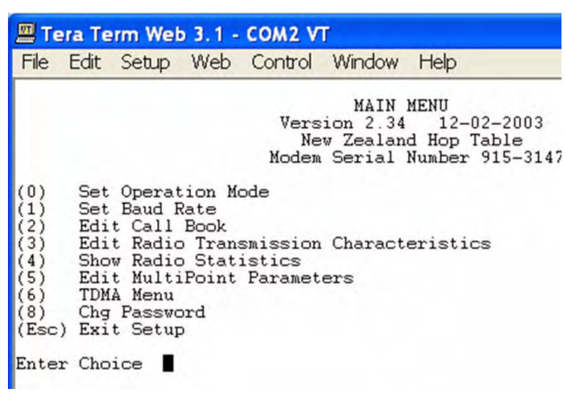
2. Connect the PC serial cable to the aircraft debug/ programming connector (if not already connected to the computer inside the GCS).

3. Press and hold the **b** key.
4. Power on the aircraft.
5. The bootloader help screen appears; Release the **b** key.
6. Type: **?**.
7. Verify the simple help screen prints out.
8. At the menu, select **M** for configure modem.
9. Go to the Modem section.



Modem

1. At the modem main menu, select **0** to change/verify operation mode.



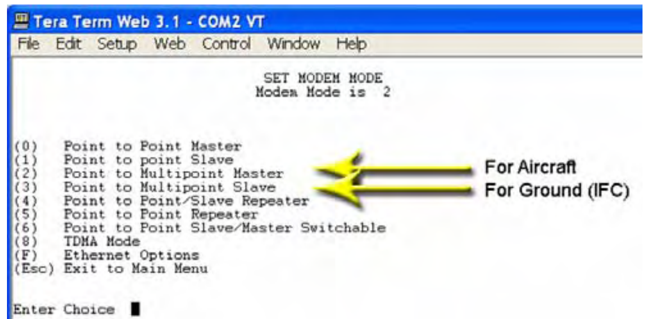
Planner

Modem settings (cont.)

Modem (cont.)

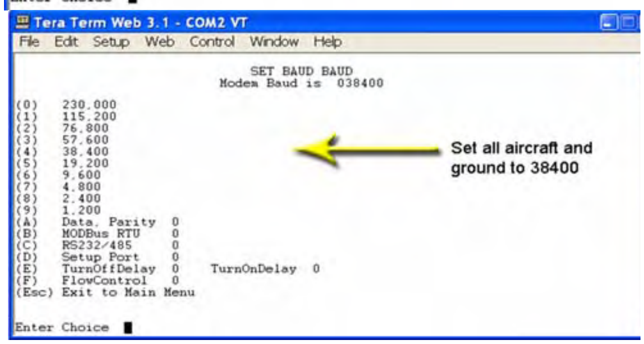
2 Aircraft is point to multipoint master; If/C is point to multipoint slave.

3 **ESC** to return to the main menu.



4 Select **1** to change/verify baud rate. 38400 is the current system wide rate.

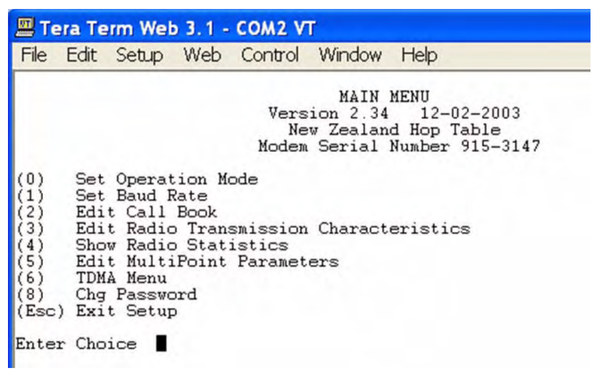
5 **ESC** to return to the main menu.

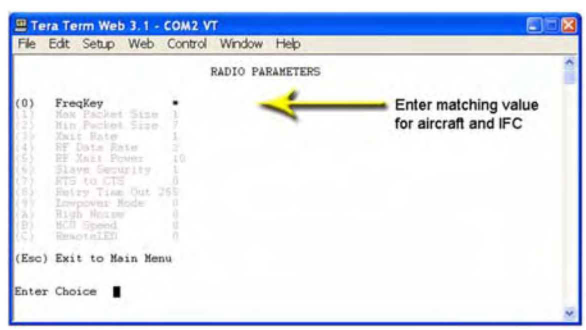


Radio parameters

1 At the modem main menu, select **3** to change/verify radio parameters mode.

Frequency key must be the same for an If/C aircraft pair. All other parameters do not change from values listed here.





