CReSIS

Avionics Flight Test Safety Report

Flight Experiment: Avionics System Test
Date: 03 August 2007
Submitted by: Kai Siegele, Flight Test Engineer
Robert Burns, Instrumentation Engineer
Kai Siegele, Vehicle Engineer
Robert Burns, Data Processing Engineer
Rylan Jager, Data Processing Engineer
Bill Donovan, Safety Officer
Ron Renz, Test Pilot

___________________________________________
Department Representative
Charge to the Safety Board

The University of Kansas, Aerospace Engineering department asks that you review this safety document relative to the safety of the operation. Your signature approving this plan only indicates that in your judgment the operation is safe.

Thank you for your willingness to share your unique expertise.

Kai B. Siegele

Safety Board Certification

Signature: _____________________________

Print Name: ___________________________

Signature: _____________________________

Print Name: ___________________________

Signature: _____________________________

Print Name: ___________________________

Signature: _____________________________

Print Name: ___________________________
Revisions:

Original Document: ................................................................. Date: 07/12/2007

Rev. A ...................................................................................... Date: 08/03/2007

Rev. B ...................................................................................... Date: 08/06/2007

Rev. C ...................................................................................... Date: ___

Rev. D ...................................................................................... Date: ___
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Test Overview

The purpose of the flight test described in this document is to test the avionics set-up for operations for the Meridian in a Cessna 182 prior to installation in the Meridian. The test proves multiple components in the avionics suite, allows for tolerances of each component to be determined, determines weaknesses and failure in components, and finally simulates the actions and responses needed for an actual flight with the avionics on board the Meridian. The test will be conducted in local vicinity to the ground station and over the horizon. The avionics package will be turned on prior to taxi, and the ground station will monitor the following:

- Range of UHF communications
- Dropout of UHF at certain configurations of the aircraft
- Dropout rate of Iridium communications
- Time between Iridium reconnections
- Time to upload 100 waypoints

The crew member onboard the Cessna 182 is present to instruct the test pilot on what maneuvers and how to perform the tests at hand. The Nav-420 sends telemetry to the processor where it is recorded for post-processing purposes.

Test Objectives

The objective of this test is to record the range of UHF communications, lost communications from aircraft attitude, dropout rate of Iridium communications, time between reconnections, and time taken to upload waypoints over the Iridium modem. A series of tests will be done by flying in the pattern with long approaches as well as pattern work (normal take-offs and touch-and-goes), clover leaf pattern (with a focal point on the ground station as well as offset from the ground station [Figure 1]), a race track pattern banking the UHF antenna away from the ground station as well as banking the antenna toward the ground station (at different bank angles [Figure 2]), a range test with figure eights at mile intervals (Figure 3). The ground station personnel are responsible for monitoring and recording the data requested above.

The first tests will be done at the Lawrence Municipal Airport (LWC). The first part of this test will have the aircraft set up for a long approach at 2900 feet MSL at 6 miles range from the runway. The aircraft will come in and do a touch and go. The other test requires that the aircraft perform pattern work or just a series of take-offs and landing. The landings will all be touch and goes.

The second series of tests will be performed over the RC field. The first test is a clover leaf pattern (see Figure 1) with the focal point at the ground station. The aircraft will fly towards and over the ground station and continue on its particular track until UHF communications from Piccolo is lost or 20 miles range is reached. The ground operator will then call up to the aircraft over the handheld radio to communicate the next leg of the test. The second test is the clover leaf pattern but with the focal point off set from the ground station. The rest of the test should be performed the same as the first test however, it is limited to 8 miles range from the ground station.
The third test (race track test [Figure 2]) will produce the limits of the bank angle and range combination. The third test has the aircraft flying south along the Clinton Lake Dam and performing a series of turns with increased bank angle after each completed circle. The third test performs a series of left turns which points the antenna away from the ground station. The fourth test is similar to the third test however, this time there are a series of right turns which points the antenna toward the ground station.

The final test is the figure-eights test (Figure 3) which tests a combination of range and aircraft attitude. This test requires the aircraft to fly south, away from the ground station, and perform a figure-eight at each mile interval away from the ground station. This test will continue until communications is lost or at a distance of 8 miles from the ground station (whichever one happens first).
The flight dance card is given in Appendix A and detailed flight test cards are given in Appendix B. Test data should be recorded during the flight on the table given in Appendix C.

**Proposed Schedule:**

The flight test has been scheduled for August 5, 2007 through August 30, 2007. Flight tests can be carried out any time between dawn and dusk during this period, depending on the availability of the team members, and the aircraft during suitable weather conditions.

**Operational Limits**

The operational limits for the airplane are as follows:

- Maximum Takeoff Weight: 3100 lbs (May not be exceeded for any reason.)
- Maximum Speed--V_{NE}: 178 KIAS (May not be exceeded at any time.)
- Maximum Structural Cruising Speed--V_{NO}: 157 KIAS (Only exceed in smooth air.)
- Minimum Speed (Power off Stall), Clean Configuration--V_{S1}: 41 KIAS
- Minimum Speed During Flight Test--V_{S1}: 80 KIAS (Giving a safety factor of 1.95)
Appendix D details the weight and balance data for the aircraft and the planned flight test. The speed envelope of 80 to 150 KIAS is defined for this flight test. The actual flight envelope chosen for this test is given in Appendix E.

As copied directly from FAR 91.119, no person may operate an aircraft below the following altitudes except for takeoff and landing:

- Anywhere: An altitude allowing, if a power unit fails, an emergency landing without undue hazard to persons or property on the surface.
- Over congested areas: Over any congested area of a city, town or settlement, an altitude of 1000 feet above the highest obstacle within a horizontal radius of 2000 feet.
- Over other than congested areas: An altitude of 500 feet above the surface, except over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer to 500 feet to any person, vessel or structure.

