NG-LLC Experimental Permit Application.

Revision 1.0

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1. Program Description (Section G-2)

Unreasonable rocket is developing two vehicles to compete at the Xprize Cup Northup Grumman Lunar Lander Challenge in 2007. The vehicles are being built by a very small father and son team in Solana Beach CA. They will be tested under amateur rules at the Remote FAR MTA rocket test facilities near Cantil CA.

1.1. Vehicle Purpose (Section G-2a)

Unreasonable rocket has a long term goal of showing that significant rocket and space flight capabilities are achievable by small motivated teams. Toward that end Unreasonable rocket is developing a vehicle design to compete at the Xprize cup Northrop Grumman Lunar Lander Challenge. Unreasonable Rocket will be building two largely identical vehicles, one to compete in the 90 second challenge and one to compete in the 180 second challenge.

1.2. Vehicle Description

1.2.1. Vehicle 3 view drawing. (Section G-2b)

The following drawings are a rendering of the vehicle.

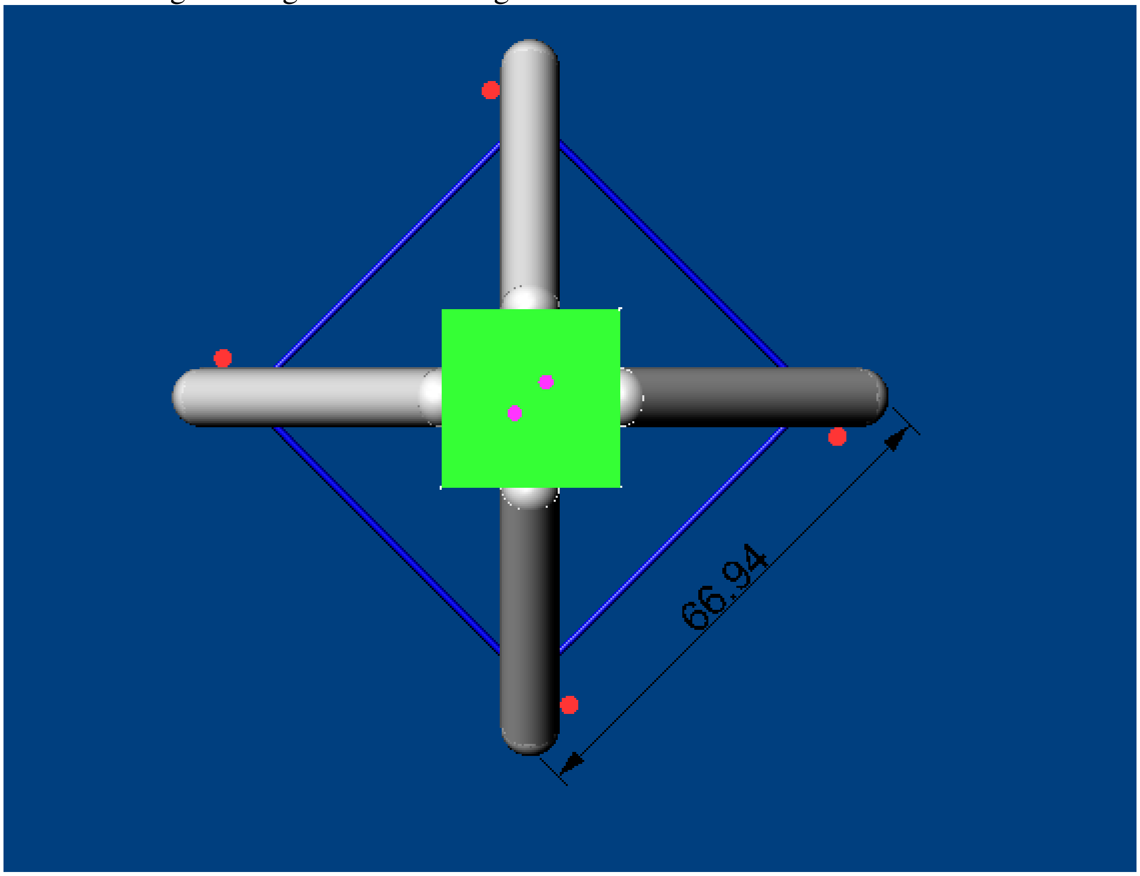


Figure 1Rendered Top view

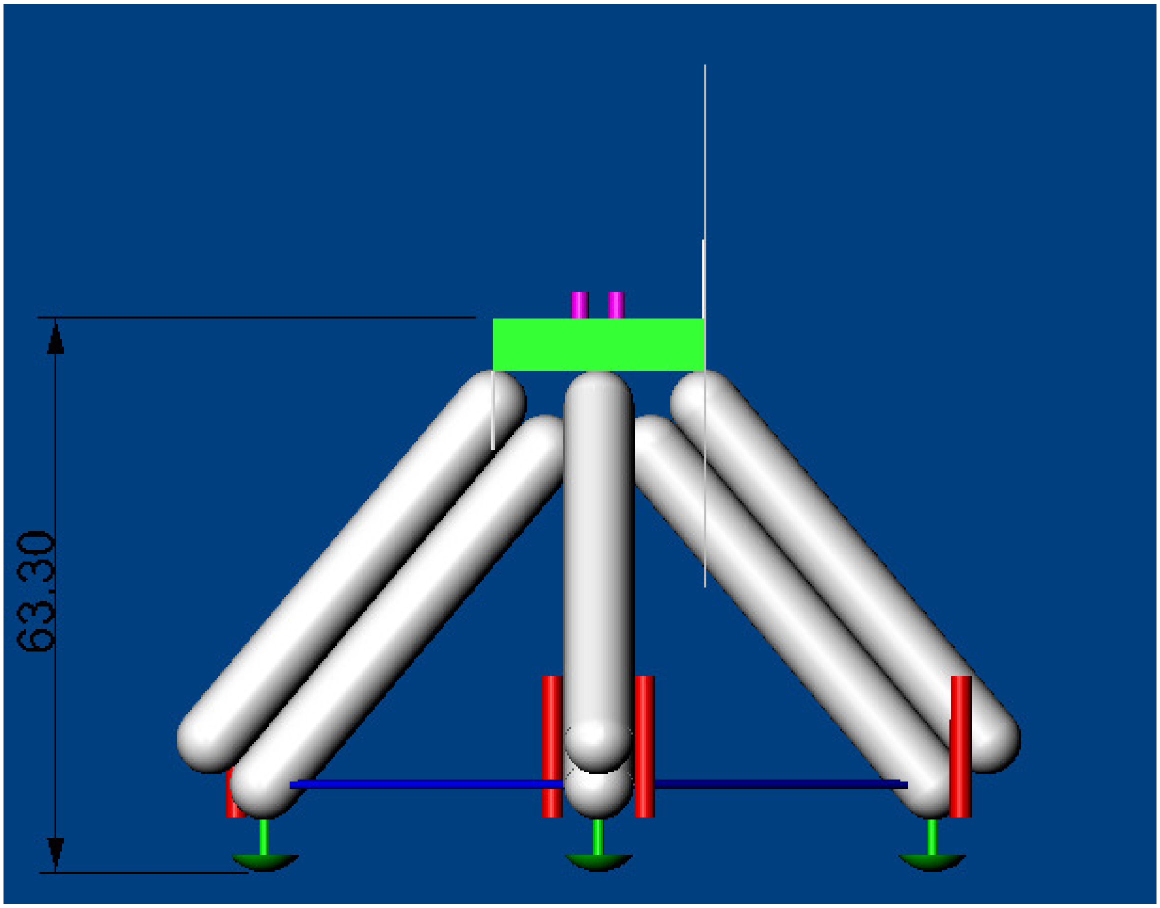


Figure 2Rendered side view

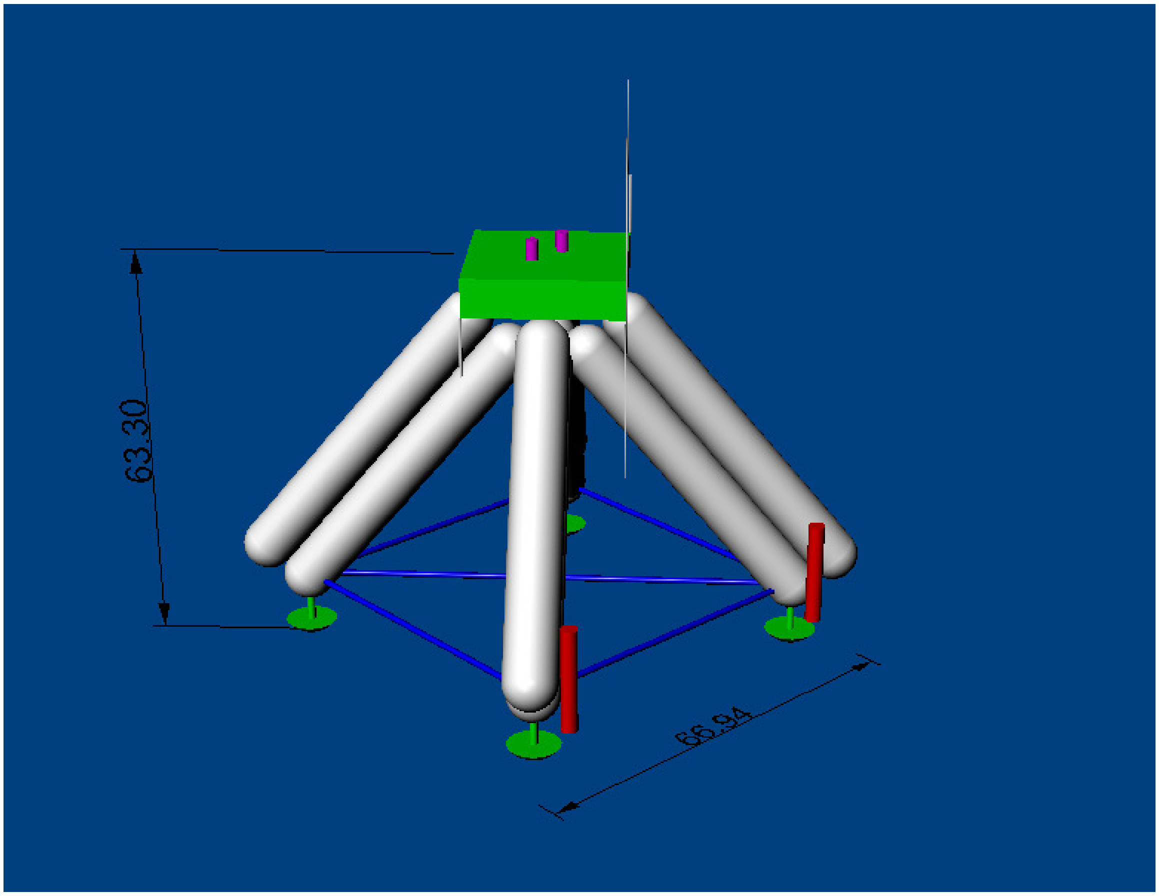


Figure 3Rendered Perspective view

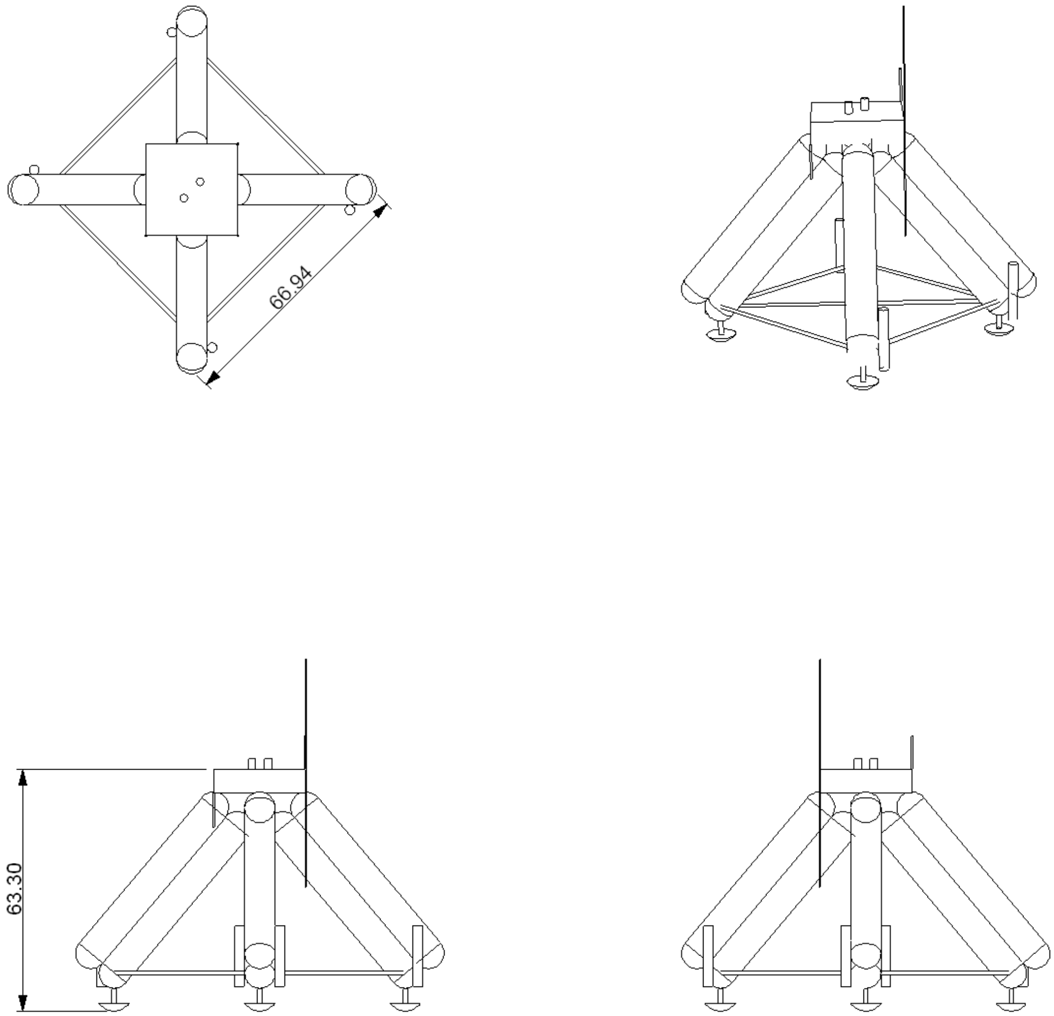


Figure 4 3Axis line drawing

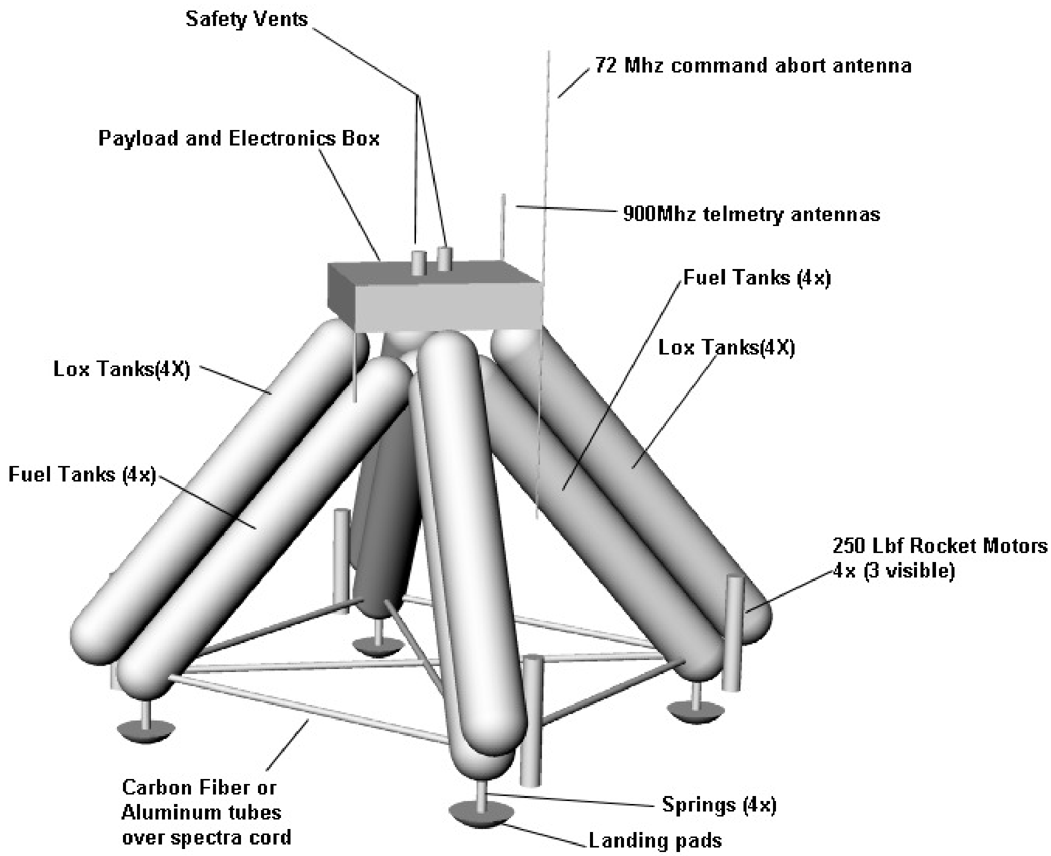


Figure 5 vehicle components

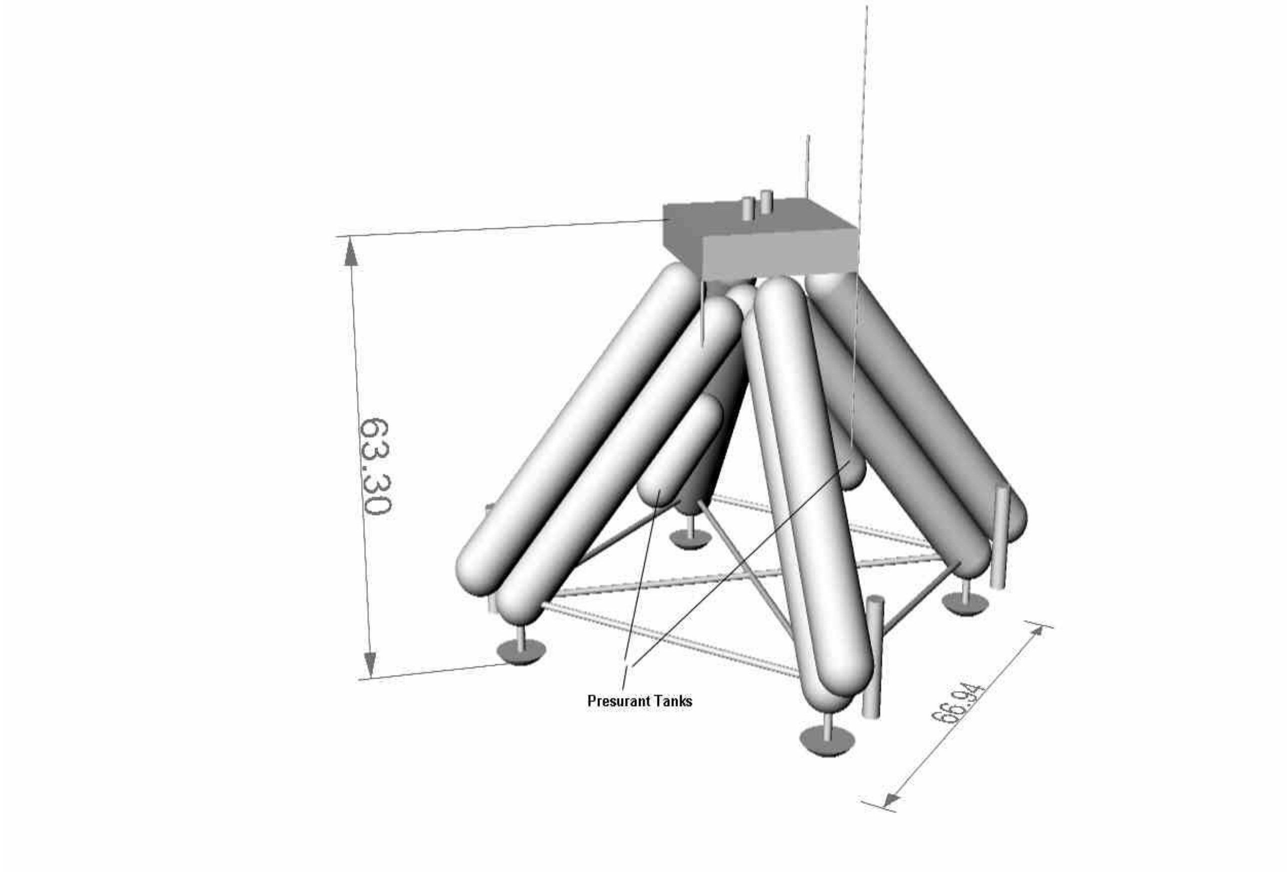


Figure 6 One Possible position for the Presurant tanks.

1.2.2. Vehicle Mass properties and thrust profile. (Section G2-c)

Empty weight ~ 288 Lbs (estimated)
GLOW ~ 935lb 180 second flight (estimated)
GLOW ~550lb for 90 second flight. (estimated)