Note: **For operation in Iraq theater, hopping bandwidth is reduced relative to full modem capability. To verify correct operation, on the radio parameters menu select <u>0</u> for freq key and then select <u>F</u> for more options. Hop table version should be = 4. This hidden menu parameter should be identical for all radios in the network. Once set, it does not need to be reset. It should be checked if modems don't communicate.**

2 **ESC** to return to the main menu.

Appendix

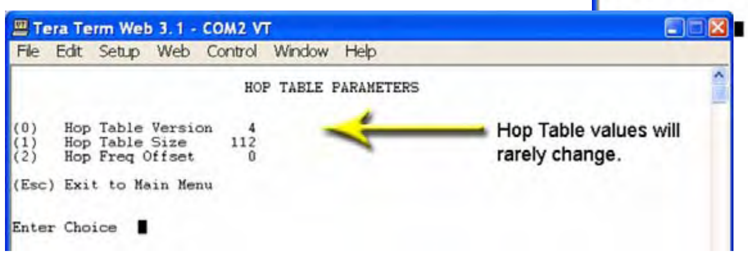
Planner

Modem settings (cont.)

Hop table parameters

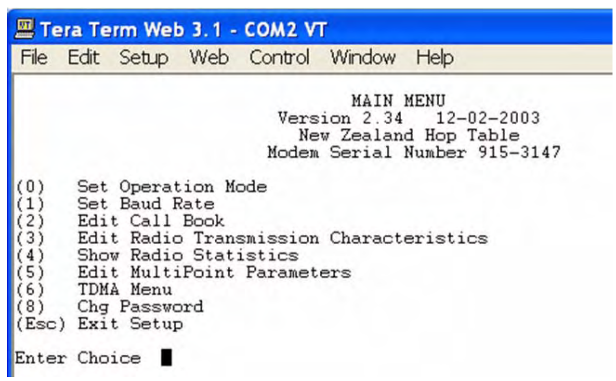
1. To change/verify hop table parameters, from Radio Parameters menu, select **0** for **FreqKey**, then **f** for more options.

2. **ESC** twice to return to the main menu.

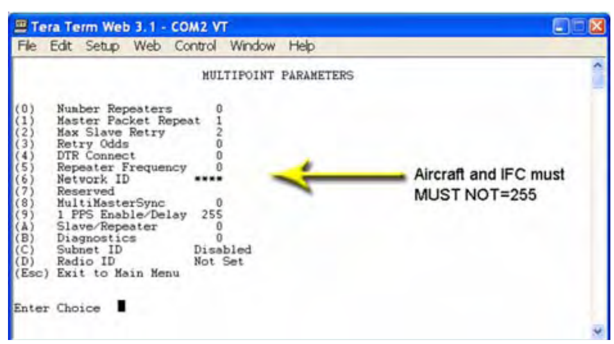


Multipoint parameters

1. From main menu, select **5** to change/ verify Multipoint Parameters.

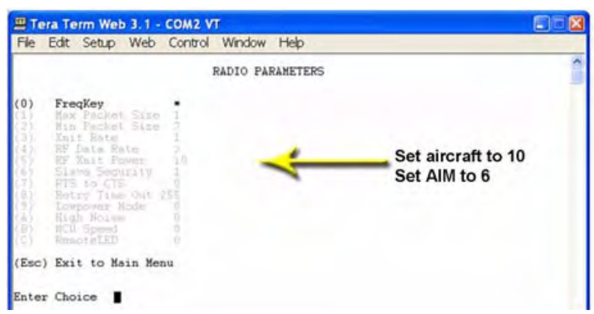


2. For Aircraft, **qqq** to quit back to bootloader and another **q** to quit bootloader and turn off aircraft.
3. For the If/C, a single escape or **qqq** will quit the modem programming and return to the If/C programming menu. The If/C can just be power cycled or shut down now.