**Weather Conditions**

The minimum visibility must be 7 statute miles. The vertical distance of the aircraft from the clouds must be 1000 feet above and 1000 feet below the clouds and with a horizontal distance of 2000 feet. Therefore the minimum ceiling is 4800 feet MSL. The maximum crosswind for landing purposes is 15 knots. Visibility is the main concern, so if at any time the FTE or the test pilot feels that the visibility might cause safety concerns, than the test can and will be terminated and rescheduled.

**Test Area**

The tests described in this document will be performed in the pattern of Lawrence Municipal Airport (LWC), in the vicinity of the remote control (RC) field and over the horizon of the ground station. The test area is defined in Figure 4 as 96°W to 94°30’W and from 38°30’N to 39°30’N.

![Figure 4: Test Areas (Not for Navigational Use)](image-url)
**On-Board Instrumentation Requirements**

The on-board instrumentation requirements are:

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mount</td>
<td>5.5</td>
</tr>
<tr>
<td>Nav-420</td>
<td>1.3</td>
</tr>
<tr>
<td>Iridium modem</td>
<td>1.4</td>
</tr>
<tr>
<td>Iridium/GPS antenna</td>
<td>0.1</td>
</tr>
<tr>
<td>SBC</td>
<td>2.4</td>
</tr>
<tr>
<td>GPS antenna</td>
<td>0.1</td>
</tr>
<tr>
<td>SBC AC adapter</td>
<td>1.2</td>
</tr>
<tr>
<td>Piccolo Autopilot</td>
<td>0.5</td>
</tr>
<tr>
<td>UHF antenna</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>TOTAL:</strong></td>
<td><strong>12.6</strong></td>
</tr>
</tbody>
</table>

The Iridium/GPS antenna may be changed to a different set of two antennas. This means that there will be two of the GPS antennas seen in Figure 5 and an Iridium antenna seen in Figure 6.
The back-up antenna weighs 14.3 oz, which is more than the other antenna; however, this weight is negligible in the weight and balance. This antenna will be mounted the same as the previous antenna.

**Ground Instrumentation Requirements**

The ground instrumentation requirements are:

1. Piccolo Ground Station
2. 2 Laptops
3. Iridium modem
4. Iridium antenna
5. Handheld Radio
6. UHF antenna
7. 2-12V batteries
8. Inverter
9. Power Strip

![Ground Station Block Diagram](image)

**Vehicle Requirements**

The vehicle must be capable of the following:
- Carry the pilot and 1 other crewmember, and sufficient fuel for 3 hours of flight.
- Be equipped with the instrumentation described above.
It must be a type of aircraft currently certified by the FAA in the experimental category and have a current Airworthiness Certificate, Registration Certificate, Operating Limitations and Weight and Balance calculations all located on board the aircraft for each flight. Maintenance must have been carried out in accordance to FAR 91.417 (Annual Inspection).

Proposed Aircraft:
- Type: 182 RG
- Registration Number: N7188C
- Owner: University of Kansas

This aircraft fulfills the above requirements.

**Vehicle Modifications and Special Requirements**

A UHF, GPS, and Iridium/GPS antenna will be installed on this aircraft.

**Installation of Equipment**

Figure 8 shows a general view of how the instruments will be installed on the Cessna 182.
Figure 8 shows all the instruments which are needed for this flight test. The single board computer (SBC) has a mounting bracket on each side of the case which will allow four bolts to hold it to the mounting board. The Piccolo II can be attached to its mount with two carbon fiber braces which are shown in Figure 9. The Piccolo mount is then secured to the avionics mount with four screws. An additional mount has been created which goes around the top of the Piccolo box. The Nav-420 is secured to the avionics mount with four bolts. The Nav-420 has holes on the corners for these bolts to go through. The Iridium modem is mounted with zip ties going around it and through the avionics mount.

![Figure 9](image)

**Figure 9: Piccolo II attached to Mount with Mounting Brace**

With each component secured to the avionics mount, the mount itself is secured to floor of the Cessna 182 with bolts. The avionics mount has been tested before since it was used with the DGPS system which was flown on the same aircraft.

The antennas are really the tough part to secure to the aircraft. The GPS antenna for the Nav-420 and the GPS/Iridium antenna will be secured to the back window to keep from interfering with the magnetic compass.

The UHF antenna will be secured to the underbelly of the aircraft and secured through with a bolt around the threaded antenna bolt.

The cables from the GPS and Iridium/GPS antennas will be strung from the back window and through an existing bundle of wires to the individual components. This wiring follows the same process which is already done for much of the wiring already in the aircraft. The cables will be attached to the wire bundle in order to keep all wires and cables from hindering the exit of the aircraft and keeps from restraining the pilot’s ability to fly the aircraft. The wiring bundle can be seen in Figure 10.

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The power required to run the avionics equipment is AC power (supplied from inverter of the deep cycle batteries) for the processor and Iridium modem. The Nav-420 and the Piccolo are supplied with 12 VDC. The AC power is located just to the port side of the avionics equipment in the installed equipment rack. The DC power is on the starboard side of the aircraft just aft of the avionics mount. Each wire supplying power will have a fuse attached to it and the wire will be connected to military standard wires. The fuses reduce the likelihood of an electrical fire on board and the military standard wires prevent smoke and nauseous fumes in case of a fire. The electrical connection will be connected to the existing test instrumentation bus so the pilot can turn off the test equipment, if required, by the use of a single switch.

Pilot and Crew Requirements

The pilot of the aircraft must have at least a commercial pilot’s license for the airplane single engine land category and high performance class. He/She must have a current class II medical exam and have a current biannual flight review within the last 24 months before the flight test date. In addition he/she must have at least three takeoffs and landings within 90 days prior to each flight in the same category and class of aircraft to meet the FAA currency requirements to carry passengers during the daytime.

