NATIONAL ENERGY TECHNOLOGY LABORATORY
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U.S. DEPARTMENT OF ENERGY

October 1, 2009

Federal Aviation Administration
Unmanned Aircraft Program Office

SUBJECT: UAS Airworthiness

Ref: National Energy Technology Laboratory Certificate of Authorization Application 10/01/09

Dear Administrator:

The following alternative Airworthiness Statement was tailored for the Guided Systems Technologies Inc. SiCX-12/Cloud Cap UAS Helicopter. The SiCX-12/Cloud Cap will be operated as a Public Aircraft as defined in 14 CFR Part 1.1. Airworthiness has been reviewed by our contractor Apogee Scientific Inc. and the Principal Investigator at NETL. The engineering and flight testing performed at Guided Systems Technologies Inc. indicate the equipment poses minimal risk to persons, equipment, property and environment for operations limited to those described in the referenced COA application and when flown in accordance with safety standards implemented at the proposed controlled-access flight area at the U.S. Department of Energy/Rocky Mountain Oilfield Testing Center.

Attached are a summary of the evaluation of Safety Procedures and Airworthiness.

Sincerely,

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Attachment 1: Airworthiness Statement/Safety Procedures

The following document describes the procedures utilized to maintain safety of flight thus limiting the possibility of injury/death and damage to equipment, property and the environment at the proposed area of operations described in the COA application. The limited flight test data were collected by the manufacturer Guided Systems Technologies Inc.

1. Preflight Procedures

Helicopter Preflight Checklist
Check aircraft logs from previous post flight inspection assuring all squawks were remediated
Pull test main and tail rotor blades, check for cracks, chips or other damage. Replace if necessary.
Check tightness of main rotor blades, must be allowed movement for lead-lag
Inspect swashplate assembly for proper function, loose fasteners
Inspect all ball-link connections
Inspect landing gear for damage
Inspect tail rotor drive belt for tension, signs of wear or misalignment
Inspect battery voltages, should be within normal operating range
Inspect servo mounting and retention screws or bolts
Inspect for proper servo operation and control deflection
Inspect main rotor drive spur gear for signs of wear or damage
Inspect all wiring harnesses and connectors for security or detachment
Inspect all strain relief connections to antennas and sensors
Inspect exhaust system for loose or leaking components
Inspect fuel tank for evidence of leakage, vibration isolation intact
Inspect engine mounts, vibration isolation intact
Examine fuel lines (supply and return) for cracks and signs of deterioration and security of connections
Check fuel quality and quantity appropriate for mission duration plus reserves

Preflight Checklist for the Cloud Cap Piccolo Autopilot System
Check and record initial battery voltage and current.
Configure map page as required for the mission.
Verify and/or load flight plans
Verify correct controller settings.
Verify mission limits including deadman status and lost communications waypoint.
Verify working aircraft GPS, check number of satellites and PDOP.
Set altimeter to local base pressure, or choose GPS update.
Select manual control and verify manual control indicated in autopilot page.
Verify control surface trims in manual mode. Adjust using pilot console.
Verify manual control, both magnitude and direction, for all control surfaces.
Verify the reported control surfaces match the actual control positions.
Check air data readings and zero them if needed.
Check the correct operation of the gyros and accelerometers by physically rotating the aircraft and verifying the sensor outputs.
Verify that the pitot tube is clear by blowing into it and seeing the airspeed response.
Set the initial fuel weight or battery charge state of the vehicle.

Configure the autopilot loops as needed; typically all auto, with the waypoint set for the launch plan.

Helicopter Ground Check-Runup
Start the engine and verify correct operation through the entire RPM range.
Note: to prevent possible injury, restrain leading edge of main rotor blade to retard rotation during startup.
Check sensor readings for signs of excessive noise due to engine vibration at different RPM.
Check communications at the far end of the runway strip. RSSI signal should indicate close to the maximum reading (-71 dBm).
Check for aircraft traffic and make any radio calls mandated by air traffic control.
Final check on the system: Battery voltage and current, GPS health, RSSI, and sensors.
Takeoff and start watch or timer.