Oxidizer LOX
The vehicle will nominally carry 377 lbs of LOX
The vehicle will carry an absolute maximum of 503 lbs of LOX

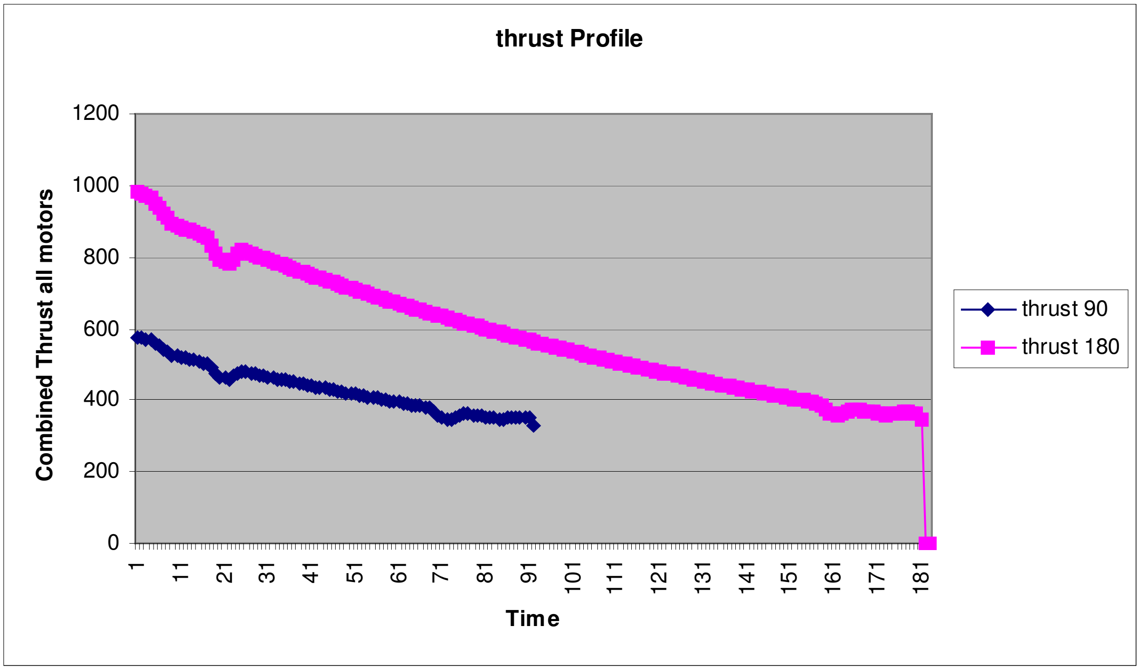
Fuel 75% Ethanol 25% water.
The vehicle will nominally carry 269 lbs of fuel.
The vehicle will carry an absolute maximum of 359 lbs of Fuel.

Pressurization:

He for Lox to 60% then blow down.
N2 for Fuel to 60% then blow down.

These pressuring gasses will be contained in two DOT certified SCI carbon fiber over-wrapped aluminum SCBA cylinders These cylinders are nominally rated for 2200 PSI with a burst of 7000PSI . They will be used at their rated pressure for the 90 second vehicle and may be used at 3000PSI for the 180 second vehicle. They each have an internal volume of 8.5 liters. The present plans call for them to be mounted as shown in Figure 6. They will be strapped to the tanks with stainless band clamps and aluminum saddles. The present plans call for two tanks. We are presently having some difficulty getting these tanks properly filled so we may go to 4 tanks in the identical locations. .

Thrust 4X 250 lb regenerative cooled motors.
Tanks 8” x 59” 0.072” wall 606X aluminum tubing.
Payload 25Kg XPC Gold box.



The total impulse is 107000 lb sec for 180 second flight.
The total impulse is 39000 lb sec for the 90 second flight.

1.2.3. Vehicle Systems (Section G2-d)

1.2.3.1. Structural

Please refer to Figure 5 vehicle components when reading this section.
The primary vehicle structural elements are the Lox and Fuel tanks.
