Pan-Pacific UAS Test Range Complex
Flight Planning Guide

Purpose
The purpose of this flight planning guide (FPG) is to identify information regarding the proposed operation and control of a specific UAS in the Test Range. While the capability to execute UAS operations is must be flexible enough to recognize that each system, sub-system, ancillary piece of equipment, and their required readiness procedures are different, there are several basic flight safety provisions that must be followed.

This FPG will remain a "living guide" regarding the operation of each system in that it is recognized that there are presently no standard FAA approved FPG procedures for any UAS which ensure that UAS flight operations are conducted in a safe manner and in accordance with operating procedures established by the Test Site and the FAA. This FPG will set forth procedures designed to identify system capabilities & vulnerabilities and verify that adequate safeguards exist to protect against the National Airspace System (NAS)

Because of the nature of UAS being relatively new to aviation, the uniqueness of each vehicle and mission is designed such that this document will undergo continuous changes as it adapts to both the NAS and the individual system needs.

Instructions
An FPG will serve as the Mission Planning Guide as it is designed to adhere to each systems limitations and capabilities as it administers changes to the NAS. The FPG will be developed for each mission and will be submitted to the FAA NLT 30 days prior to each mission date.

The Mission Commander shall ensure the FPG is developed in concurrence with all applicable FAA rules and regulations.

As subsequent missions are performed and the FPG develops further, subsequent versions will be submitted to the FAA as they evolve. Changes to the FPG will be documented in a cover letter as each subsequent version is submitted.

Required Information
1. **Mission:** Provide a brief overview of the UAS mission(s) and capabilities.
   - 1.1. Objectives
   - 1.2. Description
   - 1.3. Explain whether the proposed test will, or is expected to, exceed limitations used to predict mean time between failure or other safety models.
   - 1.4. Develop then provide fault trees and/or failure mode effects analysis.
   - 1.5. Capabilities

2. **Vehicle**
   - 2.1. User Handbook –
     - 2.1.1. Is UAS *user handbook available? Please attach.*
     - 2.1.2. *Is sub-system user handbook available? Attach*

2.1.3. *Is Ancillary system user handbook available? Attach*

2.2. Physical Characteristics
- 2.2.1. Measurements - wingspan, fuselage length, body diameter
- 2.2.2. Composition
- 2.2.3. Weight - empty and max load
- 2.2.4. Fuel - type and capacity
- 2.2.5. Landing style/type

2.3. Propulsion System
- 2.3.1. Engines –
  - 2.3.1.1. type,
  - 2.3.1.2. number,
  - 2.3.1.3. manufacturer,
  - 2.3.1.4. horsepower rating,
  - 2.3.1.5. electrical power source
- 2.3.2. Fuel Volume and Consumption Monitors
- 2.3.3. Limitations and Failure Modes
  - 2.3.3.1. By environmental conditions (temperature, icing, dust)
  - 2.3.3.2. Confirmed by test data
  - 2.3.3.3. Considered in test plan

2.4. Performance Characteristics
- 2.4.1. Performance Charts
- 2.4.2. Takeoff and Landing
  - 2.4.2.1. Distances for maximum weights
  - 2.4.2.2. Maximum crosswind tolerance
- 2.4.3. Maximum Altitude
- 2.4.4. Maximum Endurance
- 2.4.5. Maximum Range
- 2.4.6. Range vs. Altitude (Comm Link)
- 2.4.7. Airspeed –
  - 2.4.7.1. cruising,
  - 2.4.7.2. maximum,
  - 2.4.7.3. minimum
  - 2.4.7.4. stall
- 2.4.8. Rate of Climb (degrees)
- 2.4.9. Rate of Descent (degrees)
- 2.4.10. Weather Minimums (?)
  - 2.4.10.1. Clouds
  - 2.4.10.2. Instrument Flight Rules (IFR) conditions

2.5. Flight Reference Data
- 2.5.1. On-board sources of position, altitude, heading, altitude, and airspeed information to the UAS operator or autopilot
- 2.5.2. Backups

2.6. Transponder - *Does the UAS have an on-board transponder with Mode C altitude reporting?*

2.7. *ADS-B?*

2.8. *TCAS?*

2.9. Payload Options - *What payload(s) will be used on the UAS during operations?*

2.10. Hazardous Materials - *List all materials that require special handling, such as flammable, toxic, energy storage, or ordinance. Include flight termination system if applicable.*

