DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

CERTIFICATE OF WAIVER OR AUTHORIZATION

ISSUED TO
National Aeronautics and Space Administration

ADDRESS

NASA ARC
Mail Stop 158-1
Moffett Field, CA 94035

This certificate is issued for the operations specifically described hereinafter. No person shall conduct any operation pursuant to the authority of this certificate except in accordance with the standard and special provisions contained in this certificate, and such other requirements of the Federal Aviation Regulations not specifically waived by this certificate.

OPERATIONS AUTHORIZED

Operation of the RMAX UAS in Class D airspace at or below 1,000 feet above ground level (AGL) in the Moffett field Class D airspace. See Special Provisions.

LIST OF WAIVED REGULATIONS BY SECTION AND TITLE

STANDARD PROVISIONS

1. A copy of the application made for this certificate shall be attached and become a part hereof.
2. This certificate shall be presented for inspection upon the request of any authorized representative of the Federal Aviation Administration, or of any State or municipal official charged with the duty of enforcing local laws or regulations.
3. The holder of this certificate shall be responsible for the strict observance of the terms and provisions contained herein.
4. This certificate is nontransferable.

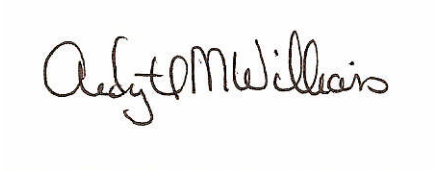
Note-This certificate constitutes a waiver of those Federal rules or regulations specifically referred to above. It does not constitute a waiver of any State law or local ordinance.

SPECIAL PROVISIONS

Special Provisions are set forth and attached.

This certificate 2008-WSA-12 is effective from 11 August 2008, through 10 August 2009, and is subject to cancellation at any time upon notice by the Administrator or his/her authorized representative.

BY DIRECTION OF THE ADMINISTRATOR



FAA Headquarters, AJR-36
(Region)

Ardyth Williams
(Signature)

6 August 2008
(Date)

Air Traffic Manager, Unmanned Aircraft Systems
(Title)

FAA Form 7711-1 (7-74)

ATTACHMENT to FAA FORM 7711-1

ISSUED TO: National Aeronautics and Space Administration

ADDRESS: NASA ARC
Aviation Management Office
Mail Stop 158-1
Moffett Field, CA 94035

NAME: Federal Aviation Administration (FAA) Certificate of Authorization (COA) for RMAX Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS) outside of restricted/warning area airspace.

ACTIVITY: Operation of the RMAX UAS in Class D airspace under the jurisdiction of Moffett ATC.

PURPOSE: To prescribe operating requirements in the NAS (outside of restricted and/or warning area airspace) for the purpose of training and/or operational flights.

DATES OF USE: This COA 2008-WSA-12 is valid from August 11, 2008, through August 10, 2009. Should a renewal become necessary, the proponent shall advise the FAA, in writing, no later than 60 days prior to the requested effective date.

GENERAL PROVISIONS:

- The review of this activity is based on our current understanding of the UAS operations, and the impact of such operations in the NAS, and therefore should not be considered a precedent for future operations. As changes occur in the UAS industry, or in our understanding of it, there may be changes to the limitations and conditions for similar operations.
- All personnel connected with the UAS operation must comply with the contents of this authorization and its special provisions.
- This COA will be reviewed and amended as necessary to conform to changing UAS policy and guidance.

SAFETY PROVISIONS:

Unmanned Aircraft (UA) have no on-board pilot to perform see-and-avoid responsibilities, and therefore, when operating outside of restricted/warning/Class A airspace areas, special provisions must be made to ensure an equivalent level of safety exists for operations had a pilot been on board. In accordance with 14 CFR Part 91, General Operating and Flight Rules, Subpart J-Waivers, 91.903, Policy and Procedures, the following provisions provide acceptable mitigation of 14 CFR Part 91.113 and must be complied with:

- Visual Observers, either ground-based or airborne, must be used.
- UAS pilots will ensure there is a safe operating distance between manned and unmanned aircraft at all times in accordance with 14 CFR 91.111, *Operating Near Other Aircraft*, and 14 CFR 91.113, *Right-of-Way Rules*. Additionally, UAS operations are advised to operate well clear of all known manned aircraft operations.
- The applicant and/or its representatives are responsible for collision avoidance with all aircraft, other aviation operations, and the safety of persons or property on the surface.