These are pressurized tanks hydrostatically tested to 1.5 their maximum operating pressure. These are welded and heat treated 6061 and 6063. They have aluminum plates welded to them forming them into pairs. The pairs are then bolted together at the top to form a square pyramid. The motors and landing gear loads are transferred directly to the tank structure via brackets. The design of these brackets is till TBD. The bottoms of the tanks are retained in a pyramid structure with spectra lashings inside lightweight carbon fiber or aluminum tubes. These are primarily loaded in tension and will see no compressive flight loads. The spectra lashings are sized for a safety factor of 4.
The initial landing shock loads are absorbed with the springs and the majority of the energy is absorbed by stretch in the lashings.

1.2.3.2. Flight control

The vehicle flight control will be accomplished with differential throttling.
Each of the four motors will be independently throttled for control of pitch and yaw.
Roll control, or control of rotation about the vertical axis will be accomplished by having opposite pairs of motors canted slightly so they impart rotation.
These throttle commands will be generated by the primary flight control computer.
If testing shows that throttling does not have enough control authority or speed then one of the proposed possible changes is to add single axis thrust vectoring to each motor.

1.2.3.3. Thermal

N/A The vehicle is a low dynamics vehicle and requires no thermal protection.

1.2.3.4. Pneumatic

N/A there are no pneumatic systems on the vehicle other than the static source for the on-board altimeter. This is covered in section 1.2.3.9

1.2.3.5. Hydraulic

N/A There are no hydraulic systems on the vehicle.

1.2.3.6. Propulsion

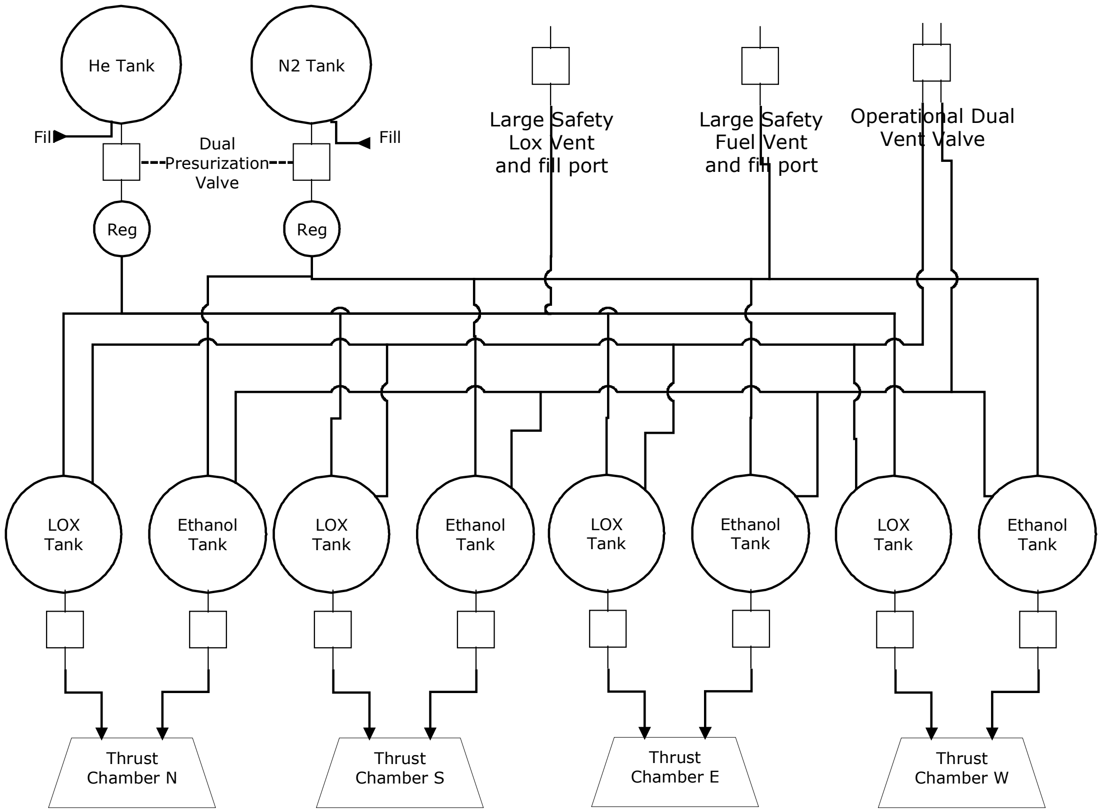


Figure 7 Basic plumbing and propulsion (igniters not shown)