3. **Command and Control Systems:** Brief paragraph that describes the systems/methods used to control the UAS during flight; include frequencies where appropriate.
   - 3.1. Control Method - primary and secondary
   - 3.2. Satellite or Line of Sight
   - 3.3. Frequency Allocation - *Is there a frequency allocation for all RF links? On what frequencies do the UAS systems operate? What is the effect of radio frequency interference on the command and control system?*
   - 3.4. Command Link Range - What *is demonstrated range of primary command and control (C2) transmitter and receiver*
   - 3.5. Backup –
     - 3.5.1. Is *there a backup C2 transmitter and receiver?*
     - 3.5.2. *Does the backup have the same effective radiated power?*
     - 3.5.3. *Is the backup link sufficiently protected from spurious command signals?*
   - 3.6. Link Analysis
     - 3.6.1. *Briefly explain how RF link analysis was performed to verify that both primary and backup transmitters can communicate with vehicle at furthest point of planned operation?*
     - 3.6.2. *Does link analysis address all RF links?*
       - 3.6.2.1. Uplinks from primary and backup ground stations
       - 3.6.2.2. Secondary uplinks from each ground station
       - 3.6.2.3. Downlinks to primary and backup ground stations
       - 3.6.2.4. Flight termination link
         - 3.6.2.4.1. *Is there at least 12 dB of signal excess in FTS link?*
         - 3.6.2.4.2. *Explain how it was determined that the vehicle primary and backup command and control receivers and FTS receivers are operating at specified sensitivity?*
     - 3.6.3. *Did our link analysis consider the RF horizon?*
     - 3.6.4. What is the maximum range for each link?
       - 3.6.4.1. List each link separately here
     - 3.6.5. *Briefly explain how we determine if the primary and backup transmitters are radiating manufacturers specified output power?*
     - 3.6.6. Frequency Masking
       - 3.6.6.1. *Are there any nulls in the C2 transmitter antenna pattern?*
       - 3.6.6.2. *Are there areas of RF masking due to location of antennas on the UAS relative to their position and to ground station antennas? (during turns or pitch?)*
       - 3.6.6.3. *Are there any RF null spots in the C2 link based on the position or orientation of the UAS relative to the control station?*
       - 3.6.6.4. *Do the operators know where these nulls are and have mission profiles been designed to avoid these nulls?*
     - 3.6.7. Multipath –
       - 3.6.7.1. *What is the link susceptibility to multipath?*
       - 3.6.7.2. *What is the system response if multipath is experienced?*
   - 3.7. Takeoff and Landing - *What is method?*
   - *3.8.* Navigation System - *What is the source of navigation information for the operator? Are there redundant sources?*

4. **Operations**
   - 4.1. Crew
     - 4.1.1. Requirements - Please *list the total number of personnel involved in the mission and their associated job functions.*
     - 4.1.2. Experience - *Detail the crew's flight qualifications, experience, and currency with this UAS. How recently did each crewmember fly this type of UAS?*
     - 4.1.3. Safety - What *information does the crew have to make safety related decisions?*
   - 4.2. Pre-Flight
     - 4.2.1. Set-up Time - Upon *arrival, how much set-up time is required to prepare for initial flight?*
     - 4.2.2. Pre-Flight Checks -- *Describe typical ground checks for the UAS and control system.*
   - 4.3. Launch - Please *describe the takeoff procedure and handoff method in detail.*
   - 4.4. Recovery - Please *describe the recovery and landing procedure in detail.*
   - *4.5.* Turnaround Time - *Describe any required post-flight maintenance and the turnaround time between missions.*

5. **Failure (Risk) Management**
   - 5.1. Safety History
     - 5.1.1. Flight history
       - 5.1.1.1. Estimated total system hours based on this UAS
       - 5.1.1.2. Approximate hours logged by all PPUTRC operators
     - *5.1.2.* Mishap history - L*ist the mishap history of the UAS*
       - *5.1.2.1. Identify for the record major failure modes.*
       - *5.1.2.2. List known system-fault crashes or failures have occurred with this UAS?*
       - *5.1.2.3. List known system-fault crashes or failures have occurred while a test system*
       - *5.1.2.4. List crashes or failures attributed to human error*
     - 5.1.3. Corrective actions taken to correct for past mishaps, crashes or failures
       - 5.1.3.1. Corrective actions implemented to circumvent any known *system-fault crashes or failures*
       - 5.1.3.2. Corrective actions implemented to circumvent any human error *caused crashes or failures*
   - 5.2. Demonstrated Reliability
     - 5.2.1. Estimated time between equipment failures
       - 5.2.1.1. Calculated from analytical or empirical data
       - 5.2.1.2. Environmental and performance limitations used to estimate reliability figures
   - 5.3. Hazard Analyses –derived from overall Safety Review of system vs. mission
   - 5.4. Software
     - 5.4.1. Explain how we implement and ensure our software safety program
     - 5.4.2. Software controlled components - What *flight critical components are software controlled?*
     - 5.4.3. Analyses - *Have any software safety analyses been performed?*
   - 5.5. Loss of Command and Control (C2) Link
     - 5.5.1. *Describe in a paragraph what happens when the C2 link is lost. Include UAS actions and flight crew actions.*
     - 5.5.2. *Describe how the UAS responds if the command link is never re-established?*
     - 5.5.3. Recognition of loss - Operator and UAS