The flight test crew other than the pilot consists of one crewmember that is knowledgeable about the nature of the test and their respective tasks. The task description of the flight test crewmember will be as follows:

Crewmember 1:
- Give pilot instructions for the flight path to be followed and the flight conditions to be in.
• Operate any equipment or instrumentation needed for the flight test except for that equipment being operated by the pilot in command.
• Assist the pilot in observing the surrounding airspace for collision avoidance during the flight test.

**Ground Support Requirements**

Ground support will take place before, during, and after each flight is completed. Prior to each flight, the team members will carry out their respective responsibilities to ensure that the aircraft is ready for the flight test and that the crewmembers have been properly briefed on the procedures to be carried out. A flow chart of the decision making process is given in Appendix F. The team members have the following positions and responsibilities during ground operations are as follows. Appendix G provides checklists for each position.

• Pilot in Command (PIC) – Has ultimate responsibility for the safety of the flight and therefore has the final authority in making a go or no-go decision. He is responsible for briefing the other crewmembers on safety and emergency procedures prior to the flight. The PIC is also responsible for performing a pre-flight inspection of the aircraft according to the pre-flight checklist and reviewing the weight and balance calculation to ensure the aircraft is not overweight and that the center of gravity will not be out of range for any portion of the flight.

• Flight Test Engineer (FTE) – Is responsible for making the go or no-go decision for purposes of the test mission success. The FTE is responsible for the overall coordination of the flight test operation and team. Therefore, he/she must ensure that the PIC has been properly briefed on the nature and procedures of the flight test. The FTE is also responsible for training and evaluating the other team members in their tasks.

• Vehicle Engineer (VE) – Assists the PIC in performing the pre-flight preparations of the aircraft. This includes understanding any special limitations of the aircraft, reviewing recent maintenance and repair records, reviewing the squawk list and the status of actions. The VE must ensure that the aircraft is ready for the test flight, and determine if the aircraft is airworthy and ready to perform the required mission. The VE is responsible for the weight and balance calculation of the aircraft and for performing a post-flight inspection of the vehicle and making additions to the squawk list if necessary.

• Instrumentation Engineer (IE) – Is responsible for ensuring that the required instrumentation is installed and operational prior to each flight test. He/she has the authority to cancel a flight if an instrument that is vital to the test is not operational. The IE performs a post flight checkout of the instrumentation system and is responsible for the documentation of the system status, including any failure, permanent or intermittent, that may occur.

• Data Processing Engineer (DPE) – Is responsible for the processing of the flight test data. This includes the maintenance and care of the raw data, documentation of the data processing procedure, adherence to the prescribed data processing procedures and for maintaining current sensor calibration data.

If at anytime either the VE or IE discovers a condition that is unsafe or inadequate for the completion of the flight test, then that team member has the responsibility to notify the PIC and
FTE. The PIC and FTE have the authority and responsibility to cancel the flight at any time they believe the flight presents a safety concern, while the FTE may cancel the flight at any time he/she believes the test cannot be successfully completed.

**Estimated Cost and Source of Funding**

The cost per hour of the Cessna 182 being rented is $150 per hour, including fuel. The cost per hour for a test pilot is $75 per hour. This flight test should not require more than 5 aircraft operating hours to complete, therefore the total cost will not exceed $1125.00. The equipment has already been acquired by CReSIS and will not require additional funding. The source of funding is CReSIS.
Appendix A: Dance Card

Dance Card for In the Pattern Test

- Take-off
- Climb to 2900 feet MSL and heading appropriate for exiting pattern and setting up for a long approach
- Configuration gear down and flaps appropriate for approach and airspeed
- Landing and Take Off Tests
  - Long approach
    - Run 1A
    - Run 2A
  - In the Pattern Test
    - Run 1B
    - Run 2B
    - Run 3B
    - Run 4B
- Land and Taxi to KU hangar

Dance Card for Flight Test over RC field

- Take-off
- Climb to 3000 feet MSL and heading appropriate for exiting the pattern toward the RC field
- Configuration gear down flaps appropriate for airspeed
- RC field test
- Clover Leaf Pattern
  - Focal point on ground station
    - Run 1C
  - Focal Point away from ground station 100 meters
    - Run 1D
- Race track pattern test
  - Antenna pointed away from ground station (Left turns)
    - Line up aircraft heading south along dam
    - Run 1E
    - Run 2E
    - Run 3E
    - Run 4E
  - Right turns
- Line up aircraft heading south along dam
- Run 1F
- Run 2F
- Run 3F
- Run 4F
- Figure eights test
  - Head South
  - Run 1G
  - Run 2G
  - Run 3G
  - Run 4G
  - Run 5G
  - Run 6G
  - Run 7G
  - Run 8G
- Head back toward Lawrence Municipal Airport
- Land and Taxi to KU hangar
# Appendix B: Flight Test Cards

<table>
<thead>
<tr>
<th>Flight Test Experiment</th>
<th>Communications (in pattern)</th>
<th>A. Preflight Procedure</th>
</tr>
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<tbody>
<tr>
<td>Aircraft Model</td>
<td>182</td>
<td>1. FTE Experiment Briefing to Pilot and Crew</td>
</tr>
<tr>
<td>Aircraft Configuration</td>
<td>clean</td>
<td>2. Pilot Safety Briefing to Crew</td>
</tr>
<tr>
<td>N-number of Aircraft</td>
<td>7188C</td>
<td>3. Hobbs time</td>
</tr>
<tr>
<td>Pilot</td>
<td>Ron Renz</td>
<td>4. Check NOTAMs</td>
</tr>
<tr>
<td>Crew</td>
<td>Kai Siegele</td>
<td>5. Fuel quantity</td>
</tr>
<tr>
<td>Date</td>
<td></td>
<td>6. Aircraft weight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7. Crew and Instrumentation Weight</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8. Preflight Inspection from pilot’s Manual check list</td>
</tr>
</tbody>
</table>