Propulsion will be provided by 4 small LOX ethanol regenerative cooled motors designed and built by Unreasonable Rocket. They will be pressure fed with, and use torch igniters. Maximum thrust will be roughly proportional to feed pressure. The maximum design thrust is 250 lbf at 300 PSI feed pressure. This pressure may change slightly as testing continues. At this time this motor design has been fired four times for runs of 16 ,24,16 and 106 seconds. Please note that each of the four motors can be turned off in one of three ways for safety purposes.

- Turn off the fuel throttle valve.
- Turn off the Lox throttle valve.
- Open the large safety vents and depressurize the feed.

1.2.3.7. Electrical

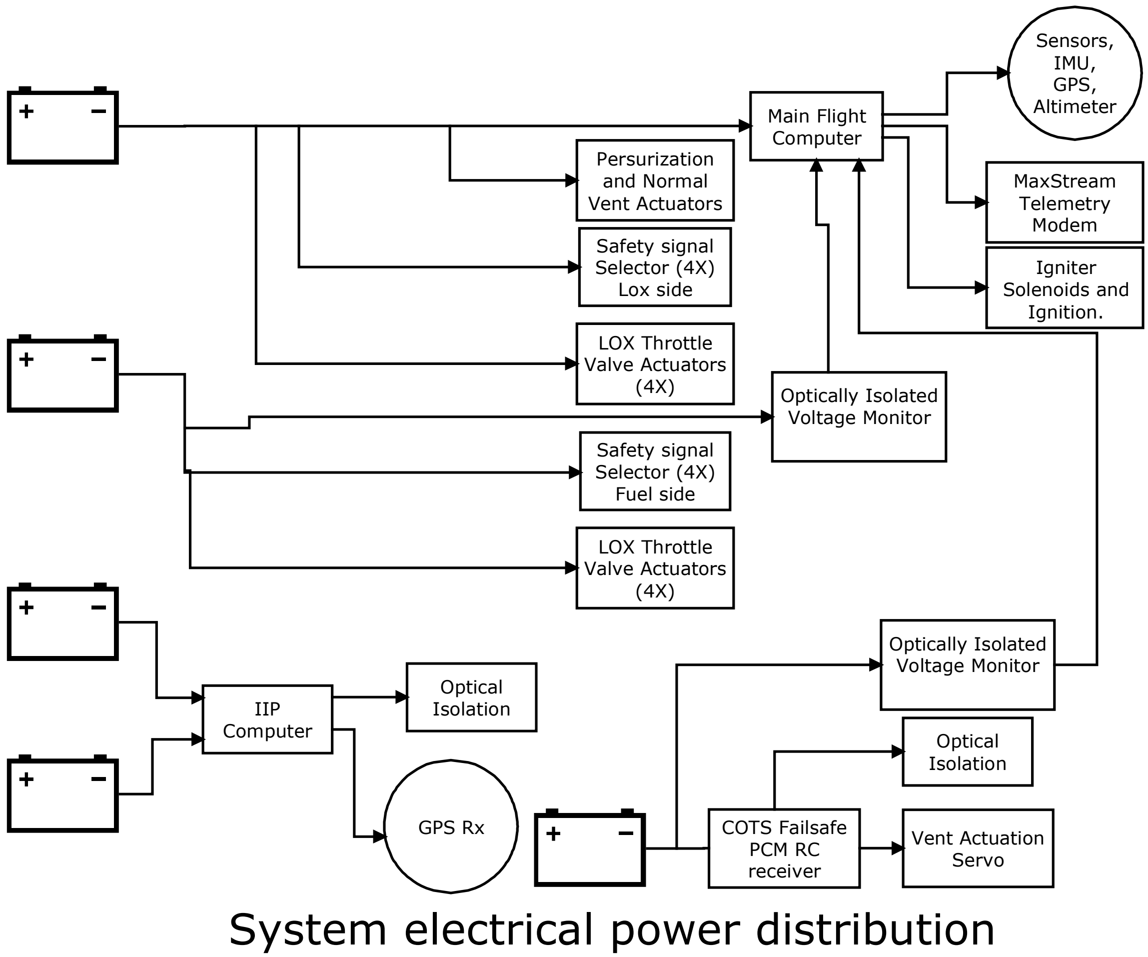


Figure 8. Electrical power distribution

The electrical power distribution is shown above. There will be 5 separate power sources. The system can be automatically or remotely shut down with the failure of any two batteries.

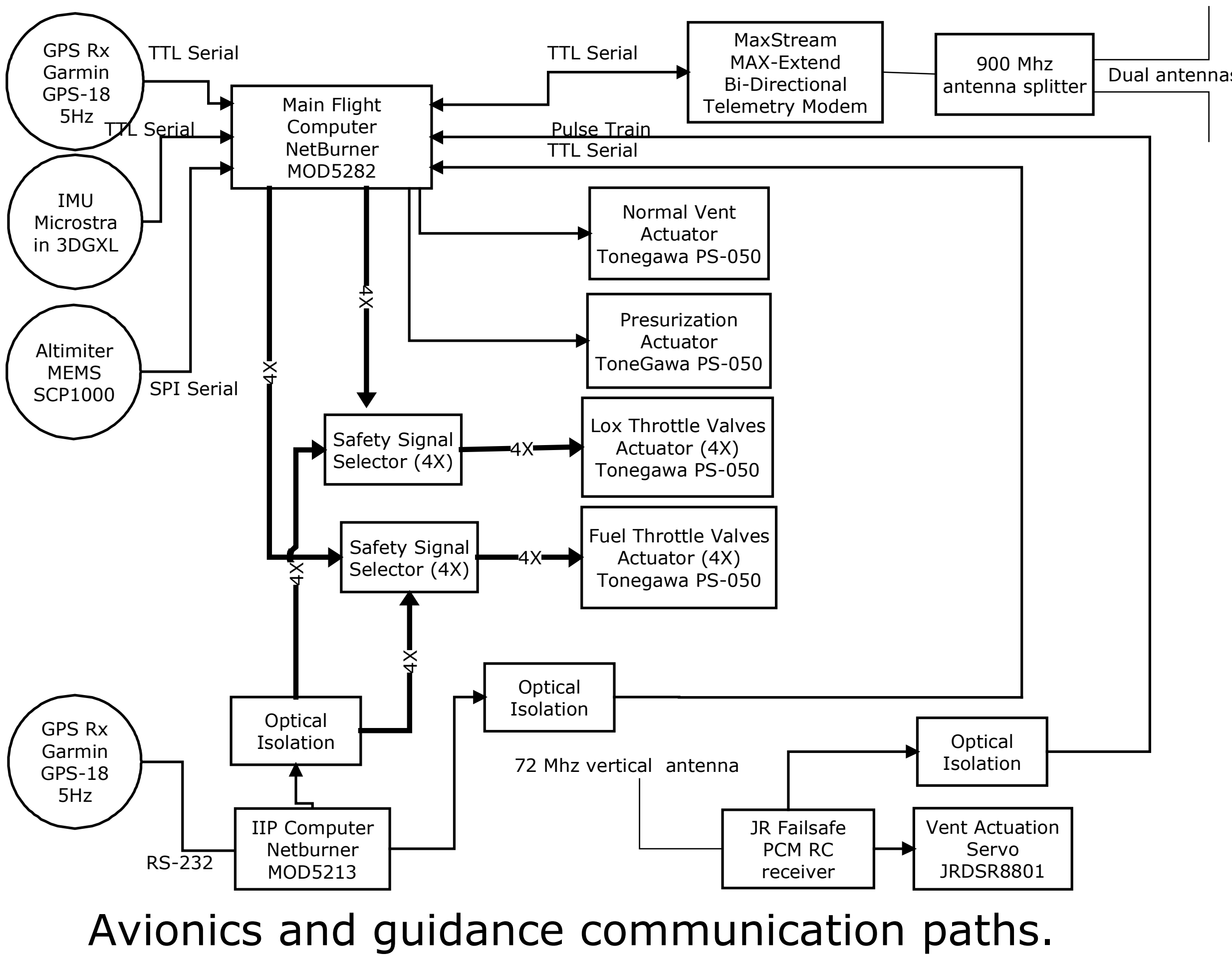
All battery power will be switched with the removal and installation of connectors. During operation the two primary safety systems and the flight computer are all optically isolated. No electrical fault will be able to propagate from one system to another.