AIRWORTHINESS CERTIFICATION PROVISIONS:

- UA must be shown to be airworthy to conduct flight operations in the NAS.
- Public Use Aircraft applications must contain one of the following:

    - A civil airworthiness certification from the FAA, or
    - A statement specifying that the Department of Defense Handbook "Airworthiness Certification Criteria" (MIL-HDBK-516), as amended, was used to certify the aircraft or equivalent method of certification.

PILOT / OBSERVER PROVISIONS:

- **Pilot Qualifications:** UA pilots interacting with Air Traffic Control (ATC) shall have sufficient expertise to perform that task readily. Pilots must have an understanding of and comply with Federal Aviation Regulations and Military Regulations applicable to the airspace where the UAS will operate. Pilots must have in their possession a current second class (or higher) airman medical certificate that has been issued under 14 CFR 67, Medical Standards and Certification, or a military equivalent. 14 CFR 91.17, Alcohol or Drugs, applies to UA pilots.

- **Observer Qualifications:** Observers must have been provided with sufficient training to communicate clearly to the pilot any turning instructions required to stay clear of conflicting traffic. Observers will receive training on rules and responsibilities described in 14 CFR 91.111, *Operating Near Other Aircraft*, and 14 CFR 91.113, *Right-of-Way Rules*. Observers must have in their possession a current second class (or higher) airman medical certificate that has been issued under 14 CFR 67, Medical Standards and Certification, or a military equivalent. 14 CFR 91.17, Alcohol or Drugs, applies to UA observers.

- **Pilot-in-Command (PIC) – Visual Flight Rules (VFR):**

    - The PIC is the person directly responsible for the operation of the UA. The responsibility and authority of the pilot in command as described by 14 CFR 91.3 (or military equivalent), applies to the UAS PIC.
    - The PIC must pass the required knowledge test for a private pilot certificate, or military equivalent, as stated in 14 CFR 61.105, and must keep their aeronautical knowledge up to date.

- There is no intent to suggest that there is any requirement for the UAS PIC to be qualified as a crewmember of a manned aircraft.

Pilot Proficiency – VFR:

- Pilots will not act as a PIC unless they have had three qualified proficiency events within the preceding 90 days.
  - The term "qualified proficiency event" is a UAS-specific term necessary due to the diversity of UAS types and control systems.
  - A qualified proficiency event is an event requiring the pilot to exercise the training and skills unique to the UAS in which proficiency is maintained.
- Pilots flying UA on other than instrument flight plans must pass the required knowledge test for a private pilot certificate, or military equivalent, as stated in 14 CFR 61.105.

PIC Responsibilities:

- Pilots are responsible for a thorough preflight inspection of the UAS. Flight operations will not be undertaken unless the UAS is airworthy. The airworthiness provisions of 14 CFR 91.7, Civil Aircraft Airworthiness, or the military equivalent, apply.
- One PIC must be designated at all times and is responsible for the safety of the UA and persons and property along the UA flight path.
- The UAS pilot will be held accountable for controlling their aircraft to the same standards as the pilot of a manned aircraft. The provisions of 14 CFR 91.13, *Careless and Reckless Operation*, apply to UAS pilots.

Pilot/ATC Instructions: The PIC will maintain direct two-way communications with ATC and have the ability to maneuver the UA per their instructions as applicable.