01
B. Frequencies

1. ASOS 121.25
2. LWC CTAF 123.0

C. Weather Conditions

1. Temperature
2. Barometric Pressure
3. Winds
4. Ceiling/Visibility

D. FTE/PIC Check-off

- Vehicle Engineer
- Instrumentation Engineer
- Flight Test Engineer
- Pilot in Command

A. Aircraft Configuration: Appropriate for position in pattern
   Landing gear down

B. Take-off

C. Normal climb to a pressure altitude of 2900 ft (MSL)

D. Depart Pattern and set up for a long approach (6 miles out)
### 04 Run 1A

Run 1A: Long approach test

1. Head in downwind direction for 6 miles and climb to 2900 ft MSL (gear down)
2. Turn base for runway
3. Turn final for runway (use appropriate flaps and gear down)
4. Do touch and go
5. Depart runway and turn for downwind on another long approach.
6. Check fuel level. If fuel gauge indicates one quarter or less, return to home base (LWC)
7. Check daylight. If sun is setting, return to LWC

### 05 Run 2A

Run 1B: Long approach test

1. Head in downwind direction for 6 miles and climb to 2900 ft MSL (gear down)
2. Turn base for runway
3. Turn final for runway (use appropriate flaps and gear down)
4. Do touch and go
5. Depart runway and stay in the pattern.
6. Check fuel level. If fuel gauge indicates one quarter or less, return to home base (LWC)
7. Check daylight. If sun is setting, return to LWC
Run 1B: Pattern Test

1. Depart runway and make appropriate cross-wind turn
2. Climb to 1800 feet MSL (pattern altitude)
3. Make left turn downwind (use appropriate flaps and gear down)
4. Make left turn for base (use appropriate flaps)
5. Make left turn for final (use appropriate flaps)
6. Do a touch and go.
7. Check fuel level. If fuel gauge indicates one quarter or less, return to home base (LWC)
8. Check daylight. If sun is setting, return to LWC

Run 2B: Pattern Test

1. Depart runway and make appropriate cross-wind turn
2. Climb to 1800 feet MSL (pattern altitude)
3. Make left turn downwind (use appropriate flaps and gear down)
4. Make left turn for base (use appropriate flaps)
5. Make left turn for final (use appropriate flaps)
6. Do a touch and go.
7. Check fuel level. If fuel gauge indicates one quarter or less, return to home base (LWC)
8. Check daylight. If sun is setting, return to LWC
### Run 3B: Pattern Test
1. Depart runway and make appropriate cross-wind turn
2. Climb to 1800 feet MSL (pattern altitude)
3. Make left turn downwind (use appropriate flaps and gear down)
4. Make left turn for base (use appropriate flaps)
5. Make left turn for final (use appropriate flaps)
6. Do a touch and go.
7. Check fuel level. If fuel gauge indicates one quarter or less, return to home base (LWC)
8. Check daylight. If sun is setting, return to LWC

### Run 4B: Pattern Test
1. Depart runway and make appropriate cross-wind turn
2. Climb to 1800 feet MSL (pattern altitude)
3. Make left turn downwind (use appropriate flaps and gear down)
4. Make left turn for base (use appropriate flaps)
5. Make left turn for final (use appropriate flaps)
6. Complete stop landing
7. Taxi to KU hangar
8. Shut down
<table>
<thead>
<tr>
<th>Post-Flight Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Hobbs time</td>
</tr>
<tr>
<td>2. Tach time</td>
</tr>
<tr>
<td>3. Refuel (top off)</td>
</tr>
<tr>
<td>Flight Test Experiment</td>
</tr>
<tr>
<td>------------------------</td>
</tr>
<tr>
<td>Aircraft Model</td>
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<tr>
<td>Aircraft Configuration</td>
</tr>
<tr>
<td>N-number of Aircraft</td>
</tr>
<tr>
<td>Pilot</td>
</tr>
<tr>
<td>Crew</td>
</tr>
<tr>
<td></td>
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<tr>
<td>Date</td>
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</tr>
</tbody>
</table>

01
F. Frequencies

1. ASOS 121.25
2. LWC CTAF 123.0

G. Weather Conditions

1. Temperature
2. Barometric Pressure
3. Winds
4. Ceiling/Visibility

H. Aircraft Configuration: Flaps as needed
   Landing gear down

I. Take-off

J. Normal climb to a pressure altitude of 3000 ft (MSL)

K. Depart Pattern to the south toward the RC field

E. FTE/PIC Check-off

   Vehicle Engineer

   Instrumentation Engineer

   Flight Test Engineer

   Pilot in Command
Run 1C: Clover Leaf Pattern at 80-120 knots, gear down, 3000 feet MSL
1. Set ground station focal point at (38° 54.91614’ N, 95° 19.044239’W)
2. Fly toward the ground station (38° 54.91614’ N, 95° 19.044239’W) crossing overhead at heading 270° at 100 knots
3. When communications is lost make standard turn to left flying at 045° and fly over ground station.
4. When communications is lost again, make a standard turn to the left and fly a heading of 180° over the ground station.
5. When communications is lost again, make a standard left turn and fly a heading of 315° over the ground station.
6. When communications is lost, make a standard left turn and fly a heading of 090° over the ground station.
7. When communications is lost, make a standard left turn and fly a heading of 225° over the ground station.
8. When communications is lost, make a standard left turn and fly a heading of 000° over the ground station.
9. When communications is lost, make a standard left turn and fly a heading of 135° over the ground station.
10. Reset GPS focal point to (38° 55.005719’N, 95° 19.044239’ W)
11. Check fuel level. If fuel gauge indicates one quarter or less, return to home base (LWC)
12. Check daylight. If sun is setting, return to LWC

