Control Station Description

A JR 9303 2.4 GHz radio transmitter will be used by the pilot to transmit commands to the Bergen RC helicopter. This transmitter provides direct pilot control of the aircraft throttle, collective pitch (main rotor pitch), roll cyclic (aileron), pitch cyclic (elevator), and yaw (tail rotor).

A DJI Innovations XP3.1 autopilot has been integrated into the Bergen RC helicopter. This integration was performed by the helicopter manufacturer, Bergen RC. This autopilot, shown in Figure 1, consists of a control system integrated with GPS, a 6-DOF inertial measuring unit, a magnetometer, and a barometer. The autopilot system weighs 1 lb (including battery) and requires 5 W of power. The XP3.1 autopilot provides the following flight modes:

- **Manual Mode:** The helicopter is under the complete control of a human pilot and receives commands via the manual 2.4 GHz RF transmitter.
- **Autopilot (Autonomous Hover) Mode:** The helicopter hovers at a fixed position and altitude. The pilot is able to issue simple forward/backward, left/right, and climb/descend commands using the manual 2.4 GHz RF transmitter.
- **Attitude Mode:** The attitude and altitude of the helicopter is locked, but not the position and velocity.
- **Waypoint Mode:** The helicopter flies through a set of waypoints that are programmed on the ground control station. The waypoints are specified in terms of altitude (AGL), latitude, and longitude, and the flight speed is also specified on the ground control station. In proceeding from one waypoint to the next, this mode offers a choice between performing a stop-and-turn maneuver or a coordinated turn.
- **Fail-Safe Mode:** The helicopter goes into autonomous hover mode, remaining at a constant position and altitude, if the manual RF communications link is lost at any time. For example, if the autopilot is operating in waypoint mode and the manual RF link is suddenly lost (i.e., the ability to execute a manual over-ride is compromised), the fail-safe mode automatically engages.
- **Home Waypoint Mode:** The helicopter returns to a pre-specified home waypoint in the event the manual RF communications link is lost for 10 seconds or more. This mode is always preceded for 10 seconds by the fail-safe mode.

Figure 1: DJI Innovations XP3.1 Autopilot System.

The autopilot has been integrated into the helicopter control system in such a manner that all commands from the JR 9303 2.4 GHz transmitter are routed through the autopilot controller. Figure 2 depicts the flow of control signals for the autopilot system as compared to a standard set-up with no autopilot. From Figure 2, it can be seen that commands from the 2.4 GHz manual transmitter pass from the onboard receiver to the autopilot controller, which in turn issues commands directly to the helicopter servos. A 3-position switch on the 2.4 GHz transmitter has been programmed to enable the Pilot to quickly switch between the manual, autopilot (i.e., hover mode), and attitude hold modes. It should be emphasized that, in manual mode, the autopilot controller simply passes the pilot control commands directly to the servos without modification.

Waypoint mode is activated by first switching from manual to autopilot mode on the RF transmitter and then clicking on the Mission Editor link on the autopilot ground control station. This link signals the onboard autopilot to begin flying the helicopter through the waypoints. When the waypoint mode is engaged, the ground control station transmits waypoints to the autopilot controller via a 900 MHz RF link. The ground control station, which takes the form of a laptop computer integrated with the 900 MHz autopilot transmitter, is used to program, execute, and monitor flight operations and waypoint path performance. The laptop computer displays a map of the operating area and aircraft flight parameters. Figures 3 – 5 illustrate portions of the autopilot interface, which provides the user with various options such as viewing the current helicopter coordinates, altitude, speed, and orientation, viewing the overall helicopter track on a map, and viewing programmed waypoints on a map.

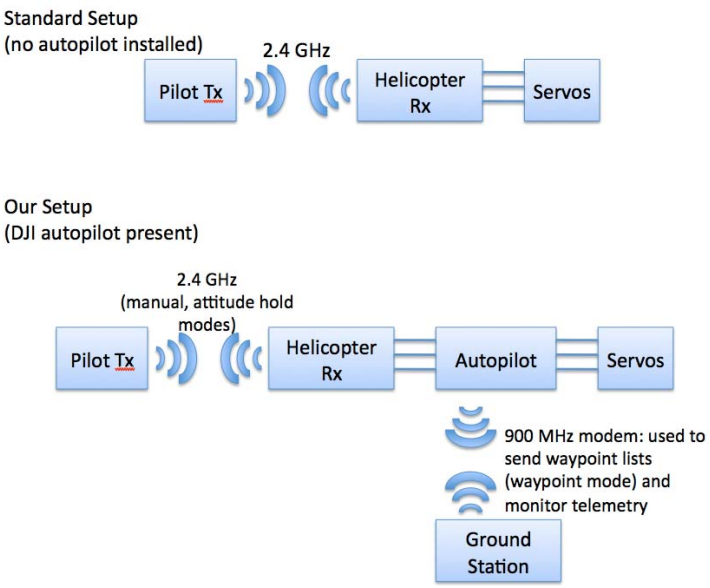

Figure 2: Control Signal Flow for the Autopilot System.