5.5.3.1. *Explain how the operator recognizes loss of the command link?*
5.5.3.2. *Explain how the UAS recognizes loss of the command link?*
5.5.4. Back-up Command and Control - How is *backup control initiated?*
5.6. Loss of navigation
5.6.1. *Explain how the UAS and vehicle autopilot respond to a loss of navigation signal.*
5.6.2. *Explain how primary navigation loss is indicated to the ground station and operator.*
5.6.3. Back-up navigation
5.6.3.1. Is *there a secondary navigation system? (briefly describe)*
5.6.3.2. *Does the UAS operator have access to any external sources of position information that could serve as a backup (radar, IFF, binoculars)?*
5.6.4. *If the UAS operator loses primary position information, is control also lost?*
5.7. Return home modes
5.7.1. Conditions that cause return home mode
5.7.2. Describe location point, path, and altitude
5.7.2.1. Selection
5.7.2.1.1. Safeguards to prevent erroneous selection
5.7.2.1.2. Ability to update in-flight
5.7.2.2. Intermediate waypoints
5.7.2.3. Multiple points
5.7.2.4. Airspace boundaries and compatibility
5.7.2.5. Line of sight from control station
5.7.3. Vehicle action and sequence of events upon reaching return home point
5.7.3.1. In event operator does not regain control
5.7.3.2. Fail-safe events
5.7.3.3. Landing
5.7.4. Navigation during return home mode
5.7.4.1. In event GPS is unavailable or jammed
5.7.5. Pre-flight check
5.8. Loss of Flight Reference Data - *How does the vehicle respond to loss of primary sources for position, altitude, heading, and airspeed and what are the indications of these losses to the UAS operator?*
5.9. Unresponsive Flight Controls
5.9.1. *What will happen if a servo or flight control sticks or becomes unresponsive?*
5.9.2. *How does the autopilot respond?*
5.9.3. *Is there a backup?*
5.9.4. *How quickly will the UAS operator recognize this?*
5.9.5. *What happens if the throttle is stuck?*
5.9.6. *How will the UAS operator recognize this condition?*
5.9.7. *Is there a recovery procedure?*
5.10. Loss of Propulsion
5.10.1. *How does UAS respond to engine or motor failure?*
5.10.2. *Can engine or motor be restarted in flight?*
5.10.3. *Is electrical power lost if engine or motor stop during flight?*
5.10.4. *Will there be sufficient link-control and electrical power for "controlled ditch" or "dead-stick landing"?*
5.11. Loss of Electrical Power –
5.11.1. *Describe UAS response if electrical power is lost.*
5.11.2. *Describe C2 response if GCS electrical power is lost*

5.11.3. *Describe back-up electrical systems and expected operating time.*
5.11.4. *Describe what happens if the UAS is too far away to make it back before this time?*
5.11.5. Battery
5.11.5.1. Expected time life
5.11.5.2. Life meter
5.11.5.3. Log
5.11.5.4. Bus - *Are there essential buses for reduced power operations and are all flight essential systems on this bus?*
5.11.6. Uninterruptible power source for ground operations
5.11.7. Backup command and emergency systems protection
5.11.8. *Does load shedding occur if power is lost?*
5.11.9. *Are there any effects on the flight termination system?*
5.12. Subsystem Failure
5.12.1. Failures that result in abort
5.12.2. Failures that result in UAS unable to fly
5.13. Flight Termination System (FTS)
5.13.1. FTS function (briefly explain)
5.13.2. FTS activation (briefly explain)
5.13.2.1. *How* is *the FTS activated?* (briefly explain)
5.13.2.2. *Does it activate if battery backup fails?* (briefly explain)
5.13.2.3. *Does it operate on independent battery circuit?* (briefly explain)
5.13.2.4. Activation authority (briefly explain)
5.13.3. Flight termination criteria
5.13.3.1. Tracking data (briefly explain)
5.13.3.2. Lack of containment in operating range (briefly explain)
5.13.3.3. Return home failure (briefly explain)
5.13.4. UAS below RF horizon
5.13.5. Sequence of events after activation (briefly explain)
5.13.5.1. Propulsion terminated
5.13.5.2. Tumble or glide
5.13.5.3. Parachute
5.13.6. Monitoring
5.13.7. Transmitter
5.13.7.1. Location
5.13.7.2. Range (exceed maximum flight range)
5.13.8. Testing and certification
5.13.9. Independence from other vehicle systems
5.13.9.1. Antenna
5.13.9.2. Receiver
5.13.9.3. Signal processing
5.13.9.4. Power supply
5.13.10. Fail Safe Mode
5.13.10.1. Activation criteria
5.13.10.2. Sequence of events upon activation
5.13.10.3. Time delay between activation and sequence of events
5.13.11. Parachute
5.13.11.1. Deployment altitude
5.13.11.2. Impact and drift rate