Run 1D: Clover Leaf Pattern (focal point at 38° 55.005719’N, 95° 19.044239’ W) at 80-120 knots and gear down, 3000 feet MSL
1. Make a standard left turn and head for focal point at a heading of 270°.
2. When communications is lost make a standard left turn and fly toward the focal point at a heading of 045°
3. When communications is lost make a standard left turn and fly toward the focal point at a heading of 180°
4. When communications is lost make a standard left turn and fly toward the focal point at a heading of 315°
5. When communications is lost make a standard left turn and fly toward the focal point at a heading of 090°
6. When communications is lost make a standard left turn and fly toward the focal point at a heading of 225°
7. When communications is lost make a standard left turn and fly toward the focal point at a heading of 000°
8. When communications is lost make a standard left turn and fly toward the focal point at a heading of 135°
9. When communications is lost make a standard left turn and fly toward the focal point at a heading of 270°
10. Check fuel level. If fuel gauge indicates one quarter or less, return to home base (LWC)
11. Check daylight. If sun is setting, return to LWC
12. Set up for 1E by entering a track at the north side of dam heading south.
Run 1E: Race Track Pattern (antenna pointed away from ground station) at 80-120 knots, gear down, 3000 feet MSL
1. Head south along dam.
2. When the ground station is abeam the aircraft, start a 10 degree banked turn to the left.
3. Circle the ground station with a steady 10° bank in coordinated flight.
4. Set up for Run 2E by heading south along the dam
5. Check fuel level. If fuel gauge indicates one quarter or less, return to home base (LWC)
6. Check daylight. If sun is setting, return to LWC

Run 2E: Race Track Pattern (antenna pointed away from ground station) at 80-120 knots, gear down, 3000 feet MSL
1. Head south along dam.
2. When the ground station is abeam the aircraft, start a 20 degree banked turn to the left.
3. Circle the ground station with a steady 20° bank in coordinated flight.
4. Set up for Run 3E by heading south along the dam
5. Check fuel level. If fuel gauge indicates one quarter or less, return to home base (LWC)
6. Check daylight. If sun is setting, return to LWC
Run 3E: Race Track Pattern (antenna pointed away from ground station) 80-120 knots, gear down, 3000 feet MSL
1. Head south along dam.
2. When the ground station is abeam the aircraft, start a 30 degree banked turn to the left.
3. Circle the ground station with a steady 30° bank in coordinated flight.
4. Set up for Run 4E by heading south along the dam
5. Check fuel level. If fuel gauge indicates one quarter or less, return to home base (LWC)
6. Check daylight. If sun is setting, return to LWC

Run 4E: Race Track Pattern (antenna pointed away from ground station) 80-120 knots, gear down, 3000 feet MSL
1. Head south along dam.
2. When the ground station is abeam the aircraft, start a 40 degree banked turn to the left.
3. Circle the ground station with a steady 40° bank in coordinated flight.
4. Set up for Run 1F by heading south along the dam
5. Check fuel level. If fuel gauge indicates one quarter or less, return to home base (LWC)
6. Check daylight. If sun is setting, return to LWC
Run 1F: Race Track Pattern (antenna pointed toward ground station) 80-120 knots, gear down, 3000 feet MSL
1. Head south along dam.
2. When the ground station is abeam the aircraft, start a 10 degree banked turn to the right.
3. Circle the ground station with a steady 10° bank in coordinated flight.
4. Set up for Run 2F by heading south along the dam
5. Check fuel level. If fuel gauge indicates one quarter or less, return to home base (LWC)
6. Check daylight. If sun is setting, return to LWC

Run 2E: Race Track Pattern (antenna pointed away from ground station) 80-120 knots, gear down, 3000 feet MSL
1. Head south along dam.
2. When the ground station is abeam the aircraft, start a 20 degree banked turn to the Right.
3. Circle the ground station with a steady 20° bank in coordinated flight.
4. Set up for Run 3F by heading south along the dam
5. Check fuel level. If fuel gauge indicates one quarter or less, return to home base (LWC)
6. Check daylight. If sun is setting, return to LWC
Run 3F: Race Track Pattern (Right turn) at 80-120 knots, gear down and 3000 feet MSL
1. Head south along dam.
2. When the ground station is abeam the aircraft, start a 30 degree banked turn to the right.
3. Circle the ground station with a steady 30° bank in coordinated flight.
4. Set up for Run 4F by heading south along the dam
5. Check fuel level. If fuel gauge indicates one quarter or less, return to home base (LWC)
6. Check daylight. If sun is setting, return to LWC

Run 2E: Race Track Pattern (Right turn) at 80-120 knots, gear down and 3000 feet MSL
1. Head south along dam.
2. When the ground station is abeam the aircraft, start a 40 degree banked turn to the right.
3. Circle the ground station with a steady 40° bank in coordinated flight.
4. Set up for Run 1G by heading due south and insert GPS coordinates of (38° 54.91614’ N, 95° 19.044239’W)
5. Check fuel level. If fuel gauge indicates one quarter or less, return to home base (LWC)
6. Check daylight. If sun is setting, return to LWC
Run 1G: Figure Eights Test (1 mile range) at 80-120 knots, gear down, 3000 feet MSL
1. Head due south (180°).
2. When 1 mile range from ground station is established perform a horizontal figure eight with a standard turn rate.
3. If communications is lost repeat Run 1G.
4. If communications is good turn to a heading of 180° and prepare for Run 2G.
5. If communications is lost a second time return to LWC.
6. Check fuel level. If fuel gauge indicates one quarter or less, return to home base (LWC).
7. Check daylight. If sun is setting, return to LWC.