Note: **It is possible some older files may not be formatted in this way (or even have update/transfer pages). If this occurs, copy data onto ACparam page directly, taking care to put new information in the right area. All spares files contain the necessary row and column numbers involved in all changes.**

Appendix

Planner	
Modem settings – GCS	
If/C modem settings	1 Start Hyperterm or Tera Term Pro: 57600, 8, N, 1. xon/xoff, 35ms line delay. **Note: Tera Term Pro is ten times faster than Hyperterm.** 2 Connect the serial cable on the PC to the debug/programming connector on the If/C (if not already connected to the computer inside the GCS). 3 Press and hold the **b** key. 4 Power on the If/C. 5 The bootloader help screen appears. Release the **b** key. 6 Type: **?**. 7 Verify that simple help screen prints. 8 Select the modem programming menu by pressing **M**. 9 The bootloader will ask which modem you would like to program. In most installations you will need to modify the configuration of both the modem inside the If/C which is connected to the omni antenna and the external modem connected via fiber to the directional antenna. If it is not known which modem is connected to which If/C port, attempt programming on all ports to see which are connected to modems, then program those modems.
AIM radio parameters	1 At the modem main menu, select **3** to change or verify radio parameters.  **Note: For 1.3 GHz operations, if the AIM has an amplifier, do not set transmit power of the modem for the AIM to a value greater than 6.** **For 900 MHz operations, set thetransmit power of the modem for the AIM to 10.** **CAUTION: With 1.3 GHz operations, setting the transmit power of the modem for the AIM to a value greater than 6 will result in damage to the amplifier.**
If/C programming	
Serial port programming	1 Start Hyperterm or Tera Term Pro: 57600, 8, N, 1. xon/xoff, 35ms line delay. 2 Connect the serial cable on the PC to the debug/programming connector on the rear of the If/C. 3 Press and hold the **b** key. 4 Power on the If/C. 5 The bootloader help screen appears. Release the **b** key. 6 Type: **?**. 7 Verify the simple help screen prints. ▪ To go to advanced mode, type **I** and press **Enter**. ▪ To go back to simple mode, type **I** again and press **Enter**.

Planner

If/C programming (cont.)

Configure IO device port mapping – serial port to device

Port mapping is needed to tell the If/C which devices are hooked up to which physical ports.

1 Read the current configuration: **r**

Note: This shows current mapping saved in flash for all available devices

```
Device                  Port on IfC
--------------------------------------
Primary Dir Antenna    Internal Modem 1
Secondary Dir Antenna  RJ45 J10,J11
Omni Antenna           Internal Modem 0
Skyhook GPS            RJ45 J7,3,12
Antenna Actuator       RJ45 J8
AHRS                   RJ45 J4
>>p
```

2 Go to program If/C port map menu: **p**

3 Map If/C ports to devices: **1**

Note: This allows programming of each device that was listed when the current port mapping was read.

```
==================================
=========IFC Port Mapping=========
==================================
1)   Map IfC Ports to Devices
2)   View Port Mapping Help
3)   View Current Choices
4)   View Map Currently in Flash
5)   Save Port Mapping to Flash
99 to exit
Choose an option: 1
```

4 Select a port to map to:

Note: Devices are programmed in the order they were listed when current port mapping was read. To skip one device and move on to the next, press <u>Enter</u>.

```
==Map Primary Directional Modem==

00)                Internal Modem 0
01)                RJ45 J10,12
02)                Fiber1 Ch1,2
03)                Fiber2 Ch1,2
04)   [*]  [*]     Internal Modem 1
05)                RJ45 J9,16
No Configuration
<ENTER> to skip
Select a port to map to:
```

CURRENTLY SELECTED IN FLASH

CURRENT SELECTION – UNSAVED

5 Once ports have been mapped to all devices, press **Enter** to continue.

This recalls the If/C port mapping menu.

```
Device                  Port on IfC
--------------------------------------
Primary Dir Antenna    Internal Modem 1
Secondary Dir Antenna  RJ45 J10,J11
Omni Antenna           Internal Modem 0
Skyhook GPS            RJ45 J7,3,12
Antenna Actuator       RJ45 J8
AHRS                   RJ45 J4

Press <Enter> to continue:
```