During operation all battery voltages will be monitored and reported as part of the telemetry data stream. During daily preflight operations each battery voltage will be measured and tested under load.

1.2.3.8. Environmental Control

N/A The vehicle is unmanned and does not leave the sensible atmosphere. There is no need for environmental control.

1.2.3.9. Avionics and Guidance



Avionics and guidance communication paths.

Figure 9 Avionics components and signal paths.

All interfaces between safety systems and other components are one way and optically isolated. The IIP computer will be subject to the AST formal software qualification requirements. My intent is to not subject the main flight computer to these requirements.

1.2.3.9.1. Command abort receiver system

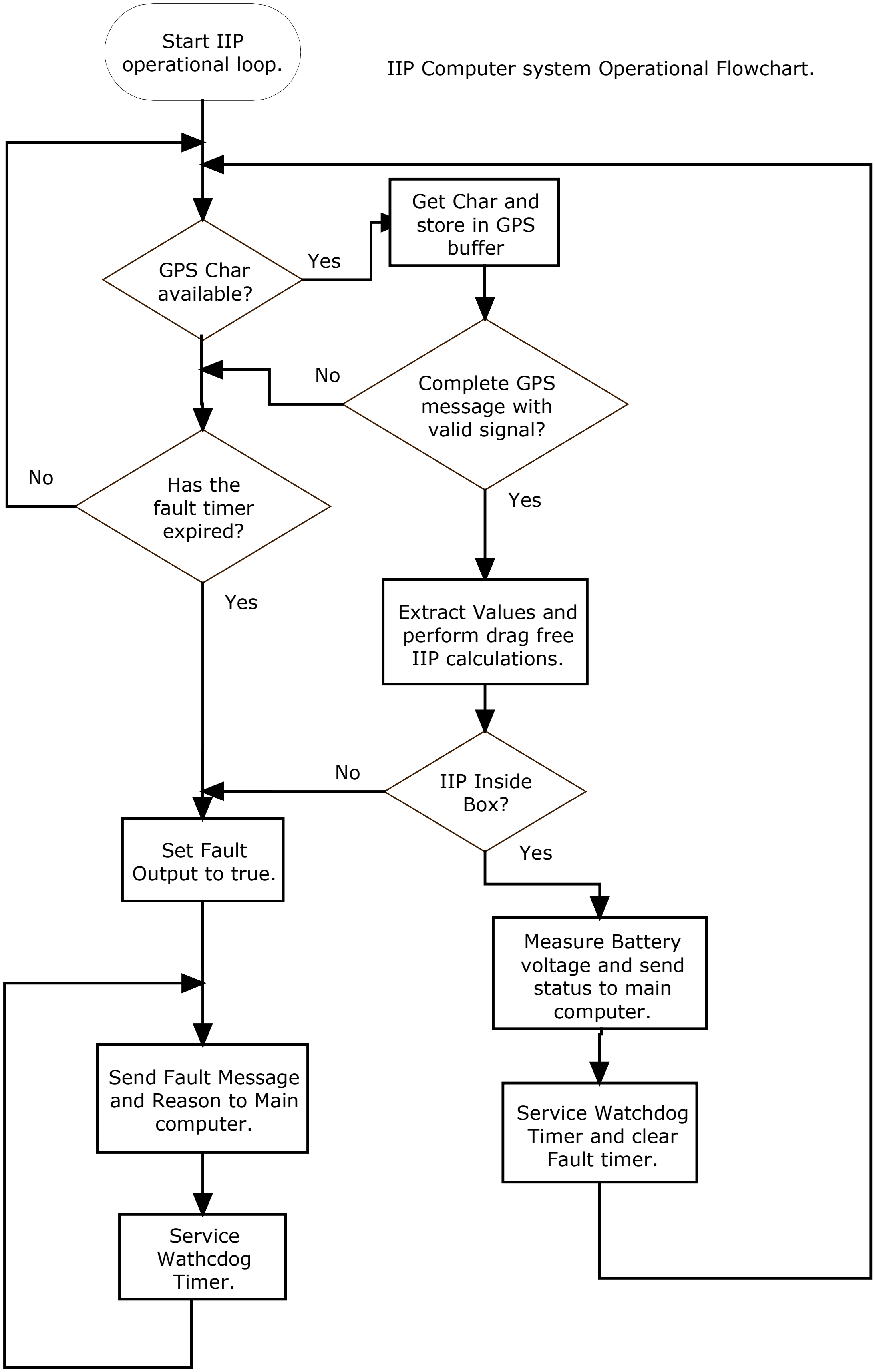
The JR off the shelf PCM RC receiver is identical to the RC equipment required by the Academy of Model Aircraft (AMA) for their model turbo jet waiver requirements. It is commercial, and widely used in a high dynamic, high vibration environment. It is completely unmodified.
If the signal is lost it will revert to outputting its signal lost programmed position in about 1 second. This preprogrammed position will actuate the vent valves terminating the flight. This will be tested in preflight checks by turning off the command transmitter.

1.2.3.9.2. IIP computer calculation system.

The IIP calculation will take the 5Hz GPS signals and calculate an IIP. If the GPS signal is lost for more than 0.5 seconds or if the calculated IIP is outside of its preprogrammed limit area it will command a shutdown to the Safety signal selector. The IIP limit area will also include a 300M maximum altitude.

The IIP computer is a key component of the safety system and will have the following features:

- All components will be industrial temperature grade –40 to +85C.
- No Tantalum or electrolytic capacitors will be used.
- All internal connections will be soldered with no sockets.
- It will have redundant power sources capable of running the unit for 6 hours each.
- It will do system FLASH and ROM checks sums on power up.
- It will have brownout power fault detection.
- It will have a watchdog timer set to one second.
- It will checksum coordinate storage at power up.
- It will report its test status over a serial port to the main flight computer that will report it to the operator.
- If any checksums or power up tests fail it will remain with its output in safe mode.
- It will require a power cycle to reset it after fault.
- It will use connector jumpers to switch power, no power switches.
- It will send its battery status to the main flight computer.
- It will have very simple operating software as shown below:
- It will have its operating area programmed by disconnecting the unit from the vehicle and connecting its serial port to a windows laptop this will then download coordinate files gathered by the location measuring box as described elsewhere in this document.


Start IIP operational loop.
IIP Computer system Operational Flowchart.
GPS Char available?
Yes
Get Char and store in GPS buffer
Complete GPS message with valid signal?
No
Has the fault timer expired?
No
Yes
Yes
Extract Values and perform drag free IIP calculations.
IIP Inside Box?
No
Yes
Set Fault Output to true.
Measure Battery voltage and send status to main computer.
Send Fault Message and Reason to Main computer.
Service Watchdog Timer and clear Fault timer.
Service Wathcdog Timer.

Basic IIP impact point calculations.
The IIP point is calculated given the following 6 values taken directly from the GPS data stream. We will use an inconsistent units of meters rather than feet. This is because the GPS NEMA uses Meters.

- Current Latitude in degrees north (Lat)
- Current Longitude in degrees west (Lon)
- Current Altitude
- Current E/W velocity (Vew)
- Current N/S velocity (Vns)
- Current Vertical Speed (VVs)

And four constants

- Acceleration due to gravity 9.8 meter/sec^2 (g)
- North south meters to degrees. (ns_m_2_d)
- East West meters to degrees. (ew_m_2_d) Not exactly a constant, but we will use it as a constant calculated for 32 degrees north.
- Field elevation.

First we calculate how many seconds from now to impact.
Altitude(t) =0.5*g*t^2 +VVs*t+altitude.

If we solve for the t when Altitude=Field Elevation.

Field Elevation = 0.5*g*t^2 +VVs*t++altitude.

0=0.5*g*t^2 +VVs*t++altitude –Field Elevation.

This can be solved with a simple quadratic equation.

T0=-VVs+/-sqrt(VVs^2-(4*g*-field elevation)/(2*g)

So given the time till impact

We tcalculate the new latitude.

IIPLat=Vns*T0*ns_m_2_d+Lat

IIPLon=Vwe*T0*ew_m_2_d+Lon

Then determine if this IIP_Lat, IIP_Lon is inside or outside of our box.

1.2.3.9.3. Safety signal selection system

The safety Signal selector will be a simple dedicated logic circuit. If it is receiving a signal from the IIP computer it will route the command pulse train from the Main flight computer to the throttle valves. If the IIP signal is lost or turned off then it will route its own pulse generator to the Throttle valves commanding them closed.
It will also optically isolate the command signal providing fault isolation for the actuators.

- All components will be industrial temperature grade –40 to +85C.
- No Tantalum or electrolytic capacitors will be used.
- All internal connections will be soldered with no sockets.