2. UAS Flight Safety at Rocky Mountain Oilfield Testing Center (RMOTC)

Ground Safety-General
All work performed at the Rocky Mountain Oilfield Testing Center shall be conducted with strict adherence to safety procedures and guidelines already implemented. All work activities including the proposed UAS Research flights are subject to inspections and approval by the Site Safety Specialist. The use of appropriate personal protective equipment is required at all times. This includes hardhat, safety glasses with side shields, hard-toed shoes, and hearing protection. The proper use, storage and labeling of chemicals (and fuels) are also required. In addition, all employees at RMOTC have stop work authority in the event that unsafe conduct is observed. Possible impacts on the environment will be evaluated and minimized. RMOTC will prepare an Environmental Impact Statement (EIS) for compliance with the National Environmental Policy Act (NEPA) in regards to the proposed test flights. No hazardous chemicals, explosive payloads, radiological or biological materials will be used in connection with these flights.

Safety-Flight Operations
RMOTC's Oilfield Testing Site is remotely located about 30 nm northeast of Casper, Wyoming. (see map, page 9), the 15 sq. mi. controlled-access, Government-owned site is sparsely populated. During the proposed UAS flights the entire area described by the mission limits will be off limits to all personnel except for crewmembers (PIC and observers). Likewise, personnel in adjoining areas may be denied access to serve as a safety buffer. All proposed missions will be flown in a direction away from people.
By far, the greatest potential hazard to persons on the ground would be a power plant failure and subsequent uncontrolled descent of the helicopter. Another possible hazard would be striking personnel or structures during flight or controlled flight into terrain (CFIT). These hazards can be mitigated by following the aforementioned safety precautions.
In the unlikely event that manned aircraft are observed operating at an altitude that UAS operation could pose a potential conflict, or if any unauthorized persons are observed in the vicinity during operations, the UAS will be immediately maneuvered clear using manual control and the flight will be ended normally. A flight may also be ended by executing the auto landing sequence using the auto land waypoint predefined in the Mission Limits or by reassigning a new auto land waypoint

and executing the auto-landing procedure. The safety pilot may also perform a manual landing. In an emergency (see emergency procedures document) the flight control software will be employed to stop the engine of the UAS and thus terminate the flight at any time. In addition, a fully redundant engine kill system has been incorporated into the SiCX-12.
Missions will be flown well within the normal flight envelope with no excessive maneuvering of the aircraft. In order to achieve our stated objectives to use these aircraft for the purpose of air monitoring, a regularly-spaced array of predefined waypoints will be employed well within the RMOTC controlled access boundaries. The SiCX-12 will fly to each point and hover for a predetermined period before moving on to the next waypoint. At no time should groundspeeds exceed 30 kts. The light weight sensors employed in air monitoring will be securely attached to the SiCX-12 in such a way that it will not exceed the normal CG envelope. Tethered flights may be conducted to determine that the installed sensors do not adversely affect flight characteristics.

Flight Monitoring/Observation Procedures
There are two persons that will act as visual line-of-sight observers during the proposed flights. The PIC will serve as the primary observer, as he will be required to maintain visual contact for the duration of the mission in the event that manual control is necessary. The PIC will have in his possession a cell phone, an air band transceiver and appropriate two-way push to talk radio for communication with other crewmembers. The secondary observer will not only serve as a backup to the safety pilot, but will also help to monitor intrusions by unauthorized persons/vehicles, both on the ground as well as in the air. In addition to a two-way push to talk transceiver and a cell phone, the secondary observer will be equipped with binoculars (must exercise caution viewing in the direction of the sun). The third crewmember at the Mission Console inside the Operations Staging Trailer, although not acting directly as an observer will monitor telemetry data from the UAS and the Primary Flight Display for abnormal indications and will make determinations as to whether the mission is progressing normally and according to the mission plan. The Mission Control crewmember will also be in direct communications with the PIC and secondary observer and will have in his possession a cell phone and two-way push to talk transceiver to notify other crewmembers of any anomalies during flight. In addition, each crewmember will be supplied with an emergency air horn to alert the PIC to an emergency situation during any period in which radio communications have failed. Any changes to a current mission plan during flight that result in change of altitude, heading, course, or groundspeed will require concurrence from the other crewmembers and will be accompanied by a countdown before execution.