<table>
<tr><th colspan="2">Planner</th></tr>
<tr><th colspan="2">If/C programming (cont.)</th></tr>
<tr><td>Configure IO device port mapping – serial port to device (cont.)</td><td>6 Save port mapping to flash:5
<code>==================================</code>
<code>=========IFC Port Mapping=========</code>
<code>==================================</code>
<code>1) Map IfC Ports to Devices</code>
<code>2) View Port Mapping Help</code>
<code>3) View Current Choices</code>
<code>4) View Map Currently in Flash</code>
<code>5) Save Port Mapping to Flash</code>
<code>99 to exit</code>
<code>Choose an option: 5</code>

7 After current mapping choices are saved to flash, a message indicates if there were any omissions during mapping.
<code>== You have chosen wisely ========</code>
Port mapping was completed successfully
<code>== You have chosen poorly ========</code>
Incorrect mapping; repeat procedure.

8 Type 99 to exit.

<u>CAUTION</u>: Failure to exit properly results in failure to save port mapping changes.

Note: When configuration is changed, the old values are set aside in internal flash memory. If a message states that there is no room for configuration, it is necessary to erase the parameter memory by typing <u>k 1 2000</u>. Internal flash memory will be full after 1,024 configuration changes. Since it can only be erased 100 times, only erase when there is no room for configuration.</td></tr>
<tr><td>If/C code – advanced mode</td><td>1 Erase code: E 1 1FFC < 3 sec
▪ Verify checksum is zero
2 Program code: P 1 1 (download ifc555.s19) < 15 min</td></tr>
<tr><td>Bootloader – advanced mode < 2 minutes</td><td>Note: Only program the bootloader if you receive Insitu release notes specifically instructing you to do so.
1 Erase internal flash bootloader code: K 1 3
2 Verify checksum is zero
3 Program internal flash bootloader code: P 1 1 (download ifc_loader_all.s19)</td></tr>
<tr><td>Checksums – verification</td><td>4 Checksum all memory sections: c
5 Compare checksums to release documentation.
▪ Int Code is equivalent to ifc555.s19
▪ Int Loader is equivalent to ifc_loader_all.s19</td></tr>
<tr><td colspan="2">Note: If/C with corrupted or empty code will not boot to the If/C code but will boot to the bootloader/serial programmer.
If the configuration has never been set on an If/C, the defaults will be used. There is a warning before the startup banner.
If/C with corrupted or empty bootloader code may not boot at all, and must be returned for service.</td></tr>
</table>

Appendix

Planner	
If/C programming	**(cont.)**
Field pitot offset correction	1 Set up aircraft for programming. 2 Power on the aircraft. **Note: Do not press <u>b</u> as when entering the bootloader.** 3 Verify that the startup banner is displayed on the terminal Example: Helmsman V 4.23.5 Rel Mar 23, 2006 TDMA N/A 38400 baud tel AC 00143 v2 CM elsnr v3 RP fstat v3 MS edwrd v1 ResSec[0.000001] TicksPerMsec[1000] PITcount[12500] SWTimerMaxSec[1879.03750] 4 Wait 10 minutes for the aircraft temperature to stabilize. 5 Verify pitot and static systems are not being excited by winds or atmospheric pressure changes. To accomplish this, see Insitu’s official procedures. An Insitu certified wind break must be used. 6 In the terminal program, type **t** for TAS to enter calibration mode. 7 Read menu items presented. 8 Type **c** to run calibration. 9 Read warning message. 10 Press **Enter**. 11 Note the offset value. Enter it as appropriate in the aircraft maintenance log. 12 If an error is reported, follow the instructions in the error message. 13 Type **q** to quit. 14 In Ground Control Station software, review TAS value. It should be around ±1 m/s). 15 If TAS is greater than ±4 m/s, retry procedure. If discrepancy persists, return for repair. **Note: This procedure can be performed while the aircraft is communicating with the ground system.**

Glossary

General Glossary

A

ADC

Analog-to-Digital Converter

AGL

Above Ground Level

AHRS

Attitude and Heading Reference System

Aileron

Airfoil that controls lateral motion.

Airfoil

Device that provides reactive force when in motion, relative to the surrounding air; lifting or controlling flight.

Amplitude

A measure of the size of a signal (often the difference between the maximum and center value of a sine wave).

Azimuth

(Used with elevation, range) The direction (angle) along the ground of a point (as opposed to the angle above the ground).

B

Bank Angle

The angle the aircraft's wings make with the horizontal plane, usually as a result of a turn. Bank angle is sometimes referred to as roll.

