1. Introduction

The Autonomous Rotorcraft Project operates two Yamaha RMAX helicopters (Fig. 1-1). This document describes the lost link procedures.

Fig 1-1. AFDD Autonomous Rotorcraft Project RMAX helicopter in operation at Fort Hunter Liggett in California.

2. Interference or loss of RC Communication

The RC link to be used for control of the RMAX during this test is an FM pulse code modulation (PCM) radio link operating at a frequency of either 72.110 MHz (L15-100-444) or 72.130 MHz (L15-100-445). There is a remote possibility that this communication link could be interfered with or fail resulting in an inability by the External Pilot (EP) to convey control commands to the aircraft.

2.1 Mitigation

The use of FM PCM communication reduces the possibility of radio interference through improved signal-to-noise ratio and encoding of commands. Also, prior to each flight, an Aero Spectra frequency analyzer (Fig. 2-1) will be used to determine if any transmissions are present on the intended operational frequency. Airfield Operations will be given advance notification of any planned use of the RC transmitter in accordance with the flight release.

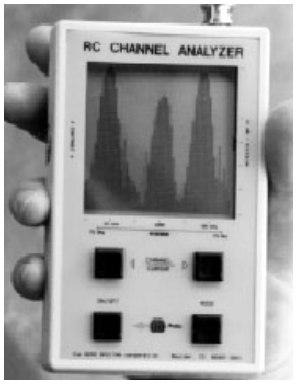

Fig. 2-1. Aero Spectra frequency analyzer

Signal strength during flight is monitored by the RMAX vehicle itself and indicated both via an annunciation light on the RC transmitter and a caution light on the aircraft (Fig. 2-2) thus enabling rapid detection and landing in the event of signal degradation. If a condition of a very weak or non-existent signal persists for more than approximately two seconds, then the on-board flight control computer will automatically command a leveling of the swashplate and lower the throttle position and main rotor collective position to ground. This will result in a hard landing of the aircraft but will prevent any uncontrolled flight over an extended distance. Since the aircraft will not be allowed to be commanded to fly outside the assigned flight area or over any person or vehicle, it is highly improbable that a hard landing will result in anything other than damage to the RMAX itself.

Fig. 2-2. Aircraft caution light.

3. Interference or loss of Telemetry

If both the 900 Mhz and 2.4 Ghz telemetry links to the RMAX (not the RC link) are lost, the ability of the Ground Station to control the RMAX will be lost.

3.1 Mitigation

The manufacturer-reported probability of failure per hour of the Freewave DGR09 radio modem is 2.5×10^{-5}. Since there are two modems (one on each end) the cumulative probability of failure per hour is 3.75×10^{-5}. Multiplying this by a safety factor of 10 yields a probability of failure per hour of 3.75×10^{-4} which is classified as Remote.

Even if the telemetry link is lost entirely, the flight control laws continue to function without ill effect. If the link is lost, then the aircraft would travel to the last waypoint that had been entered where it would stop in a hover. The aircraft would remain there until such time that telemetry is reestablished and a new command is given, or the EP retakes control by disengaging via the engagement button on the RC transmitter. Upon disengagement the system reverts to normal RC control.

The EP always retains the ability to retake control of the aircraft by depressing the engagement switch on the RC transmitter. If the Ground Station determines that the telemetry link has been lost, then the GSO may simply inform the EP to retake control.