SPECIAL PROVISIONS:
The FAA recognizes that, by nature, UAS have no on-board pilot to perform see-and-avoid responsibilities. Therefore, when operating outside of Restricted Airspace, special provisions must be made to ensure and equivalent level of safety exists for operations had a pilot been on board. Listed below are the special provisions that must be complied with. All personnel connected with this UAS operation shall comply with the contents of this authorization and its special provisions.

1. All UAS operations shall be conducted under Visual Flight Rules (VFR) in Visual Meteorological Conditions (VMC) in accordance with CFR 14 Part 91.

2. For the purpose of see-and-avoid, visual observers must be utilized at all times when operating outside of restricted, prohibited or warning area airspace. The visual observers must remain within 0.25 mile laterally and/or 1,000 feet vertically of

the UAS during all operations. Pilot/observers must not operate the RMAX at a distance beyond that at which see-and-avoid responsibilities can be exercised. The visual observers may be either ground based or in a chase aircraft. The observer(s) must keep the UAS in sight at all times.

3. Operations outside of restricted airspace may only be conducted during daylight hours and during ATCT hours of operations.

4. The UAS position/navigation/anti-collision strobe lights shall be activated at all times during flight, if equipped.

5. In the event of a Lost Link, Lost Communication or Emergency the:
   - Pilot will notify (Moffett Field) of the condition and provide the following:
     - UA last known location
     - UA altitude
     - Direction of flight/heading
     - Fuel on board
     - Pilots intentions
   - Aircraft will execute Lost Link/ Mission Procedures as covered in paragraph 2.1 and 3.1. The aircraft will either, execute automatic procedures and land (2.1) or the External Pilot (EP) will retake control of the aircraft, land the helicopter and bring the rotors to a stop (3.1).
   - Aircraft will execute Lost Communication Procedures as covered in paragraph 2.1 or 2.2. The EP retakes manual control, lands the helicopter and brings the rotors to a stop.
   - Aircraft will execute Emergency Procedures as outlined in Emergency Procedures paragraph 2. If a fault is detected warranting emergency procedures, the EP will be notified, retake control, and land the aircraft.
   - See attachment 4.
   - Pilot will notify Moffett Tower when recovery and landing has been completed.

6. Operations including lost link not be conducted over populated areas, heavily trafficked roads, or an open-air assembly of people.

7. Special VFR operations are not authorized.

8. The RMAX shall have two completely independent command and control links, to mitigate the risk of fly away.

9. The RMAX flight operations will be conducted well clear of persons and valued property because of the design of the loss of link system.

10. UAS operators must have instantaneous two-way radio communication with air traffic control. This will be done via trunk radio using repeater stations.

11. During RMAX Air Taxi operations that are contained within the "UAS Air Taxi Operations Area" (attachment 2), runway 32L may be used for manned aircraft operations. During manned aircraft landing and departures the RMAX will contain its operations to the East side of the Runway edge for runway 32R.

12. During operations outside of the "UAS Air Taxi Operations Area", but within the area depicted in attachment 3 both runways are closed to all fixed wing traffic. Manned helicopter operations may be conducted as long as they are contained to the south of taxiway A.

13. NASA Ames Research Center shall meet with the Air Traffic Manager at Moffett Field ATCT prior to commencing UAS operations to conduct a review of operating procedure and mission plans.

14. 14 CFR Part 91. 215 ATC Transponder and altitude reporting equipment and use is waived based on the special termination procedures. Note: see attachment 4.

15. NASA has several UA operations at Moffett Field. It is the responsibility of NASA ARC to coordinate with the other UA operators to ensure that only one UA if flying at any time.

NOTAM: A distance (D) Notice to Airman shall be issued when UA operations are being conducted. This requirement may be accomplished through your local base operations or NOTAM issuing authority. You may also complete this requirement by contacting the Automated Flight Service Station at 1-800-WX-BRIEF (992-7433) not more than 72 hours in advance, but not less than 48 hours prior to the operation and provide:

- Name and Address of operator filing NOTAM request
- Location, Altitude or the operating Area
- Time and nature of the activity

NOTE FOR PROPONENTS FILING THEIR NOTAM WITH DoD ONLY: This requirement to file with the AFSS is in addition to any local procedures/requirements for filing through DINS. The FAA Unmanned Aircraft Systems Office is working with the AFSS, and to eliminate the requirement to file a NOTAM with both the AFSS and DINS in the near future.