BDA

Battle Damage Assessment

Bogies

Unidentified (and possibly enemy) aircraft.

C

CEP

Circular Error Probable. The radius of a circle such that 50% of a set of events occur inside the boundary.

CHT

Cylinder Head Temperature

Command Center

Houses the hardware and software components for the UAV mission (typically in a mobile trailer), and controls and monitors operations from launch to retrieval.

CWS

Control-Wheel Steering

CWT

Control-Wheel Tracking

D

DAC

Digital-to-Analog Converter

Datalink

An interconnecting link between two locations for the purpose of transmitting and receiving data.

Deadman

Switch that enables ignition switch.

DGPS (Differential Global Positioning System)

System that uses two GPS receivers to measure their relative positions with great accuracy.

E

EO (Electro-Optic) Camera

This inertially stabilized camera is used on Insitu's UAV to keep a target in view while the aircraft is maneuvering during daylight operations.

EPLRS

Enhanced Position Locating Reporting System. This system provides the military with means for identification, positioning, and navigation.

Extrema Log

Saved maximum and minimum values for a group of data variables.

F

FAF

Final Approach Fix.

FlightSim

Insitu's software tool for development and simulation of onboard and ground elements, operator training, mission planning, and some elements of aircraft design.

Fuel Slosh

Motion of the fuel in the aircraft tank, that affects aircraft dynamics.

G

GCS

Ground Control Station

GPS (Global Positioning System)

Sensor that uses radio signals from several satellites to determine a position on the Earth's surface.

Groundbase

Insitu's flight operation software that provides comprehensive access to low-level states and controls on the aircraft and ground system, working in cooperation with Insitu's graphic I-MUSE software.

H

Helmsman

The software on the aircraft, which includes: navigation/control, guidance/tracking, safety, and on-board comm relay.

HiL (Hardware-in-the-Loop)

Exercises the aircraft system/software using a combination of both actual flight hardware and simulation.

I

If/C

Interface Computer. Contains the embedded software for connecting to the aircraft, and includes: comm relay, antenna pointing, pilot console uplink, clear to land switch, groundstation GPS/upload, and heartbeat upload.

I-MUSE

Insitu's (graphic) Multiple UAV Software Environment for flight planning, monitoring, and operation, working in cooperation with Insitu's Groundbase software.

Interpolation

Approximation of the value of a function using two nearby known values.

IR (Infrared) Camera

This inertially stabilized camera is used on Insitu UAV to keep a target in view while the aircraft is maneuvering during night operations.

ISA

International Standard Atmosphere

ISR

Intelligence, Surveillance, and Reconnaissance

Isometric

Having equal dimensions or measurements.

L

Lossy

Data compression algorithm which actually reduces the amount of information in the data.

LUT

Look Up Table

M

Magnetometer

An instrument for measuring the magnitude and direction of a magnetic field. Insitu UAV are capable of accommodating smaller-design magnetometer sensors in order to provide magnetic sensing and mapping on UAV missions.

Mnemonic

Short sequence of characters which represents a longer name.

N

Non-dynamic

Very simple simulation (no equations of motion).

P

Pitch

Motion of the aircraft (position or rate) associated with the nose/tail rising/falling while the wings remain level.

Pitot Static Tube

Instrument for measuring air speed and altitude through the pressure difference between the dynamic and static ports.

Pitot Tube

Instrument for measuring air pressure.

Pneumatic

Use of air or gas.

Potentiometer Voltage

Measurement of electrical voltage output, as a result of a variable resistor angular position.

Q

Quaternion Orientation

A mathematical construct used to define and manipulate the orientation of the aircraft.

Quickset

The actuator that allows the antenna used for command and control and video to point at the aircraft based on GPS input.

Quiescent

Quiet or still or inactive.

R

Radians

A measure of angular rotation (1 revolution = 360 degrees = 2 PI radians).

Radii

Plural of radius.

Reynolds Number

Non-dimensional number that characterizes fluid flow by the ratio of:

$$\frac{\text{density x speed x length}}{\text{viscosity}}$$

Roll

Motion of the aircraft (position or rate) associated with the right/left wing falling/ raising while the body remains level.

S

Servo

Small mechanical device that produces motion on the aircraft, based on input electrical signals.