1.2.3.9.4. Ground based Avionics

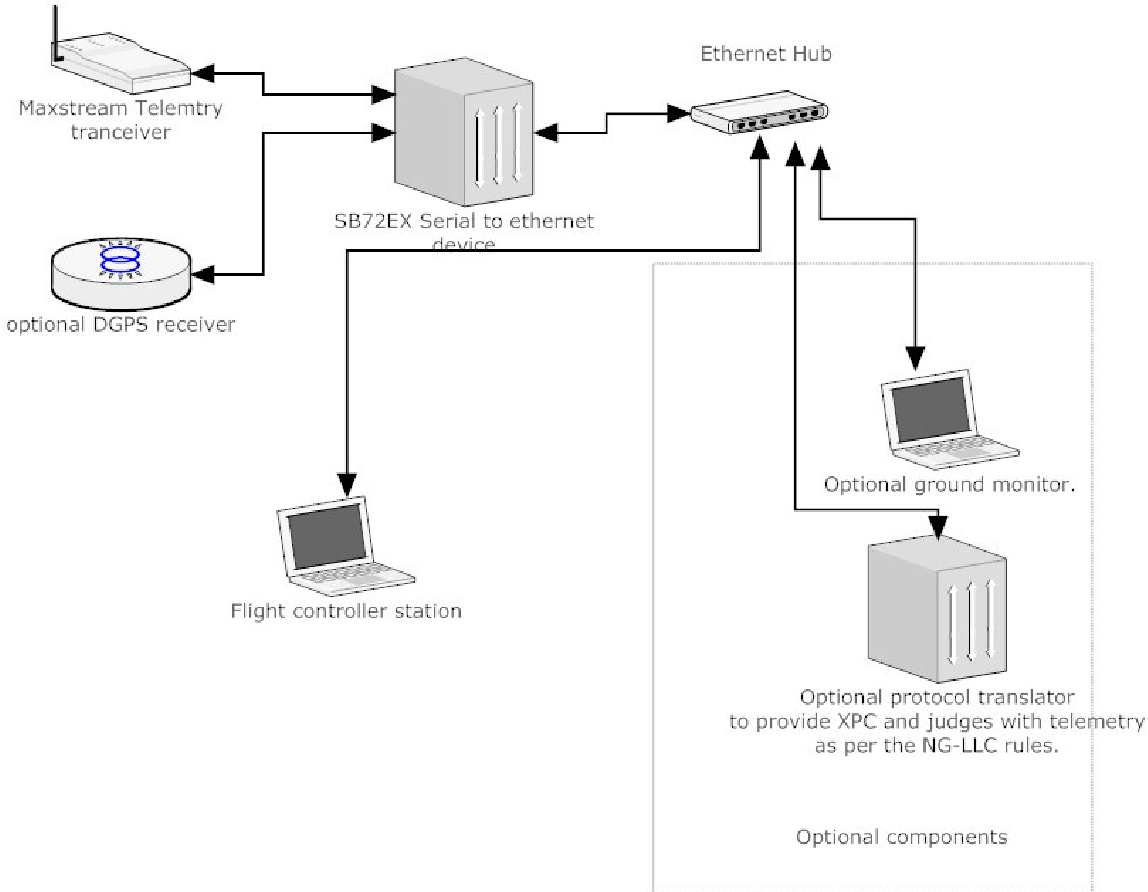


Figure 10 Ground avionics

The vehicle will be operated from the flight control station.

Prior to launch the system will provide a large number of displays.

- All battery voltages.
- IIP computer sign on messages.
- IIP computer status.
- Navigational parameter reports.
- GPS receiver status.
- Position relative to operating area. (the operating area will be extracted from the IIP computer sign on message)
- Location relative to IIP and navigational waypoints.

Prior to flight it will only offer three commands:

- Safe
- Safety Test mode. (sets throttle valves slightly off their closed stops)
- Pressurize
- Initiate Launch

Once launch is initiated the flight control station only has a limited display and a limited number of commands. It will display in real time:

- Position of the vehicle graphically on a map of the allowed operating area.
- Position of the vehicle IIP graphically on a map of the allowed operating area.
- Altitude of the vehicle.
- Remaining flight time.
- Battery voltage levels.
- Possibly fuel remaining if capacitive level sensors are added.

It will offer only two commands…

- Descend begin a 1m per second descent.
- Abort shutdown all engines and depressurize vehicle.

In addition to the ground avionics shown in Figure 10 Flight operations will use a JR XP9303 72 MHz RC transmitter to be operated by the ground safety line observer and used to initiate manual abort.

Prior to flight Unreasonable Rocket will be using a modified IIP computer box to gather position data. This is a GPS receiver, and IIP computer with modified software and an added switch. This will be used to learn/ measure navigation points such as the boundary of the operating area and the point A and B navigational locations. The use of this box is described in the flight operations section.

1.2.3.9.5. EMI EMC considerations.

All computing cores are Netburner core designs and have passed the FCC and /or CE Class A and B EMC tests for both emission and immunity.
The RF systems will be all separated in frequency by at least a factor of 5.

- RF Abort receiver 72 MHz or possible 50Mhz. 750 mW
- RF telemetry transceiver 910 to 932 ISM band 1W spread spectrum.
- RF Video transmitters (part of XPC gold box) 5.6Ghz 1W.

Unreasonable Rocket has significant concerns that XPC will not have an EMC/EMI spectrum management plan in place and this could jeopardize LLC vehicles and or personnel. TV, radio and event personal are not used to an environment where their wireless cameras and wireless microphones could cause physical hazards.

Part of each preflight checklist will include using a hand held spectrum scanner to insure that there is no active RF interference that will cause safety issues.

1.2.4. Payload (Section G-2e)

The only payload to be carried on the vehicle is the Xprize cup required Gold Box. This will be a two or three channel 5.6 GHz video transmitter and cameras as well as inert material necessary to bring the total payload weight up to 25Kg.
If testing determines that parts of the vehicle (such as the landing gear) may require repair between flights spares of these components may be added to the payload.

1.2.5. Foreign Ownership (Section G-2f)

Unreasonable rocket is 100% owned by a U.S. citizen Paul Breed.

2. Flight Test Plan. (Section G-3)

The vast majority of the flight tests will occur under amateur rules or under a license waiver for burn time. at the Friends of amateur rocketry site near Cantil CA. The FAR site is the cleared square visible at Google earth at 35 20' 49.82" N and 117 48' 31.71" W.

If the AST requests it is also possible to do full sequence test flights under a burn time waiver at the NG-LLC trial flights tentatively scheduled for September.

Unreasonable rocket does not expect to do any flights requiring an experimental permit, with this vehicle, other than the NG-LLC flights.

2.1. Flight Test Flights. (Section G-3a)

As this is an experimental flight test program it is hard to be specific about the exact date and number of test flights. The progression of flights will be fixed, but the exact number of each type and the exact dates are still TBD. The following list of flight tests and objectives only covers the complete vehicle tests. The subsystem tests are covered in the verification matrix. Each series will be completed with 100% of the previous objectives satisfied before the next series is started.

2.1.1. Series 1 Full Vehicle static tests.

The vehicle will be mounted on a test stand or bolted to the ground. All four engines will be ignited and run through a throttle sequence. GPS IIP and commanded abort operations will be tested. This will require at least two tests.

2.1.1.1. Objectives:

2.1.1.1.1. Reliably light all four motors.

2.1.1.1.2. Verify Motors shutdown on loss of GPS signal.

2.1.1.1.3. Verify Motors shutdown on abort command.

2.1.1.1.4. Verify shutdown and safing with no fires or hazardous events.

2.1.2. Series 2 Tethered Stable Hover tests.

The vehicle will be suspended from a crane or other structure on a tether. The vehicle will ignite all four motors and the vehicle will rise under rocket power ~ 1 meter to a stable hover and then descend to landing. This will require a minimum of 1 flight. Most likely, it will take 5 or more attempts to satisfy the test objectives.

Objectives:

2.1.2.1.1. Achieve Stable Hover with altitude.4 feet + 4/-0 Feet

2.1.2.1.2. Descend to land or till tether supports vehicle.

2.1.2.1.3. Verify shutdown and safing with no fires or hazardous events.

2.1.3. Series 3 Un-tethered Stable Hover tests.

The vehicle will start resting on a concrete pad. The vehicle will ignite all four motors and the vehicle will rise ~ 2 meters to a stable hover and then descend to landing. This will require a minimum of 1 flight. The engine burn duration will be limited to 15 seconds to stay within the amateur rules.

Objectives:

- 2.1.3.1.1. Achieve Stable Hover with altitude. 8 feet +/-4 feet
- 2.1.3.1.2. Descend to land.
- 2.1.3.1.3. Verify shutdown and safing with no fires or hazardous events.
- 2.1.3.1.4. Verify vehicle is undamaged.

2.1.4. Series 4 Un tethered 50 Meter test

The vehicle will start resting on a concrete pad. The vehicle will ignite all four motors and the vehicle will rise to 50 meters to a stable hover and then descend to landing. This will require a minimum of 1 flight. This flight will require a burn time waiver of at least 45 and preferably 60 seconds.

Objectives:

- 2.1.4.1.1. Stay within the NG-LLC 10 meter (32.8 ft) circle.(32.8ft)
- 2.1.4.1.2. Rise to 50M +5/-0 (165ft)
- 2.1.4.1.3. Verify shutdown and safing with no fires or hazards.
- 2.1.4.1.4. Verify vehicle is undamaged.

2.1.5. Series 5 NG-LLC Simulation test

This series is the key “final exam” event in our operational verification tests.
The vehicle will start resting on a concrete pad. The vehicle will ignite all four motors and will rise to 50 meters (165 feet), achieve a stable hover, translate 100 meters (328 feet), and then descend to landing. This will require a minimum of 5 flights with no incidents.
This series of flights will require a burn time waiver of at least 60 seconds and preferably 200 seconds. Unreasonable Rocket may substitute the following flight profile for this test: Rise to 50 meters translate 50 meters and stop, translate 50 meters back to the origin and land.

Objectives:

- 2.1.5.1.1. Stay within the NG-LLC 10 meter (32.8 ft) (32.8 ft)circle on ascent.
- 2.1.5.1.2. Stay within the NG-LLC 10 meter (32.8 ft) (32.8ft) circle on descent.
- 2.1.5.1.3. Rise to 50M +5/-0 (165 ft)
- 2.1.5.1.4. Verify shutdown and safing with no fires or hazards.
- 2.1.5.1.5. Verify vehicle is undamaged.