INCIDENT / ACCIDENT REPORTING: The following information is required to document unusual occurrences associated with UAS activities in the NAS.

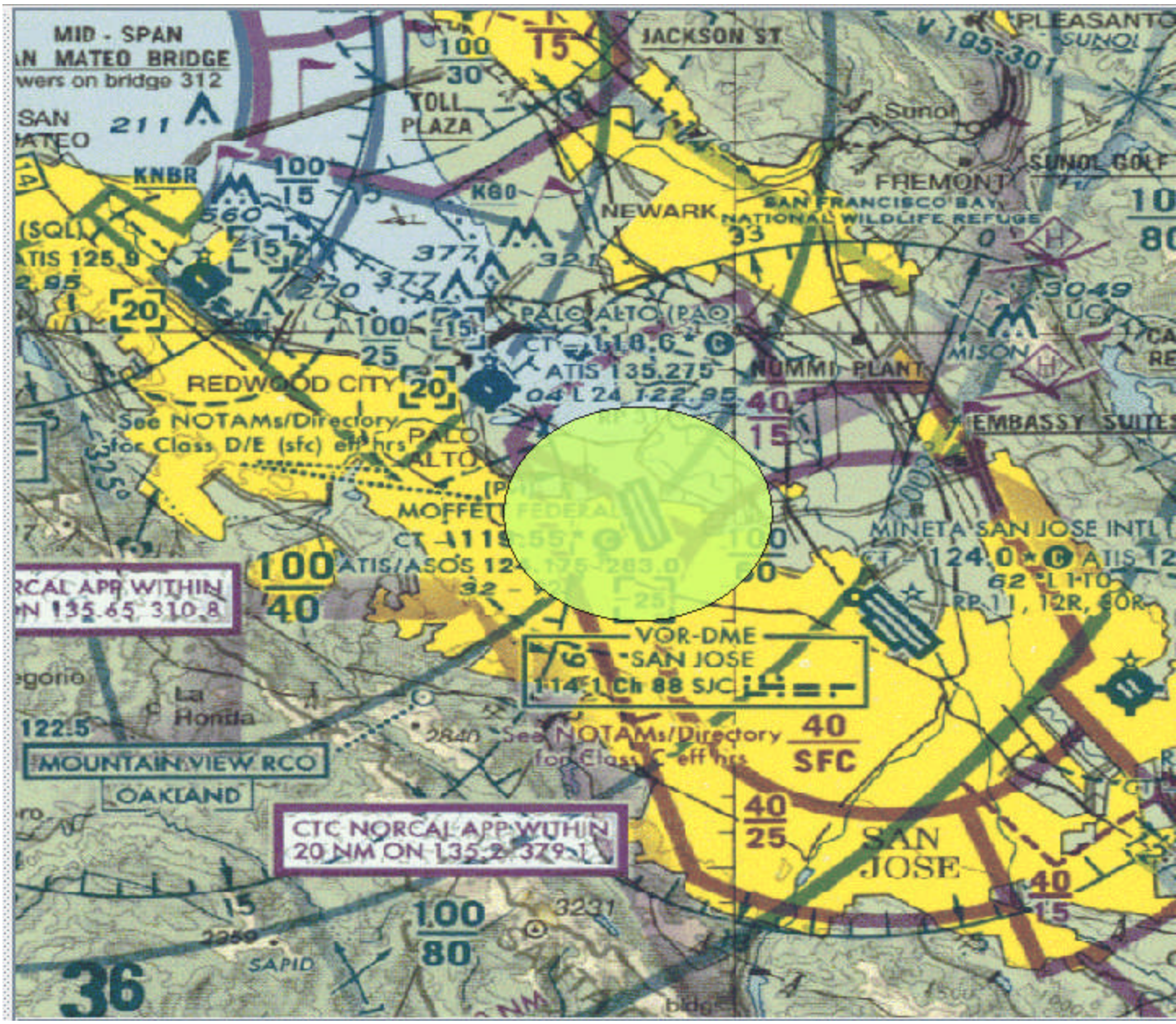
- The proponent for the COA shall provide the following information to Donald.E.Grampp@faa.gov on a monthly/annual basis:

  - Number of flights conducted under this COA.
  - Pilot duty time per flight.
  - Unusual equipment malfunctions (hardware/software).
  - Deviations from ATC instructions.
  - Operational/coordination issues.
  - All periods of Loss of Communications.

- The following shall be submitted to Donald.E.Grampp@faa.gov within 24 hours:

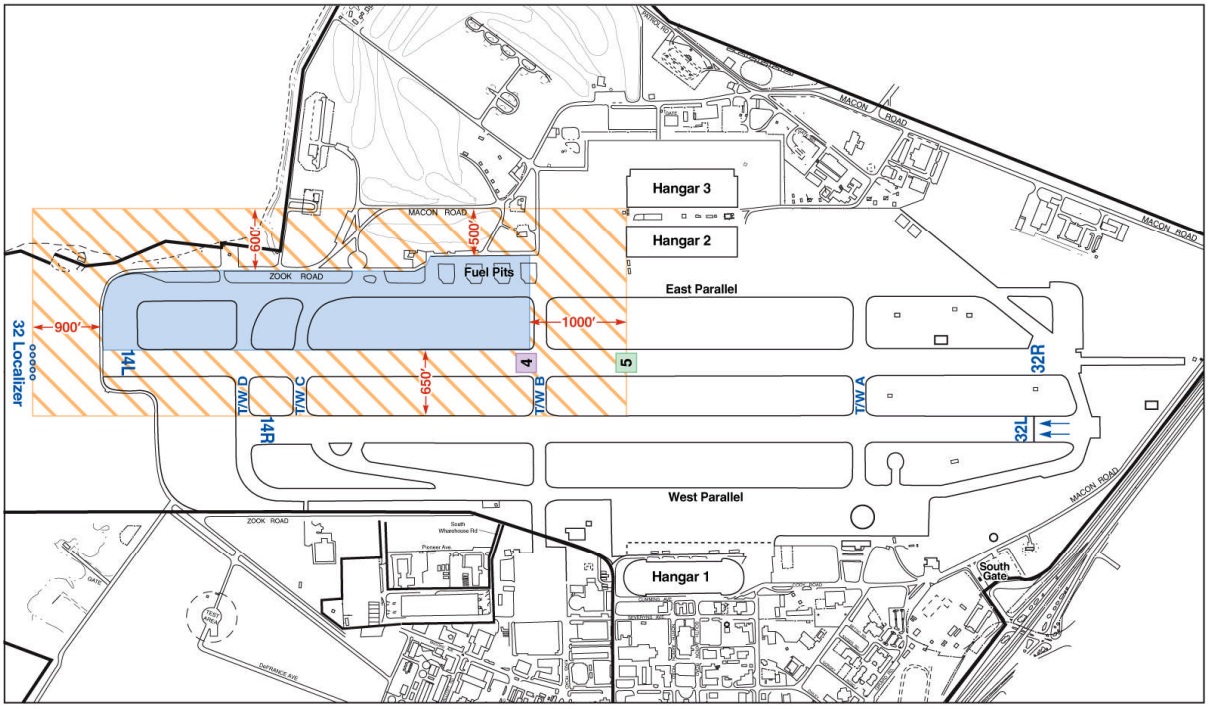
  - Deviations from the "Special Provisions" contained in the COA.
  - All periods of Loss Link, including duration.
  - All incidents involving the UAS as defined in 49 CFR 830.
  - All accidents involving the UAS as defined in 49 CFR 830.