Mission Parameters
Except for the purpose of takeoff and landing, flights will be conducted at an altitude that will provide safe clearance from obstructions and terrain at or below 400 ft AGL. The mission lateral limits for the proposed flights will never exceed 1 nm or unobstructed visual observation range, whichever is less or those limits approved by the Administrator in the COA. These limits are set in the Mission Limits of the Piccolo Autopilot System software.

Obstruction/Terrain Clearance
Obstructions are known for all areas at RMOTC and are maintained in a Geographical Information Systems Database. These include power lines, poles, towers and derricks. Terrain obstructions data are available from an accurate digital terrain model (DTM) acquired using LiDAR data aboard a manned helicopter used for a geophysical survey conducted in 2008. Terrain and obstructions avoidance will be accomplished through detailed review of this information and selection of an

appropriate altitude at or below 400 AGL prior to conducting any flights. Also, a thorough reconnaissance of the flight area will be conducted on the ground and a simulation of the flight plan will be rehearsed. A takeoff and landing area that is free of obstructions will be selected that will also afford good visual observation during flight. The missions control crewmember for the proposed flights at RMOTC will conduct his duties from inside a hard-sided trailer equipped with a wide shatter-resistant plastic window prior to takeoff and landing and until the aircraft is at a safe distance. The window will afford a panoramic view of the takeoff and landing area. The PIC and observers will be the only personnel permitted outside the safety of the trailer during this phase of flight. A fire extinguisher and first aid kit shall be available at the Flight Staging/Operations trailer.

Communications

The nearest airport in the area is Iberlin Ranch (WY18), a privately-owned field without a designated CTAF frequency. Casper Natrona County (KCPR), a tower-controlled airport in class delta airspace, uses CTAF/Tower frequency 118.3 MHz. Another public airfield in the area, Harford (KHAD) uses the multicom frequency, 122.9 MHz. A handheld (PEP 5 Watts) airband transceiver will be available to the PIC to monitor local air traffic for the possibility of contacting participating manned aircraft that may be overhead, enroute to or from one of these local airports during the proposed UAS flights as an added measure of precaution. The telephone numbers for notification of the local FSDO, facility providing tower enroute control, and the Casper FSS will be readily available, if needed.

The PIC will communicate with the flight observers using a handheld two way radio system. Communications checks will be conducted prior to any flight to ensure that all observers can reliably communicate with the PIC. In the event of communications loss with any observer, the PIC will immediately command the UAS to land and will not re-launch the UAS until communications have been reestablished. Each observer will also have access to an emergency air horn that he will use to alert the PIC to an emergency situation during any period in which radio communication have failed

Weather

Good Day-VFR weather conditions as defined in the *Aeronautical Information Manual* (visibility >5 SM and ceilings >=3000 ft) shall predominate during the proposed UAS flights. Weather information will be obtained from various aviation weather resources including Flight Service Station standard weather briefings, and Official Internet Sources (http://www.aviationweather.gov). Winds shall not exceed 15 kts. Wind conditions can be obtained from a multi-parameter meteorological station installed at RMOTC. Real time wind/direction information will be obtained from a calibrated windsock installed at the launch/recovery area.

Go/No Go Authority

The PIC will act as final authority on whether a flight will proceed provided all other requirements are met. Flights will be ended normally on the first sign of deteriorating weather conditions also at the discretion of the PIC.

Post-Flight

A debriefing and detailed log of each flight will be maintained by the PIC and flight crewmembers. These logs will include date, time, and duration of flight, mission parameters, and weather conditions. Additionally, the SiCX-12's flight data recording capability (ground station only) permits logging of mission telemetry during all phases of flight and can be played back in simulator mode at the control station or any suitable PC.

3. Guided Systems Technologies Piccolo System and SiCX-12 Operational Statistics

GST has extensively tested the completely functional SiCX-12 UAS system over the past 24 months. Records of vehicle performance have been recorded in Vehicle and Safety Pilot logbooks. Testing has included Autorotation recoveries, payload capabilities, full flight envelop, and center of gravity, and different landing gear, tail boom, and main blade configurations.

Several SiCX-12 users have achieved good results with minimal maintenance to the SiCX-12 vehicle. In one case, it was reported that a hundred flights were achieved without a safety pilot's intervention. Safety pilots have also complimented the vehicles' ease of control and stability under manual manipulation.