Shuttle (Altitude Shuttle)

The short track, aligned from the entry waypoint along the upcoming segment, used for climb or descent.

Sine Wave

A waveform of a single constant frequency and amplitude, resembling a sine curve.

Sinusoidal

Having a succession of waves or curves.

SkyHook

Insitu's patented SkyHook™ retrieval system uses a GPS unit and antenna to provide near-vertical recovery for Insitu UAV on land or aboard a sea vessel.

Slew Rate

Speed at which a variable changes from one value to another.

Slope

The rate at which an output value changes as compared to the rate the input changes.

SPOI (Sensor Point of Interest)

The point at which the payload or sensors are focused. Thus, for a camera, the SPOI is the center of the video image, or the point the camera is aimed at.

Standalone

Exercises the aircraft software using a single PC only, without additional hardware.

State Variable

One of the pieces of data that is required to completely define the current aircraft condition (position, orientation, etc.).

Superwedge

The patented Superwedge™ launcher provides the initial velocity and rate of climb for Insitu UAV, from land or aboard a sea vessel.

T

TAS

True Air Speed

Telemetry

Automatic transmission of measurement data from the aircraft to the ground by radio.

Terminus

End point.

TGCS

Transportable Ground Control Station

TT&C

Tracking, Telemetry, and Control

U

UAV

Unmanned Aerial Vehicle

Uplink

Transmission of data from ground to aircraft.

Y

Yaw

Motion of the aircraft (position or rate) associated with a change of heading while both the body and wings remain level.

Approach Theory Glossary

A

Approach Coordinate System — N/A

An x,y,z right-hand coordinate system used to define approaches.

Origin: base (Earth-fixed approach) or ground station (Non Earth-fixed approach)

X axis: aligned along the final true heading

Y axis: aligned to the right

Z axis: aligned down

The x-y plane is level to the ground.

Many approach parameters are defined relative to the approach coordinate system.

Final Approach Course — N/A

The track to be followed during final approach. The final approach course passes through the touchdown point (TD) and is oriented in the direction of the final true heading (FTH).

B

Base — base name, base lat, lon, alt

Earth-fixed approach only: An arbitrary point (latitude, longitude, altitude) chosen by the operator that acts as the origin of the 3D approach coordinate system. Many approach parameters are defined relative to this base point. The base can be specified by latitude/longitude, ground-station GPS data, a waypoint, or any landmark in the landmark file.

C

Clear to Land — observer

Permission for the aircraft to proceed with an approach, signaled by a switch controlled by an observer on the ground. Clear to Land can be signaled using either the pilot console switch or the trigger switch.

Glossaries

D

Decision Point **DH above TD**

Runway approach only: The point along the descent slope where the aircraft checks the health of the approach and decides to either execute a missed approach or to continue the approach.

If the decision is to continue the approach, the aircraft commands minimum speed, zero air brake, and idle throttle. If the autopilot is in SAFE mode (as with lost uplink), the ignition is cut automatically; otherwise it is left to the operator.

After the aircraft flies beyond the decision point, it has committed to the approach and a missed approach cannot be called by the aircraft, observer, or operator.

The decision point is where the decision height (DH) intersects the descent slope. The decision height is defined relative to the touchdown point and is always positive.

Downwind Threshold (d/w) and Upwind Threshold (u/w)

Runway approach only: The centerline points at the downwind and upwind ends of the runway. The downwind threshold is at the start of the runway and downwind of the touchdown point; the upwind threshold is at the end of the runway and upwind of the touchdown point. During a successful approach, the aircraft will fly past the downwind threshold but will not reach the upwind threshold.

Earth-fixed runway approach: **d/w and u/w tshld lat, lon, alt**
The thresholds are defined by latitude, longitude, altitude.

Non Earth-fixed runway approach: **GS->d/w and GS->u/w TH x,y,z**
The thresholds are defined in approach coordinates relative to the ground station. The x, y, and z components may be positive or negative.

E

Earth-Fixed Approach **Earth-fixed = 1**

An approach that is defined relative to a point fixed on the Earth's surface.

F

Final Approach **N/A**

The final approach is the phase of the approach sequence where the aircraft aligns itself with the final approach course and begins tracking the descent slope. The length of the final approach is the distance between the final approach fix (FAF) and the touchdown point (TD).