2.1.6. Series 6 90/180 Second Hover Duration Test

The vehicle will start resting on a concrete pad. The vehicle will ignite all four motors and the vehicle will rise to 50 meters to a stable hover remain aloft for 68 or 158 seconds before descending for a flight total of 90 or 180 seconds. This test may be combined with one of the Series 5 flights. This will require a burn time waiver of 200 seconds.

Objectives:

2.1.6.1.1. Stay within the NG-LLC 10 meter (32.8 ft) circle on ascent.
2.1.6.1.2. Stay within the NG-LLC 10 meter (32.8 ft) circle on descent.
2.1.6.1.3. Rise to 50M +5/-0 (165 ft)
2.1.6.1.4. Stay Aloft for 90 or 180 seconds.
2.1.6.1.5. Verify shutdown and safing with no fires or hazards.
2.1.6.1.6. Verify vehicle is undamaged.

2.1.7. Series 7 Optional NG-LLC flight at Holloman.

If the XPC makes a testing date available at Holloman Air Force base in September, Unreasonable Rocket would like the option of participating in this test under a burn time waiver. This series of light tests would be an exact duplicate of the permit flights to be flown at the XPC in October.

Objectives:

2.1.7.1.1. Stay within the NG-LLC 10 meter (32.8 ft) circle on ascent.
2.1.7.1.2. Stay within the NG-LLC 10 meter (32.8 ft) circle on descent.
2.1.7.1.3. Rise to 50M +5/-0 (165 ft)
2.1.7.1.4. Stay Aloft for 90 or 180 seconds.
2.1.7.1.5. Verify shutdown and safing with no fires or hazards.
2.1.7.1.6. Verify vehicle is undamaged.
2.1.7.1.7. Verify compliance with all NG-LLC rules.

2.2. Flight test geographic boundaries. (Section G-3b)

All flight tests prior to the flights of 2.1.7 will be done at the Friends of Amateur Rocketry site. This is the cleared square at 35 20’ 49.82” N and 117 48’ 31.71” W, and is visible in Google earth or Google maps. The square is about 200 meters on a side and all flights will be within this square. This information is provided to support the application for a license waiver for burn time. We do not plan to do any permitted flights at FAR.The test flight in series 7 at Holloman will be flown within the confines of the operating area defined for the NG-LLC. (TBD)

3. Operational safety documentation. (Section G-4)

Unreasonable rocket plans to do its testing, prior to flights under its experimental permit under amateur rules and a burn time waiver. The purpose of these flights is both technical development and team operational development. Toward that end we will be using the same operational flight rules for both efforts.
Our team will consist of a minimum of three personal.

- Flight controller.
- Manual safety abort person.
- Pad operations person.

3.1.1. Preflight operations. (Section G-4a)

The Unreasonable Rocket preflight activities are broadly divided into two main areas: Activities necessary to insure that the safety systems are operational, and activities necessary to make the vehicle ready for flight. Some of these activities will be done daily and some of these will be done prior to each lift off. The specified NG-LLC operating process is to take the vehicle from the staging area to the pad make it ready for flight and then fly the NG-LLC profile. Flight Operations (Section G-4a)

3.1.1.1. Per-site one time preflight operations.

Prior to flying at a site the following steps will be necessary to develop a set of operating area restriction coordinates.

- Take the position learning box and turn on or cycle the power.
- Wait until the GPS reports 3 D lock.
- Physically carry the box to each of the IIP abort locations in sequence clockwise around the operating area.
- At each location press the Learn button.
- Attach the learning box to a computer serial port and download the record giving it a unique file name...
- Record the generated MD-5 coordinate checksum in the logbook.
- Verify the reported number of points matches the intended number of points.

Prior to flying at a site the following steps will be necessary to develop a set of operating navigational coordinates.

- Take the position learning box and turn on or cycle the power.
- Wait until the GPS reports 3 D lock.
- Physically carry the box to the center of the LLC “A” Pad.
- Press the Learn button.
- Physically carry the box to the center of the LLC “B” Pad.
- Press the Learn button.
- Attach the learning box to a computer serial port and download the record giving it a unique file name.
- Record the generated MD-5 coordinate checksum in the logbook.
- Verify the reported number of points equals 2.

3.1.1.2. Daily Preflight operations.

Prior to the first flight of the day the following preflight actions will take place.

- The vehicle will be inspected for loose hardware, and physical damage from storage or handling.
- Each valve on the system will be examined for hardware integrity.
- Thrust chambers will be examined for signs of leakage or damage.
- All antennas will be examined for mounting integrity and damage.
- All externally visible cable runs will be inspected.
- All batteries will be tested with an external 150% nominal load and verified as charged.
- The RF environment will be tested with an Icom IC-R3 receiver to see if any conflicting transmitters are present.
- The GPS satellite availability with a mask angle of 15 degrees will be calculated for the day and location.

3.1.1.3. Preflight operations associated with a change in operating area.

The physical configuration of the NG-LLC pads and operating area at HOLLOMAN are still in a state of flux. It may be that the team will be assigned different operating area pads during the contest. The following checklist will be followed once for each operating area and any time the operating area location changes while the vehicle is sitting on the pad in prior to fueling.

- Relocate the vehicle from the staging area to the takeoff pad.
- Pad operations personal will Power up the main flight computer telemetry and then the IIP computer.
- Flight control will verify that the IIP computer self test is complete and that the reported MD-5 cryptographic checksum matches the value in the logbook for this operating area.
- If this is wrong use the IIP loading procedures to load the proper operating area into the unit and restart this checklist.
- Verify that the main flight computer navigational targets match the values in the log book for this flight operation area.
- Verify that the main computer location distance display is within 17 feet of the start navigational target.

3.1.2. Flight operations.

This check list assumes that the flight computer is powered up and telemetry is established between the flight computer and the flight controller.

- Pad operations personal will ask the flight operations for communication verification
- Pad operations personnel will ask the flight operations for IIP valid signal verification.
- Pad operations will visually verify that all throttle valves are closed.
- Pad operations will request that the computer be put into safety test mode.
- Pad operations will visually verify that all throttle valves have moved from their closed position.
- Pad operations will place an aluminum pie plate or other RF opaque device over the IIP GPS receiver.
- Pad operations will visually verify that all throttle valves are closed.
- Pad operations will ask flight operations to verify telemetry is reporting an IIP fault.
- Pad operations will remove the GPS obscuration device.
- Pad operations will disconnect and reconnect the IIP computer forcing a reboot.
- Pad operations will ask the safety abort operator to command an abort.
- Pad Operations will then manually close the safety vent valves and ask the abort operator to command normal operation latching the abort valves.
- Pad Operations will then ask the abort operator to turn of the transmitter.
- Pad Operations will verify abort valves open.
- Pad operations will ask the abort operator to turn the transmitter back on.
- Pad operations will ask the safety abort operator to command an abort.
- Pad Operations will then manually close the safety vent valves and ask the abort operator to command normal operation latching the abort valves.
- Pad operations will ask the safety abort operator to command an abort.
- Pad Operations will verify abort valves open.
- Pad operations will now verify with the flight controller that the IIP system has rebooted and is reporting valid GPS data and position.
- Pad operations will visually verify that all throttle valves have moved from their closed position.
- Pad Operator will request that flight operations command the vehicle to safe.
- Pad operations will visually verify throttle valves closed, pressurize valves closed and vent valves open.
- Pad operations will now fill the vehicle with fuel.
- Pad operations will verify no visible fuel leaks.
- Pad Operations will command that all uninvolved personal get clear of the safety clear area.
- Pad Operations will connect the Lox fill line(s).
- Pad Operations will verify that all uninvolved personal are clear of the safety clear area.

- Pad operations will ask event control for permission to fill LOX.
- Pad operations will fill LOX.
- During Lox fill Pad operations will audibly verify that lox vents are open.
- Pad Operations will connect the Ln2 and He pressurization lines and fill the pressurization bottles.
- Pad Operations will ask flight control to verify the Pressurization bottle fill pressures.
- Pad Operations will disconnect the pressurization lines.
- Pad Operations will then manually close the safety vent valves and ask the abort operator to command normal operation latching the abort valves.
- Pad Operations will seek shelter.
- Flight control will ask event control to verify the safety clear area is clear.
- Flight control will ask event control for permission to pressurize.
- Flight control will verify battery voltages, IIP status and pressurization pressures are nominal.
- Flight control will verify that metrological flight rules are met.
- Flight control will ask event control to verify the flight hazard area is clear.
- Flight control will ask event control for permission to launch.
- Flight control will ask the abort operator if they are in position and ready.
- Flight control will advise all on the operation net that we are cleared to launch.
- Flight control will initiate a count down and command launch.

- Flight control will monitor the vehicle position and status on the flight control display.
- If the vehicle is not following the programmed path the flight controller will command a descent.
- If the vehicle is seen outside the operating limits area the flight controller will command an abort.
- Once the vehicle has landed the flight controller will command the vehicle to safe.
- Flight controller will monitor that the tanks have depressurized.
- Once Tanks have depressurized the flight controller will announce that the vehicle is safe to approach and announce starting post flight checklist.

3.1.2.1. Accelerated fly off flights.

The NG-LLC rules have the potential to break ties by having a fly off where a vehicle is rewarded for flying back and forth between point A and B as many times as possible. Unreasonable Rocket will conduct the very first leg of the fly off as per the normal flight check list. For safety purposes we will treat the flight as if it is continuous until the vehicle needs to be refueled. This could consist of many individual flights back and forth between pads.