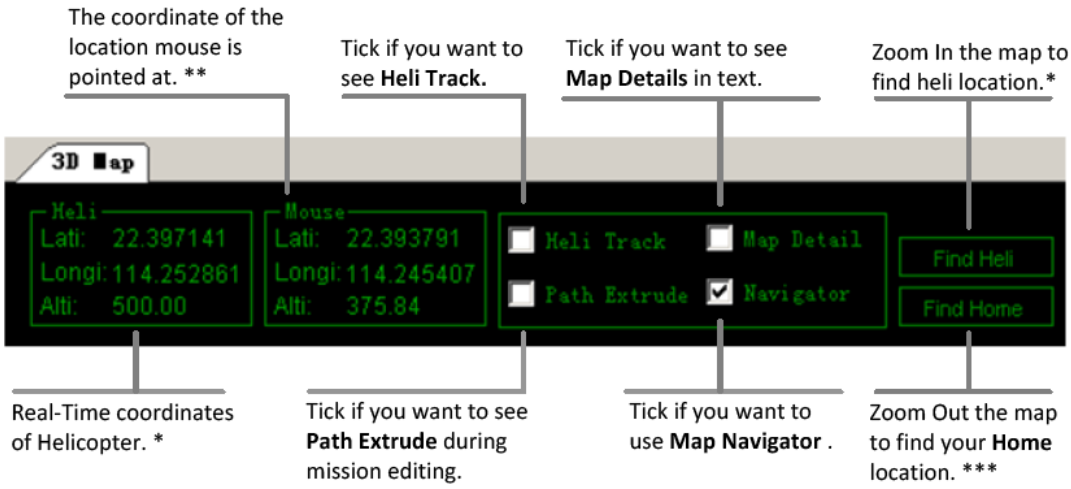

Figure 3: Autopilot Interface with Options for Viewing the Helicopter Status.

Figure 4: Autopilot Interface showing Ground Speed, Air Speed, Altitude, and Orientation.

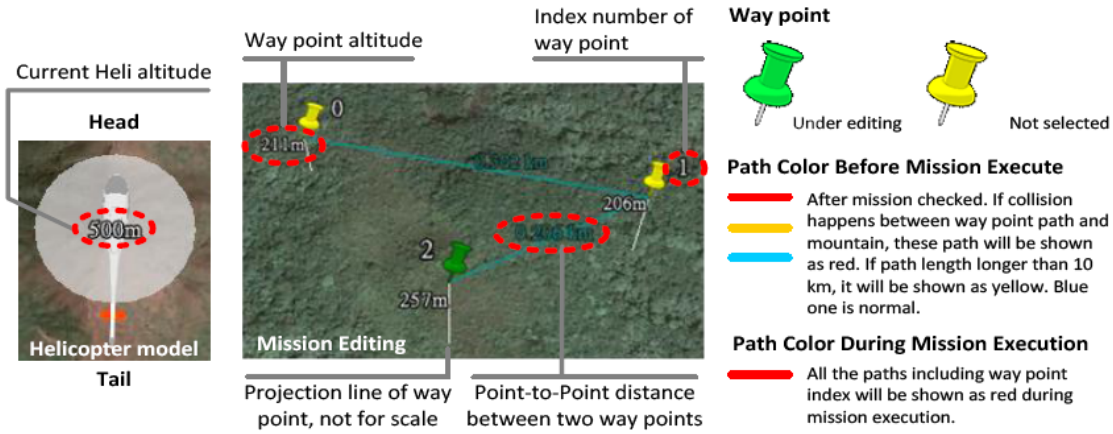

Figure 5: Autopilot Interface with Options for Viewing the Helicopter Flight Path and Programmed Waypoints.

Data will be transmitted from an onboard sensor package to the ground station via a 5 GHz wireless network. A Ubiquiti Nanostation M5 will serve as the onboard router and a Ubiquiti LiteStation SR71 will be connected to the ground station in order to receive the data. These data will be processed on the ground station and used to compute GPS waypoints for the autopilot.