Final Approach Fix (FAF) **FAF x**

The FAF point specifies the downwind edge (start) of the final approach course. It is defined in the approach coordinate system (relative to the base or ground station).

Because the FAF is along the approach line, only the x component needs to be specified (FAF x). (The y component is the same as the TD point's y component and therefore

Glossaries

does not need to be explicitly specified. The z component is determined by the angle of the approach glide slope.) FAF x can be positive or negative. **hold type = abs**

Final True Heading (FTH) — **final true hdg**

The direction of the aircraft's final approach course defined positive clockwise relative to true north. When possible, the FTH should be selected into the wind.

Example: If the FTH = 90 degrees, the aircraft is flying from west to east.

G

Go Around — **miss type = go around; sidestep**

A missed approach in which the aircraft tracks parallel to the final approach course while throttling-up (in order to climb). Unlike the wave off, the aircraft does not turn to the hold point until reaching either the FAF altitude (minus 5 m tolerance) or the Max Upwind x point, whichever comes first. The parallel track followed during the go-around may be offset from the final approach course by a specified sidestep distance, positive-right. (i.e. A positive sidestep will shift the aircraft to the right of the final approach course.) Note that the turn direction can not be specified or predicted.

Ground Station (GS) — **N/A**

Non Earth-fixed approach only: The ground station point is the origin of the 3D approach coordinate system. Many SkyHook approach parameters are defined relative to this point.

Specifically, the ground station point is the location of the ground station's GPS antenna which is typically located at the tip of the SkyHook boom directly above the rope. The operator does not specify the ground station location because this information is obtained from the GPS receiver.

H

Hold Point — **hold type; base->hold x, y, z; hold lat, lon, alt**

The point that the aircraft orbits while descending to the final approach fix (FAF) altitude and while awaiting clearance to proceed with the final approach.

Upon starting an approach, the aircraft will maintain its current altitude, fly to the hold point, and then spiral down about the hold point to the FAF altitude. It will hold at the FAF altitude and continue to orbit the hold point while awaiting clearance to proceed with the final approach.

The hold point can be set to:

FAF (most common). **hold type = faf**

A point specified relative to the base/ground station. **hold type = rel**

Earth-fixed approach only: An absolute point specified by latitude, longitude, altitude.

Glossaries

L

Low Pass **low pass len**

SkyHook approach only: The phase of the approach sequence during which the aircraft is tracking the descent slope and a missed approach will be triggered if:

- The aircraft height overshoot exceeds rope headroom
- The aircraft cross-track error is greater than one wingspan in the direction of the SkyHook

The aircraft is in the Low Pass phase of the approach when it is within low pass length of the touchdown point (TD). Low pass length is always positive.

M

Max Upwind x **max upwind x**

The maximum upwind distance from TD that the aircraft may fly before initiating a missed approach. Max Upwind x is always positive and is defined relative to the TD point.

Note: When executing a go around missed approach, the aircraft will turn to the FAF upon reaching Max Upwind x (unless it has already turned because it first reached FAF altitude (minus 5 m tolerance)). See *Go Around* definition.

Missed Approach **N/A**

Procedure for aborting an approach in progress, either by wave off or go around. A missed approach can be either automatically called by the aircraft or called by an observer on the ground.

N

Non Earth-Fixed Approach **Earth-fixed = 0**

An approach that is defined relative to a point (ground station) that is not necessarily stationary with respect to the Earth's surface.

R

Rope Headroom **rope headroom**

SkyHook approach only: Maximum allowable aircraft overshoot of the descent slope during a low pass. This value (always positive) should be less than the distance from the rope suspension to the touchdown point. If the aircraft distance above the descent slope exceeds rope headroom, the aircraft will execute a missed approach. Rope headroom provides a safety ensuring that the aircraft will not hit the SkyHook boom.

Runway Approach **retrieve type = Runway**

An approach terminating in a belly landing. (The runway is defined by the operator and is not necessarily an actual paved runway.)

Runway Area — N/A

Runway approach only: The area of the runway (runway width x runway length). While it is desired that the aircraft land at the touchdown point, the runway area defines the area on the map within which the aircraft is allowed to land.

Runway Length — rwy length

Runway approach only: The distance between the upwind and downwind thresholds. The runway length is always a positive value.

Runway Width — rwy width

Runway approach only: The width of the runway. The aircraft will execute a missed approach at the decision height if it is projected to reach TD outside the runway edge.

