EMERGENCY PROCEDURES

3. EMERGENCY PROCEDURES

Once the need for emergency landing is identified, the UAS operator must decide what type of landing to execute. The UAS operator has the option of expediting a standard landing that returns to the launch site (currently Southern California Logistics Airport in Victorville, CA), landing off-site, or if there is a drive system, engine, or tail rotor control failure, commanding an autorotation. This section describes each landing and the associated procedures. During flight, UAS operators have access to detailed checklists for each procedure.

3.1 Expedited Landing

YMQ-18A emergency procedures recommend that the operator expedite a standard landing when it is not prudent to continue flight, but when losing the aircraft is not imminent. Examples of this situation are slowly rising system temperatures that trend towards exceeding limits or the loss of a non-flight critical sensor like a torque sensor or exhaust gas temperature sensor. In such a case, the UAS operator begins executing the standard landing procedure immediately, while initiating focused attention on the anomaly. Standard landings approach the Warrior Ramp, the normal take off and landing site at Southern California Logistics Airport (SCLA), from the northeast (assuming normal winds) at 40 kts and 200 ft/min. Below is the checklist for standard landings:

3.2 Off-site Landing

If there is an immediate risk of losing control of the aircraft, YMQ-18A emergency procedures recommend that the UAS operator execute an off-site landing. Examples of this situation are unexpected increases in vibrations or loss of generators requiring running on batteries for a lengthy period. In an off-site landing, the UAS operator brings the YMQ-18A to a hover over a safe landing spot at an altitude high enough to maintain the telemetry link. The UAS operator then engages the "abort" autonomous flight plan which executes a 200 ft/min hover descent and touchdown, even if the datalink is lost. If link is still lost, the YMQ-18A after touchdown automatically shuts down the engine, fuel pumps, and cooling fans.

A team of flight test engineers explored the Victorville desert that the YMQ-18A flies over to determine safe landing locations. They generated the map in **Figure 1**, which is posted in the ground control station. SCLA is located at the bottom of the map. The YMQ-18A flies in the triangular section north of the airport that is outlined in light purple, but avoids flying over red "avoid" areas. YMQ-18A operations avoid these areas because of inhabited structures or significant terrain variations. These areas must also be avoided in an off-site landing. Except where marked, the desert is quite open and flat, allowing landings in many locations.

Below is the checklist for off-site landing descent:

OFF SITE LANDING

- ❑ Airspeed ..... 40 KTS
- ❑ Descent Rate ..... 200 FPM
- ❑ RPM ..... SET FOR APPROACH
- ❑ Wind Compensation..... OFF
- ❑ "Takeoff Preset" horsepower (300 hp) ..... SET
- ❑ Landing Gear ..... DOWN
- ❑ Landing Switch ..... LANDING
- ❑ FLIGHT PHASE: **LANDING**..... CONFIRM