The following is a brief description of incidents and their causes in an attempt to document and establish the success rate for the SiCX-12 vehicle.

Tail Failure:

During early development, a vehicle was lost due to a tail rotor failure. It was determined that a mismatch in parts was overlooked and resulted in the failure. This incident sparked the development of an assembly checklist which includes this item. This is the only reported incident of this nature to GST knowledge.

Engine Failures:

1. During initial testing, a new vehicle was starved of fuel during a test flight. The vehicle was taken under manual control and auto rotated successfully and did not suffer any damage. The investigation concluded an improper fuel mixture caused the premature low fuel level experienced during this flight. The solution to this problem on future vehicles is to extensively ground test, tune, and incrementally fly new vehicles until a fuel burn rate of a known and acceptable value is attained.

2. Another vehicle encountered a surging engine during a flight and was taken under manual control and landed immediately. The engine design incorporated a two head bolt design which can allow a vacuum leak situation. Also, if carburetor or exhaust manifold bolts become loose, similar problems can occur. Solution: The engine design has been updated and preflight checklists have been generated to address such failure points. Also, a vehicle maintenance schedule is under development.

3. In another instance, an engine seized during climb out. The vehicle was taken under manual control and successfully auto rotated resulting in no damage. It is likely that too lean of a fuel mixture lead to the engine failure.

4. A customer seized an engine after 150+ flights while experimenting with fuel mixture controls. Photos suggested too lean of a mixture was set.

Crashes or Hard Landings:

1. A customer crashed a vehicle under manual control. The vehicle had been test flown and trimmed by GST personnel and deemed airworthy before incident. Possible cause, loss of orientation.
2. Safety pilot took manual control on two occasions during landing and slammed vehicle down resulting in damaged landing gear.
3. Vehicle false detected ground check during landing phase and slammed down from three feet resulting in broken landing gear. Code was improved and alternative sensors identified to improve performance.

In Summary:

With many fielded vehicles and end users, the SiCX-12 has achieved several hundred successful missions with few failures. GST continues the development and documentation of the vehicle and strives to improve performance, features, and training for our clients. Through our extensive operational experience with the SiCX-12, we have determined it to be a safe and effective UAS Platform.

4. Types of Failures

Most Likely System Failures					
Type of Failure	**Sign of Problem**	**Monitored through Telemetry**	**Solution**	**Impact on Mission**	**Risk Level to Vehicle**
Low Signal Strength	Vehicle is slow to respond to manual commands or PCC commands. A/P terminates steering mode. Audible and warning light alarms	Yes, Signal strength displayed in percentage and packet update rate	Turn A/P on and abandon manual flight. Initiate auto-land	Judgment call. If a poor signal is experienced and does not improve, recommend terminating flight. May continue with caution	Minimal depending on operators recognition of problem
Loss of Communication	A/P terminates manual control, or fails to respond to PCC commands. Audible Comm. alarm and warning	Yes	The vehicle returns to loss comm waypoint, hovers until elapse of flight timer, then commences	Terminated by A/P.	Minimal if vehicle and mission are set up properly

	light		auto-land procedure.		
Loss of GPS	First indication is poor altitude hold performance, also poor position hold during hover	Yes, indicated by number of satellites tracked and GPS Quality PDOP	Return to visual and land under manual control	Terminate Immediately by safety pilot	Minimal if Safety Pilot is utilized
Low Power Avionics	System voltage warning audible and warning light	Yes	Land immediately, manual quickest method	Terminate	Minimal
Low Power Actuators	Lower than nominal voltage displayed	Yes	Land Immediately	Terminate	Minimal
Generator Failure	Actuator or system voltages begin to fall	Yes	Land when batteries near fall to nominal voltages	Continue with caution. Monitor voltages closely	Minimal
Vehicle Damage	Vibration, strange noise, bad performance	No	Land immediately	Terminate	Moderate
Engine Failure	Noise level or RPM changes, engine looses power	Yes, monitored by rotor RPM thru the RPM sensor	Return and land immediately. If engine dies initiate autorotation procedure	Terminate	Moderate
Tail Rotor Failure	Loss of tail control	No	Switch to manual control and initiate autorotation procedure	Terminate	Severe

Flight Area Maps