5.13.11.3. Rate of descent at max weight
5.13.11.4. Deployment limitations
5.13.11.4.1. Altitude
5.13.11.4.2. Airspeed
5.13.11.4.3. Attitude
5.13.11.5. Weight-on-gear inhibit
5.13.11.5.1. Testing
5.13.11.5.2. Status telemetry to ground
5.13.11.6. Engine shutoff
5.13.11.6.1. Requirement
5.13.11.6.2. Failure of engine shutdown
5.13.11.6.3. *Can propeller cut shroud line?*

5.14. Ditching
5.14.1. Criteria
5.14.2. Pre-planned locations
5.14.2.1. Selection and criteria
5.14.2.2. Free of population
5.14.2.3. Attainable from any point in flight path

5.15. Collision Avoidance: *Describe procedures utilized for collision avoidance, including UAS response time to flight change commands.*
5.15.1. Airspace
5.15.1.1. Exclusive or shared
5.15.1.2. Compatibility with other aircraft or missions
5.15.1.3. Risk reduction to other aircraft (explain avoidance strategy)
5.15.1.4. Manned aircraft communication
5.15.1.5. ATC communication
5.15.2. Flight Routes
5.15.2.1. Consideration of published standard approaches and departures
5.15.2.2. Standoff distances
5.15.2.2.1. Densely populated areas
5.15.2.2.2. Hazardous sites
5.15.2.2.3. Civilian airfields
5.15.2.2.4. Surface structures (includes vessels, roads, power lines, pipelines, etc.)
5.15.2.2.5. Published or known airways
5.15.3. Means of Detect, Sense and Avoid (DSA) (explain total risk mitigation strategy)
5.15.4. Collision Prevention Markers (lights, strobes, high-vis paint scheme)
5.15.5. Loss of IFF
5.15.5.1. Procedure
5.15.5.2. Notification of ground operator
5.15.6. Chase Aircraft
5.15.6.1. Type of flight following (parallel, S-turns, high or low offset)
5.15.6.2. Standoff distance
5.15.6.3. Continuous surveillance and procedure if observer loses sight of UAS
5.15.6.4. Communications between PIC, chase pilot and ground safety

5.16. In the Event of a Crash:
5.16.1. Could crash cause a fire?
5.16.2. Could crash cause a hazardous materials release incident?
5.16.3. Could crash cause an explosive reaction?

5.16.4. What warnings (if any) do Public Safety First Responders need to know before approaching the UAS? (explosive bolts, hazmat leaks, poisonous gasses, etc.)

6. Ground Support

6.1. Ground control stations (GCS) - *Please describe the ground stations involved in the UAS operations. Include mission control stations, launch/recovery stations and payload control stations as appropriate.* For each GCS list:

6.1.1. Function of station
6.1.2. Desired placement location (i.e., in hangar, on runway)
6.1.3. Power and infrastructure requirements
6.1.4. What happens if power is lost?

6.2. Logistics Support - *For each item below, please list exact requirements and how facility/equipment will be used*:

6.2.1. Hangar facilities (in square feet)
6.2.2. Office space
6.2.3. Telephone requirements (number of lines)
6.2.4. Computer equipment (number of workstations, printers, internet access)
6.2.5. Handheld communications (number of units and channels required)
6.2.6. Fuel
6.2.7. Tow/support vehicles
6.2.8. Portable generators
6.2.9. Classified handling/security provisions

7.0 Configuration Management

7.1. All changes to the UAS will be logged.

7.2. Any changes to the UAS will be evaluated by the range Aeronautical Safety Engineer to determine if the airworthiness statement is still valid.

8.0 Air Traffic Service Provider Coordination/Communication

A specific plan for communicating with the controlling and adjacent Air Traffic Service providers will include contingency plans, phone numbers and any other pertinent information as designated by the parties involved.