This COA does not, in itself, waive any other (CFR 14 91.215 is waived) Federal Aviation Regulation (FAR) nor any state law or local ordinance. Should the proposed operation conflict with any state law or local ordinance, or require permission of local authorities or property owners, it is the responsibility of the NASA to resolve the matter. This COA does not authorize flight within Special Use Airspace without approval from the Using Agency. The NASA is hereby authorized to operate the RMAX UAS in the operations area depicted in "Activity" above and attachment 1-2 &3 below.

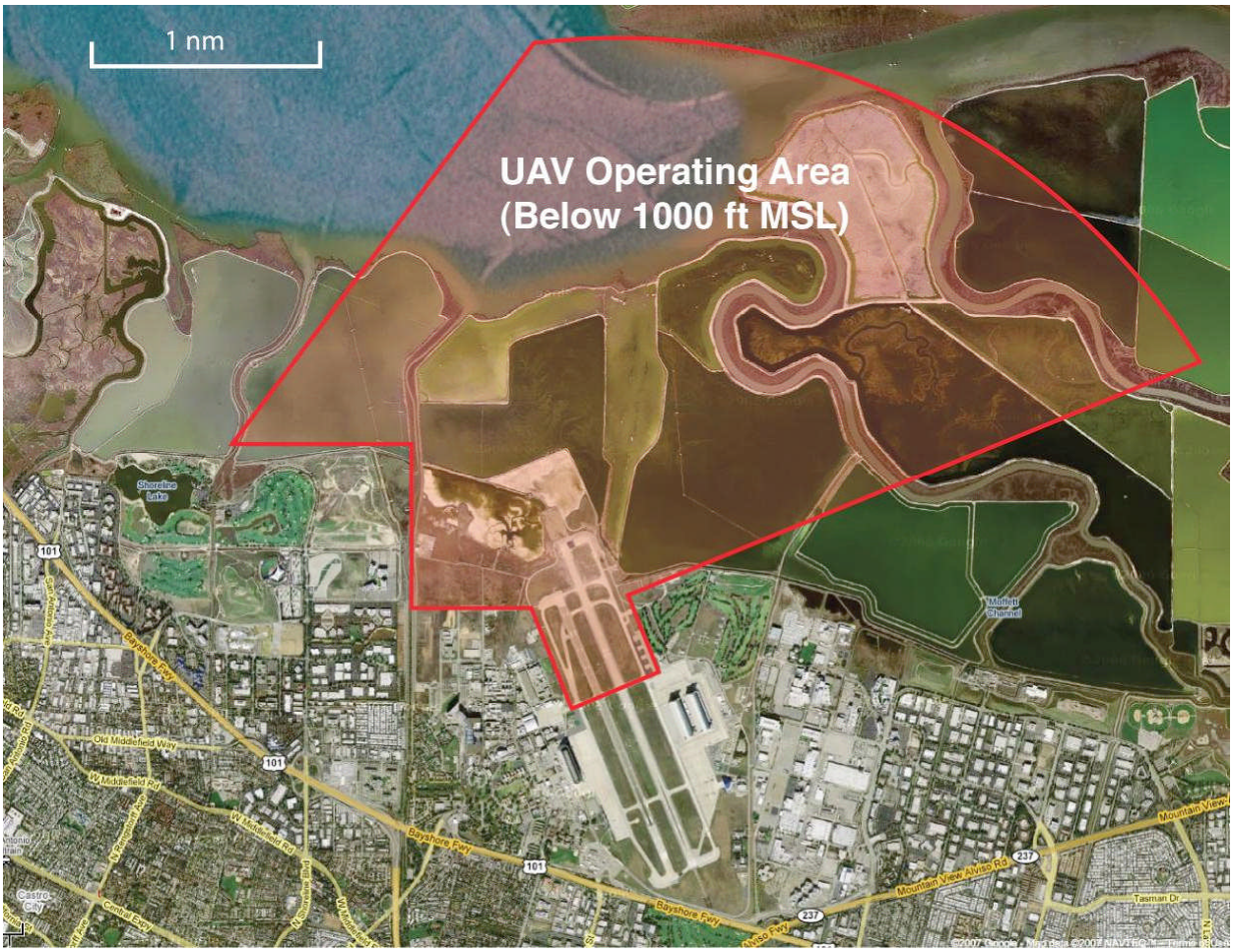


RMAX Attachment 1

UAV HELICOPTER AIR TAXI AREA



UAV air taxi operations area- attachment 2



Moffett Field UAV Operating Area – Attachment 3

Lost Link/Mission Procedures

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 on 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.

Emergency Procedures

1. Introduction

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

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

Most emergency procedures are described in the previous attachments for lost link and lost communications.

The remaining emergency procedures are covered by the Yamaha RMAX Operators Manual and the AFDD Aircraft Accident (Incident) Alert Roster.

2. Yamaha Emergency Procedures

The RMAX is factory equipped with an extensive selfmonitoring system (Ref. 1). Vehicle status and health are indicated via warning lights both on the back panel and on the underside of the vehicle (Fig. 2-1). Prior to engine start the system monitors and displays faults in the YACS, the backup control system, the signal system, the actuators, the IMU, the charging system, low fuel, and weak radio communication. The system will prevent engine start if any faults are detected. During flight the ARP system monitors and display the same faults in the ground station. These faults are displayed on the Situational Awareness display in the ground station and audibly annunciated over the ground station sound system and voice communications system.

Fig 2-1. Rear warning lights.

In the event that the External Pilot (EP), Safety Observer (SO), or Ground Station Operator (GSO), detect a fault, the EP will be notified, retake control, and land the aircraft.

3. Accident (Incident)

In the event of an accident, ATC shall be notified immediately of the accident and the need for any emergency medical attention or fire suppression.