Run 2G: Figure Eights Test (2 mile range) at 80-120 knots, gear down, 3000 feet MSL
1. Continue on heading 180° until 2 miles from ground station.
2. When 2 miles range is reached, perform a horizontal figure eight.
3. If communications is lost repeat Run 2G.
4. If communications is good turn to a heading of 180° and prepare for Run 3G.
5. If communications is lost a second time return to LWC.
6. Check fuel level. If fuel gauge indicates one quarter or less, return to home base (LWC).
7. Check daylight. If sun is setting, return to LWC.
Run 3G: Figure Eights Test (3 mile range) at 80-120 knots, gear down, 3000 feet MSL
1. Continue on heading 180° until 3 miles from ground station.
2. When 3 miles range is reached, perform a horizontal figure eight.
3. If communications is lost repeat Run 3G
4. If communications is good turn to a heading of 180° and prepare for Run 4G.
5. If communications is lost a second time return to LWC.
6. Check fuel level. If fuel gauge indicates one quarter or less, return to home base (LWC)
7. Check daylight. If sun is setting, return to LWC

Run 4G: Figure Eights Test (4 mile range) at 80-120 knots, gear down, 3000 feet MSL
1. Continue on heading 180° until 4 miles from ground station.
2. When 4 miles range is reached, perform a horizontal figure eight.
3. If communications is lost repeat Run 4G
4. If communications is good turn to a heading of 180° and prepare for Run 5G.
5. If communications is lost a second time return to LWC.
6. Check fuel level. If fuel gauge indicates one quarter or less, return to home base (LWC)
7. Check daylight. If sun is setting, return to LWC
### Run 5G

**Run 5G: Figure Eights Test (5 mile range) at 80 to 120 knots, gear down, 3000 feet MSL**

1. Continue on heading 180° until 5 miles from ground station.
2. When 5 miles range is reached, perform a horizontal figure eight.
3. If communications is lost repeat Run 5G
4. If communications is good turn to a heading of 180° and prepare for Run 6G.
5. If communications is lost a second time return to LWC.
6. Check fuel level. If fuel gauge indicates one quarter or less, return to home base (LWC)
7. Check daylight. If sun is setting, return to LWC

---

### Run 6G

**Run 6G: Figure Eights Test (6 mile range) at 80 to 120 knots, gear down, 3000 feet MSL**

1. Continue on heading 180° until 6 miles from ground station.
2. When 6 miles range is reached, perform a horizontal figure eight.
3. If communications is lost repeat Run 6G
4. If communications is good turn to a heading of 180° and prepare for Run 7G.
5. If communications is lost a second time return to LWC.
6. Check fuel level. If fuel gauge indicates one quarter or less, return to home base (LWC)
7. Check daylight. If sun is setting, return to LWC
<table>
<thead>
<tr>
<th>Run 7G</th>
<th>Run 8G</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Run 7G</strong>: Figure Eights Test (7 mile range) at 80-120 knots, gear down, 3000 feet MSL</td>
<td><strong>Run 8G</strong>: Figure Eights Test (8 mile range) at 80-120 knots, gear down, 3000 feet MSL</td>
</tr>
<tr>
<td>1. Continue on heading 180° until 7 miles from ground station.</td>
<td>1. Continue on heading 180° until 8 miles from ground station.</td>
</tr>
<tr>
<td>2. When 7 miles range is reached, perform a horizontal figure eight.</td>
<td>2. When 8 miles range is reached, perform a horizontal figure eight.</td>
</tr>
<tr>
<td>3. If communications is lost repeat Run 7G</td>
<td>3. If communications is lost repeat Run 8G</td>
</tr>
<tr>
<td>4. If communications is good turn to a heading of 180° and prepare for Run 8G.</td>
<td>4. Check fuel level. If fuel gauge indicates one quarter or less, return to home base (LWC)</td>
</tr>
<tr>
<td>5. If communications is lost a second time return to LWC.</td>
<td>5. Check daylight. If sun is setting, return to LWC</td>
</tr>
<tr>
<td>6. Check fuel level. If fuel gauge indicates one quarter or less, return to home base (LWC)</td>
<td></td>
</tr>
<tr>
<td>7. Check daylight. If sun is setting, return to LWC</td>
<td></td>
</tr>
</tbody>
</table>
## Appendix C: Avionics and Communication Data

The data collected for this experiment will be done by the ground station and its crew. The ground station records the following data:

In the pattern test

<table>
<thead>
<tr>
<th>Run A</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Distance UHF lost (Run 1):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distance UHF acquired (Run 1):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leg on which UHF lost (Run 1):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distance UHF lost (Run 2):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distance UHF acquired (Run 2):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leg on which UHF lost (Run 2):</td>
<td></td>
</tr>
</tbody>
</table>

|       |                  |                  |
| Run B |                  |                  |
|       | Leg on which UHF lost (Run B): |                 |
|       | Leg on which UHF lost (Run B): |                 |
|       | Leg on which UHF lost (Run B): |                 |

RC Field Test

<table>
<thead>
<tr>
<th>RUN 1C</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Distance UHF signal acquired (course 270°):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distance UHF signal lost (course 270°):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distance UHF signal acquired (course 045°)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distance UHF signal lost (course 045°):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distance UHF signal acquired (course 180°)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distance UHF signal lost (course 180°):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distance UHF signal acquired (course 315°)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distance UHF signal lost (course 315°):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distance UHF signal acquired (course 090°)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distance UHF signal lost (course 090°):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distance UHF signal acquired (course 225°)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distance UHF signal lost (course 225°):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distance UHF signal acquired (course 000°)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distance UHF signal lost (course 000°):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distance UHF signal acquired (course 135°)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distance UHF signal lost (course 135°):</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RUN 1D</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Distance UHF signal acquired (course 270°):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distance UHF signal lost (course 270°):</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distance UHF signal acquired (course 045°)</td>
<td></td>
</tr>
<tr>
<td>Course</td>
<td>Distance UHF signal lost</td>
<td>Distance UHF signal acquired</td>
</tr>
<tr>
<td>---------</td>
<td>--------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>045°</td>
<td>_________________________</td>
<td>___________________________</td>
</tr>
<tr>
<td>180°</td>
<td>_________________________</td>
<td>___________________________</td>
</tr>
<tr>
<td>090°</td>
<td>_________________________</td>
<td>___________________________</td>
</tr>
<tr>
<td>225°</td>
<td>_________________________</td>
<td>___________________________</td>
</tr>
<tr>
<td>000°</td>
<td>_________________________</td>
<td>___________________________</td>
</tr>
<tr>
<td>135°</td>
<td>_________________________</td>
<td>___________________________</td>
</tr>
<tr>
<td>10°</td>
<td>_________________________</td>
<td>___________________________</td>
</tr>
<tr>
<td>20°</td>
<td>_________________________</td>
<td>___________________________</td>
</tr>
<tr>
<td>30°</td>
<td>_________________________</td>
<td>___________________________</td>
</tr>
<tr>
<td>40°</td>
<td>_________________________</td>
<td>___________________________</td>
</tr>
</tbody>
</table>