S

SkyHook Approach — retrieve type = Skyhook

An approach leading to a level-flight pass through a specified point in space (meant to place the aircraft in contact with the Skyhook rope).

T

tan(final) — tan(final) >=

Runway approach: The descent slope on final approach with no headwind.

Skyhook approach: The maximum descent slope on final approach with no headwind. (The slope decreases to zero as the aircraft reaches the touchdown point.)

Both approaches: The aircraft may elect to increase the angle to compensate for headwind.

Tan(final) is always positive. The angle is represented as tan(final) for convenience; tangent is a ratio (opposite over adjacent). For example, if the descent slope angle is 2.8 degrees, tan(final) = 0.05 = (5/100). In this case, the aircraft will descend 5 m for every 100 m of flight along the final approach course.

tan(lowpass) — tan(lowpass)

Skyhook approach only: The slope of the shallow section of the final approach descent slope. (Technically, the SkyHook approach descent slope is a polynomial curve fit to the final and low pass descent slopes.)

Tan(lowpass) is always positive. Like tan(final), it is convenient to think of tan(lowpass) as a ratio.

TD from Threshold — tchdown frm TH

Runway approach only: The distance between the downwind threshold and the touchdown point (TD). TD from Threshold is always positive.

Touchdown Point (TD) **B->TD x, y, z; or GS->TD x, y, z**

An x,y,z point specified in the approach coordinate system which defines the desired touchdown/retrieval point. The x, y, and z components of this point can be positive or negative values.

U

Upwind Threshold (u/w)

See *Downwind Threshold*.

W

Wave Off **miss type = wave off; direction**

A missed approach in which the aircraft immediately and simultaneously throttles-up (in order to climb) and turns away from the final-approach course to return to the hold orbit. The operator specifies the turn direction as either to the aircraft's right or left. For a SkyHook approach, the specified direction should be **away** from the SkyHook boom.

Wind Direction **N/A (see surface wind table)**

The wind direction is defined positive clockwise relative to true north. Meteorological convention dictates that the wind direction angle is the direction the wind is coming from. This is in contrast to aviation convention which dictates that the aircraft heading is the direction the aircraft is heading to. A 90 degree wind is a wind that is blowing from the east to the west. An aircraft with a heading of 90 degrees is flying from the west to the east.

In an ideal situation, the wind vector should oppose the aircraft final true heading so that the aircraft is landing directly into a headwind. In practice, a small crosswind is permitted but a tailwind is not recommended. (Large crosswinds have led to SkyHook retrieval failures. A tailwind will increase the groundspeed and therefore the likelihood of aircraft damage upon contacting the ground or SkyHook rope. Given the constraints of the landing site (obstacles, etc.), a crosswind or tailwind may be unavoidable.)

For the approach theory discussion, a pure headwind is assumed. This assumption is reflected in the naming convention of other approach parameters such as the upwind and downwind thresholds.

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INSITU

Feedback Form

Please tell us how well this handbook meets your needs, and how we can improve it to assist you further. We appreciate your feedback!

Product: **Operator's Handbook V2.1 – October 2006**

Is the information in this handbook complete and accurate for your needs? ❑ Yes ❑ No

If not, where have you noticed problems? ____

____

Is it easy to locate specific information quickly in this handbook? ❑ Yes ❑ No

If not, what would make it easier? ____

____

For what purposes has this handbook been useful to you or your department:

❑ Reference ❑ How To... ❑ Overviews ❑ Technical specs
❑ Training ❑ Maintenance ❑ Troubleshooting ❑ Marketing

How often do you use this handbook? ❑ Frequently ❑ Occasionally ❑ Seldom

What have you found most helpful? ____

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What would you improve? ____

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What form of documentation do you prefer? ❑ Printed ❑ Online Help ❑ Both

Additional comments about this handbook, the training, or the product: ________________________

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Optional: Your name: ______________________ Organization: ______________________

Your title/role: ______________________ Email or phone: ______________________

Return your comments to us at:

FAX: Attn: Documentation Dept., Insitu, 509-493-8601
MAIL: Attn: Documentation Dept., Insitu, 118 E. Columbia River Way, Bingen, WA 98605

Thank You!

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Operator’s Handbook

Unmanned Aerial Systems

Setup, Launch, Flight, Retrieval

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