AFDD has an established alert roster in the event of an accident or incident (Ref. 2, attached)

Any incident involving an RMAX will be a ground

accident because under current US Army AR 385-40, it is a UAV. Information pertinent to completing a DA Form 285 will be gathered on scene for future reporting.

4. References

1. Yamaha RMAX Operation Manual, L15-28199-01, First edition, Jun. 1998.
2. AFDD Aircraft Accident (Incident) Alert Roster, Dec. 5, 2006.

Lost Communication Procedures

1. Introduction

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

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

2. Loss of Communications

Radio checks are performed prior to operations to ensure working voice communications between the crew members and the Moffett ATC tower on the UHF trunking radio frequency.

The External Pilot (EP), the Safety Observer (SO), and the Ground Station Operator (GSO) use UHF trunking radios to enable voice communication with the ground station and the Moffett ATC tower. All the radios are set to scan both the dedicated project frequency and the Moffett ATC tower ground traffic communications.

In the event that voice communication is lost, all parties also carry cell phones to enable backup communications.

2.1 Loss of Comm with Ground Crew

If the EP and SO lose communication with the ground station, then the EP retakes manual control of the aircraft with the RC transmitter, lands the helicopter, and brings the rotor to a stop. The EP always retains the ability to retake control of the aircraft by depressing the engagement switch on the RC transmitter. The helicopter is always operated within line-of-sight at a straight line distance of less than 750 ft.

After the vehicle has landed, the SO uses a cell phone to call the GSO to inform him that voice communications have been lost and that operations have been stopped. The SO also informs the Moffett ATC tower of the situation using the trunking radio if possible, and if not, using a cell phone.

2.2 Loss of Comm with ATC Tower

If the EP and SO lose communication with the Moffett ATC tower, then the EP retakes manual control of the aircraft with the RC transmitter, lands the helicopter and brings the rotor to a stop. The EP always retains the ability to retake control of the aircraft by depressing the engagement switch on the RC transmitter.
After the vehicle has stopped, the SO uses a cell phone to call the Moffett ATC tower to inform him that voice communications have been lost and that operations have been stopped.

ATTACHMENT #4.