**RUN E**

<table>
<thead>
<tr>
<th>Bank angle</th>
<th>Heading angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 mile</td>
<td></td>
</tr>
<tr>
<td>2 mile</td>
<td></td>
</tr>
<tr>
<td>3 mile</td>
<td></td>
</tr>
<tr>
<td>4 mile</td>
<td></td>
</tr>
<tr>
<td>5 mile</td>
<td></td>
</tr>
<tr>
<td>6 mile</td>
<td></td>
</tr>
<tr>
<td>7 mile</td>
<td></td>
</tr>
<tr>
<td>8 mile</td>
<td></td>
</tr>
</tbody>
</table>
Length of time Iridium call is dropped: __________________
Length of time Iridium call is dropped: __________________
Length of time Iridium call is dropped: __________________
Length of time Iridium call is dropped: __________________
Length of time Iridium call is dropped: __________________
Length of time Iridium call is dropped: __________________
Length of time Iridium call is dropped: __________________
Length of time Iridium call is dropped: __________________

Total times Iridium call is dropped: __________________

Time to upload 100 waypoints over Iridium: __________________
Appendix D: Weight and Balance

Figure 11 illustrates the Cessna 172P center of gravity envelope and the flight test center of gravity range within that envelope. The following data generates Figure 11.

Empty Weight (includes oil, fixed equipment, and unusable fuel) 2174 lbs
Full Fuel (88 gal at 6 lbs/gal (useable fuel)) 528 lbs
Pilot 170 lbs
FTE (front seat) 180 lbs
Maximum Takeoff Weight 3100 lbs
*Clipboards, pencils, stopwatches, and other such items are included in crew weight.

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight (lbs)</th>
<th>Arm (in)</th>
<th>Moment (in-kips)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empty Wt</td>
<td>2174</td>
<td>43.19</td>
<td>93.90</td>
</tr>
<tr>
<td>Max Fuel</td>
<td>528</td>
<td>46.5</td>
<td>24.55</td>
</tr>
<tr>
<td>Equipment</td>
<td>12.6</td>
<td>45.0</td>
<td>0.57</td>
</tr>
<tr>
<td>Pilot</td>
<td>170</td>
<td>37.0</td>
<td>6.29</td>
</tr>
<tr>
<td>FTE</td>
<td>180</td>
<td>37.0</td>
<td>6.66</td>
</tr>
<tr>
<td>Totals:</td>
<td>3064.6</td>
<td></td>
<td>131.96</td>
</tr>
</tbody>
</table>

Table 2: Takeoff Weight and Balance

Table 2 shows that takeoff weight is 3064.6 lbs and the center of gravity is located at 43.1 inches, while Figure 11 indicates that the forward c.g. limit is 123 in-kips or 40.2 inches, and the aft c.g. limit is 142.5 in-kips or 46.6 inches.

The worst case assumes the flight will burn all of its fuel, less the day VFR reserves of 45 minutes, or about 60 lbs of fuel, as is illustrated in Table 3.

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight (lbs)</th>
<th>Arm (in)</th>
<th>Moment (in-kips)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empty Wt</td>
<td>2174</td>
<td>43.19</td>
<td>93.90</td>
</tr>
<tr>
<td>Min Fuel</td>
<td>60</td>
<td>46.5</td>
<td>2.79</td>
</tr>
<tr>
<td>Pilot</td>
<td>170</td>
<td>37.0</td>
<td>6.29</td>
</tr>
<tr>
<td>FTE</td>
<td>180</td>
<td>37.0</td>
<td>6.66</td>
</tr>
<tr>
<td>Equipment</td>
<td>12.6</td>
<td>45.0</td>
<td>0.57</td>
</tr>
<tr>
<td>Totals:</td>
<td>2596.6</td>
<td></td>
<td>110.20</td>
</tr>
</tbody>
</table>

Table 3: Landing Weight and Balance

Table 3 shows that the minimum fuel landing weight is 2596.6 lbs and the c.g. is located at 42.44 inches, while Figure 11 indicates that the forward c.g. limit is 91 in-kips or 35.1 inches, and the aft c.g. limit is 119 in-kips or 46 inches.
Figure 11: C182RG CG and Flight Test Envelope (Copied from C182RG Manual)
## Appendix E: Flight Envelope