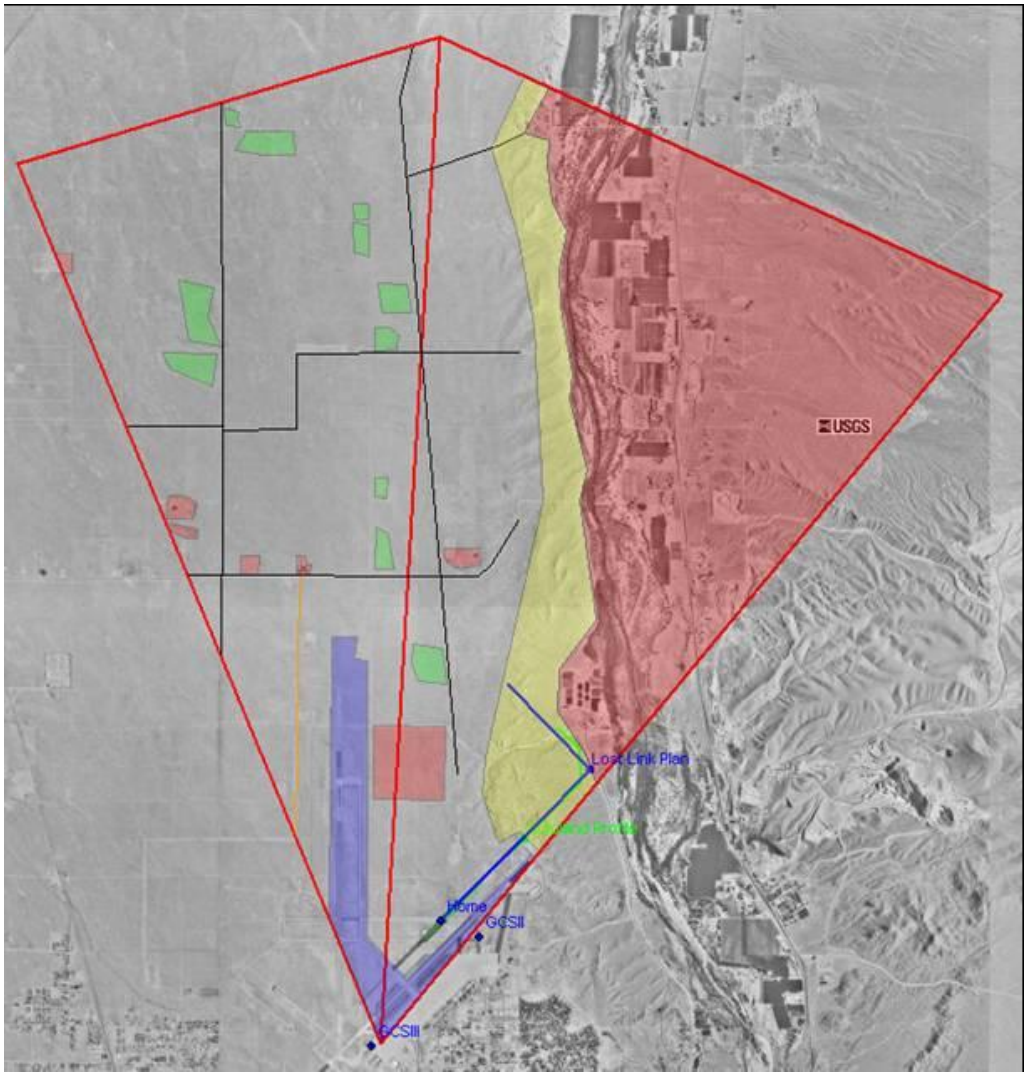
- ❑ Approach Path and Landing Site ..... SET
- ❑ At ~200 feet AGL ..... SLOW TO HOVER
- ❑ Abort Switch ..... ENGAGE
- ❑ Call to Tower: "Landing off site" ..... COMPLETE
- ❑ Call to Ground Crew: "Landing off site" ..... COMPLETE

Likely loss of datalink descending below 2850 MSL

"Abort" automation will shut off aircraft after touchdown

- ❑ Aircraft Location..... RECORD
- ❑ Locate Aircraft ..... COMPLETE
- ❑ Safe and Shutdown Aircraft..... COMPLETE

Figure 1: YMQ-18A Operating Area and Landing Zones (Green areas are optimal emergency landing sites)



3.3 Autorotation

In the case of engine or other drive system failure, the YMQ-18A must execute an autorotation. By virtue of the YMQ-18A RPM control architecture, the YMQ-18A automatically enters and maintains autorotation upon loss of drive torque. The UAS operator must then enable the touchdown logic using a panel switch, identify a safe landing location, and guide the aircraft to that location. The autorotation timeline below provides a summary of autorotation events. .

- Loss of power
- YMQ-18A automatically enters and maintains autorotative descent
- Operator enables autorotation switch.
  - YMQ-18A autonomously controls RPM to 280
  - Disallows lost link flight plan
  - Operator maintains control of speed and heading
    - Commands efficient airspeed ~60 kts
    - Navigates toward safe landing spot
- At ~200 ftAGL
  - YMQ-18A autonomously begins increasing rotor RPM to 405 to store maximum energy
  - YMQ-18A autonomously starts cyclic flare
- At ~100 ftAGL, YMQ-18A autonomously zeros heading rate and sideslip
- At ~30 ftAGL, YMQ-18A autonomously starts collective flare
- Just after touchdown, YMQ-18A autonomously shuts down engine, fuel pumps and cooling fans.

Below is the checklist for autorotation:

AUTOROTATION

- ❑ Forward Speed to 60 kts (if advisable) ..... SET
- ❑ Autorotation Switch ..... ENGAGE
- ❑ Landing Site ..... PICK
  - Steering is still operator controlled
  - Forward speed can be adjusted down to change glide path

After touchdown:

- ❑ Call to Tower: Off site landing ..... COMPLETE
- ❑ Call Ground Crew: Off site landing ..... COMPLETE

The brevity of the checklist is meant to allow completion in the limited time available before the YMQ-18A reaches the ground. To this end, the touchdown logic enabled by the autorotation switch automates several tasks, such as lowering the landing gear.