Figure 12 illustrates the Cessna 172P flight envelope and the planned flight test envelope. The following data generates Figure 12.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Test Altitude</td>
<td>2000 ft AGL</td>
</tr>
<tr>
<td>Maximum Test Altitude</td>
<td>5800 ft MSL</td>
</tr>
<tr>
<td>Minimum Test Speed</td>
<td>80 KIAS</td>
</tr>
<tr>
<td>Maximum Test Speed</td>
<td>150 KIAS</td>
</tr>
<tr>
<td>Maximum Sustained Flight Altitude</td>
<td>5800 ft MSL</td>
</tr>
<tr>
<td>Minimum Flight Altitude (other than landing approach)</td>
<td>1200 ft AGL</td>
</tr>
<tr>
<td>Stall Speed (Level Flight, Max Gross Wt, Flaps Up)--$V_{S_1}$</td>
<td>41 KIAS</td>
</tr>
<tr>
<td>Maximum Structural Cruising Speed (Max Gross Wt)--$V_{NO}$</td>
<td>157 KIAS</td>
</tr>
<tr>
<td>Maximum Maneuvering Speed (3100 lbs)--$V_A$</td>
<td>112 KIAS</td>
</tr>
<tr>
<td>Maximum Maneuvering Speed (2600 lbs)--$V_A$</td>
<td>102 KIAS</td>
</tr>
<tr>
<td>Maximum Maneuvering Speed (2100 lbs)--$V_A$</td>
<td>91 KIAS</td>
</tr>
</tbody>
</table>

### Risk Assessment:

Since the flight envelope and the weight and c.g. limits of the test aircraft will not be exceeded during the specified test flight, this flight test is classified as low risk.
Figure 12: C182 Flight Test Envelope
Appendix F: Flow Chart

This flow chart illustrates the preflight process and authority of each individual.

Airplane is ready and adequate for the test.

___________________________
Vehicle Engineer—

Required instrumentation is ready and properly calibrated.

_________________________________
Instrumentation Engineer—

All preflight checks of the test apparatus are complete and the test can be completed successfully.

_________________________________
Flight Test Engineer—

All preflight preparations regarding weather and aircraft checks are complete and the flight test can be completed safely.

_________________________________
Test Pilot—
Appendix G: Personnel Checklists:

The following checklists detail the duties of each individual and must be completed prior to conducting the flight test.

Flight Test Engineer:

Vehicle Engineer checklist reviewed

Vehicle as signed off by Vehicle Engineer is ready for the test.

Instrumentation Engineer checklist reviewed

The instrumentation as signed off by the Instrumentation Engineer is adequate and ready for the test.

Instrumentation has been implemented to the vehicle in a proper fashion.

Pilot has been briefed about his tasks during the test

Data Processing Engineer has been briefed about his tasks during the test

Test status: Go □ Cancel □

_______________________________________            ____________
Flight Test Engineer                                            Date
**Instrumentation Engineer:**

1 Nav-420 installed

1 Piccolo installed

1 Iridium modem installed

2 Knee-boards, pencils, papers collected

2 Headsets and intercom systems collected and checked

Single Board Computer installed

Fuses installed

Nav-420 calibrated in Cessna 182

2-12V batteries charged

Single Board Computer collects Nav-420 data correctly

Piccolo connects through Iridium

Radios set for ground communications

____________________________  _________________________
Instrumentation Engineer        Date
**Vehicle Engineer:**

Aircraft scheduled for test times.

All aircraft documentation is on board

- Airworthiness Certificate
- Registration Card
- Operations Manual
- Weight and Balance Data

UHF Antenna Installed

Iridium/ GPS antennas installed

Fuel Tanks Full

_______________________________________            ____________
Vehicle Engineer                                              Date
## Amendment A: Ground station dance card

<table>
<thead>
<tr>
<th>01</th>
<th>02</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Iridium Ground Station- In the Pattern Test</strong></td>
<td><strong>UHF Ground Station- In the Pattern Test</strong></td>
</tr>
<tr>
<td>A. Start GoBook</td>
<td>A. Start GoBook</td>
</tr>
<tr>
<td>B. Open Operator Interface on GoBook.</td>
<td>B. Open Operator Interface on GoBook</td>
</tr>
<tr>
<td>C. Iridium ground station, make call to Piccolo modem before aircraft taxi and call on cell phone for confirmation of good link.</td>
<td>C. Start recording telemetry</td>
</tr>
<tr>
<td>D. Start Recording Telemetry</td>
<td>D. Record the bank angle, pitch, distance, and leg when signal is dropped</td>
</tr>
<tr>
<td>E. Record dropped calls on data sheet (length of dropped call until reconnect, bank angle when dropped, and pitch angle when dropped).</td>
<td>E. After each pass communicate with FTE about signal and test status with handheld radio</td>
</tr>
<tr>
<td></td>
<td>F. Record distance when out of UHF range</td>
</tr>
<tr>
<td></td>
<td>G. Communicate when out of UHF range with handheld radio</td>
</tr>
<tr>
<td>Iridium Ground Station- RC Field Test</td>
<td>UHF Ground Station- RC Field Test</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>A. Start GoBook</td>
<td>A. Start GoBook</td>
</tr>
<tr>
<td>B. Open Operator Interface on GoBook.</td>
<td>B. Open Operator Interface on GoBook</td>
</tr>
<tr>
<td>C. Iridium ground station, make call to Piccolo modem before aircraft taxi and call on cell phone for confirmation of good link.</td>
<td>C. Record distance when UHF signal is acquired</td>
</tr>
<tr>
<td>D. Start Recording Telemetry</td>
<td>D. Start recording telemetry</td>
</tr>
<tr>
<td>E. Record dropped calls on data sheet (length of dropped call until reconnect, bank angle when dropped, and pitch angle when dropped).</td>
<td>E. Record the distance during clover leaf pattern when signal is lost</td>
</tr>
<tr>
<td>F. After range test, upload 100 waypoints to Piccolo and record the time it takes to upload all 100 waypoints.</td>
<td>F. After each pass communicate with FTE about signal and test status with handheld radio</td>
</tr>
<tr>
<td>G. Repeat step F.</td>
<td>G. Record the distance and bank angle when signal is dropped during race track pattern test</td>
</tr>
<tr>
<td>H. After each pass communicate with FTE about signal and test status with handheld radio</td>
<td></td>
</tr>
</tbody>
</table>
UHF Ground Station - RC Field Test

I. Record bank angle and range when signal is dropped during the Figure eights range test.

J. Communicate with FTE after each figure eight is accomplished