Abbreviated fly off checklist:

- Upon landing the flight controller will command the vehicle to pressurize mode.
- Flight control will ask the Judges if they can fly the other way.
- Flight control will verify that the flight computer shows the next destination as the other pad.
- Flight control will verify that metrological flight rules are met.
- Flight control will ask event control to verify the flight hazard area is clear.
- Flight control will ask event control for permission to launch.
- Flight control will ask the abort operator if they are in position and ready.
- Flight control will advise all on the operation net that we are cleared to launch.
- Flight control will initiate a count down and command launch.

- Flight control will monitor the vehicle position and status on the flight control display.
- If the vehicle is not following the programmed path the flight controller will command a descent.
- If the vehicle is seen outside the operating limits area the flight controller will command an abort.
- Repeat this abbreviated check list until the vehicle needs fuel or oxidizer.
- If the vehicle is going to be refueled safe the vehicle and restart the entire flight checklist.

3.1.3. Normal Post flight operations. (Section G-4a)

- Have the abort operator command the safety vent valves open.
- Verify that the safety vents are open.
- Notify event control that the flight hazard area is now unused.
- Approach the vehicle and disconnect the power connections from IIP, abort control and Main flight computer.

- Notify event control that the safety clear area is no longer needed.
- Load the vehicle on the transporter and return to the staging area.

3.2. Hazard analysis. (Section G-4b)

Unreasonable Rocket's hazard analysis process consists of four parts:

1) Identifying and describing the hazards,

2) Determining and assessing the risk for each hazard,

3) Identifying and describing risk elimination and mitigation measures, and

4) Validating and verifying risk elimination and mitigation measures.

Our assessment of the risks is a qualitative process. Risk accounts for both the likelihood of occurrence of a hazard and the severity of that hazard. The levels for the likelihood of occurrence of a hazard, presented in Table 3, and the categories for the severity of a hazard, presented in Table 2, were used in combination with the four-step hazard analysis process to develop our list of hazards. The severity and likelihood are combined and compared to criteria in a risk acceptability matrix, as shown in Table 4. We used the following FAA/AST guidance document to perform its hazard analysis: *AC 437.55-1, Hazard Analysis for the Launch or Reentry of a Reusable Sub orbital Rocket Under an Experimental Permit.*

As our flight test program progresses, there will be anomalies that will be credited to component, subsystem, or system failures or faults; software errors; environmental conditions; human errors; design inadequacies; and/or procedural deficiencies. As these anomalies occur during our program, a risk elimination/mitigation plan will be developed. In addition, we will provide verification evidence (i.e. test data, demonstration data, inspection results, and analyses) in support of our risk elimination/mitigation measures. Our hazard analysis will be continually updated as our test program progresses. See Appendix B for a list of the identified hazards. Appendix D provides a description, of our verification plan.

Table 1 Severity of Hazard

Description	Category	Consequence Definition
Catastrophic	I	Death or serious injury to the public or safety-critical system loss.
Critical	II	Major property damage to the public, major safety-critical system damage or reduced capability, decreased safety margins, or increased workloads.
Marginal	III	Minor injury to the public or minor safety-critical damage.
Negligible	IV	Not serious enough to cause injury to the public or safety-critical system damage.

Table 2 Likelihood of Occurrence of Hazard

Description	Level	Individual Item
Frequent	A	Likely to occur often in the life of an item, with a probability of occurrence greater than 10^{-2} in any one mission.
Probable	B	Will occur several times in the life of an item, with a probability of occurrence less than 10^{-2} but greater than 10^{-3} in any one mission.
Occasional	C	Likely to occur sometime in the life of an item, with a probability of occurrence less than 10^{-3} but greater than 10^{-5} in any one mission.
Remote	D	Unlikely but possible to occur in the life of an item, with a probability of occurrence less than 10^{-5} but greater than 10^{-6} in any one mission.
Extremely Remote	E	So unlikely, it can be assumed occurrence may not be experienced, with a probability of occurrence less than 10^{-6} in any one mission.

Table 3 Risk Acceptability Matrix

Severity / **Likelihood**	Catastrophic I	Critical II	Marginal III	Negligible IV
Frequent (A)	1	3	7	13
Probable (B)	2	5	9	16
Occasional (C)	4	6	11	18
Remote (D)	8	10	14	19
Extremely Remote (E)	12	15	17	20

Category 1 – High (1-6, 8). Elimination or mitigation actions must be taken to reduce the risk.
Category 2 – Low (7, 9-20). Risk is acceptable

3.3. Operating Area Containment. (Section G-4c)

Containing the vehicle in the operating area will depend on the two primary safety systems. The GPS IIP calculation system and the ground observer with command shut off capability. With this in mind we calculated the distances the vehicle could fly given the worst possible behavior and fixed shutdown delays of 1 second for the IIP computer and 3 seconds for the human actuation.

Vehicle blast radius was calculated per DoD 6055.9, using the vehicle propellant weight of 647 lbs. The net explosive weight equivalent was taken as 0.52, rather than 0.2 as recommended in 6055.9, for purposes of accounting for focused blast. This conservative factor was used by FAA/AST and the XPF in the 2007 X PRIZE Cup. Taking a K factor of 40 (also used by XPF), we calculate a blast standoff off radius of 300ft.

As the operating area for the NG-LLC is still a topic of discussion between FAA, XPF and HAFB we will user the following generic operating area in our containment discussions.

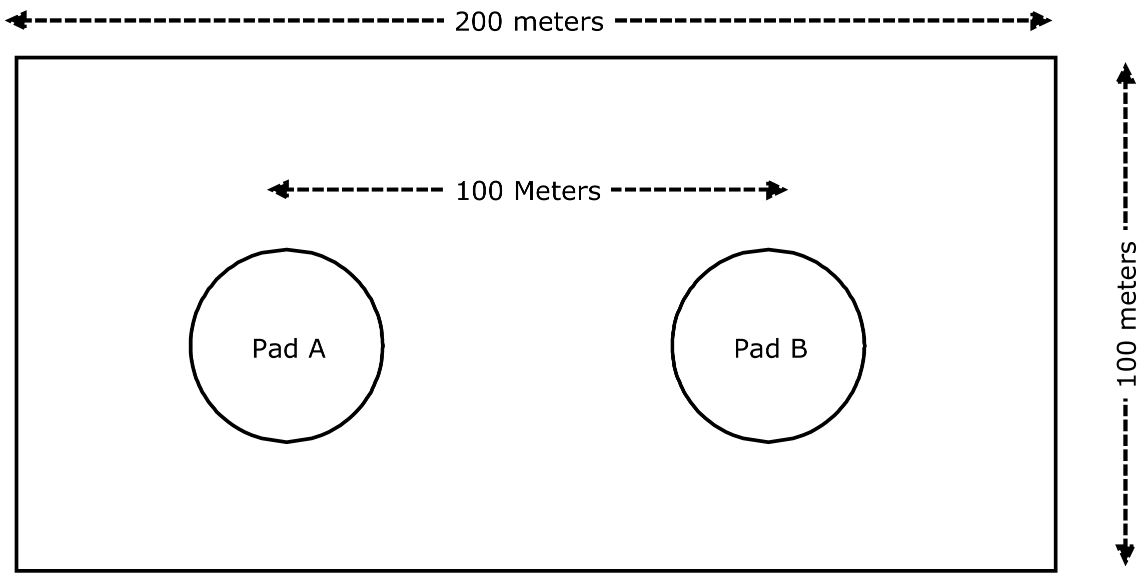


Figure 11 Assumed hard abort limit lines.

In the containment discussions we will be using the following definitions.

"Safety Clear Zone" - circle around a pad that exists while a vehicle is pressurized (defined by quantity distance calculations based on the amount of propellant present).

"Hard Abort Limit Lines" - GPS box that constrains the IIP to the limits of the containment area. If the vehicle leaves this box then both pilot and independent safety systems will execute a hard abort including thrust termination.

“Visual Flight Termination Line” - The visual flight termination line will be a set of poles or stakes in the ground between the vehicle operating area and the most hazardous direction (probably between the operating area and the crowd). The safety abort observer will terminate the flight if the vehicle crosses this line.

"Operating Area" - A three-dimensional region where permitted flights may take place

"Flight Hazard Area" - An area that includes the operating area and room for any explosive effects, with a safety factor "buffer" added on as well. This also defines the minimum distance between the vehicle launch pad and the crowds.

3.3.1. Flight termination calculation methodology

Unreasonable rocket wrote a program that models the flight behavior of the vehicle at selectable intervals for the NG-LLC flight. It does this with simple piece wise integration of the equations of motion. At each calculated interval we determine the vehicle weight and the maximum thrust available given an optimistic ideal gas law c view of the pursuant gas available to pressurize the propellants. Given that we do a 2d simulation of flying the vehicle at angles from purely horizontal to purely vertical in small steps. For each of these trajectories we determine the point in time when either the position or IIP (selectable) crosses the operating area line. At that moment we then calculate all of the trajectories from horizontal to vertical in steps and we remember which of all these trajectories got the farthest. We report this value for the maximum distance. For a 180 second flight calculated in 0.1 second steps with 0.1 degree departure angle steps we actually calculate 81,000 possible trajectories for each time interval of 0.1 seconds for 1.4 billon possible trajectories. We then report the worst case. Below is an example of worst deviant case impact distance from the course centerline for the 180 second flight vs. time into the flight.

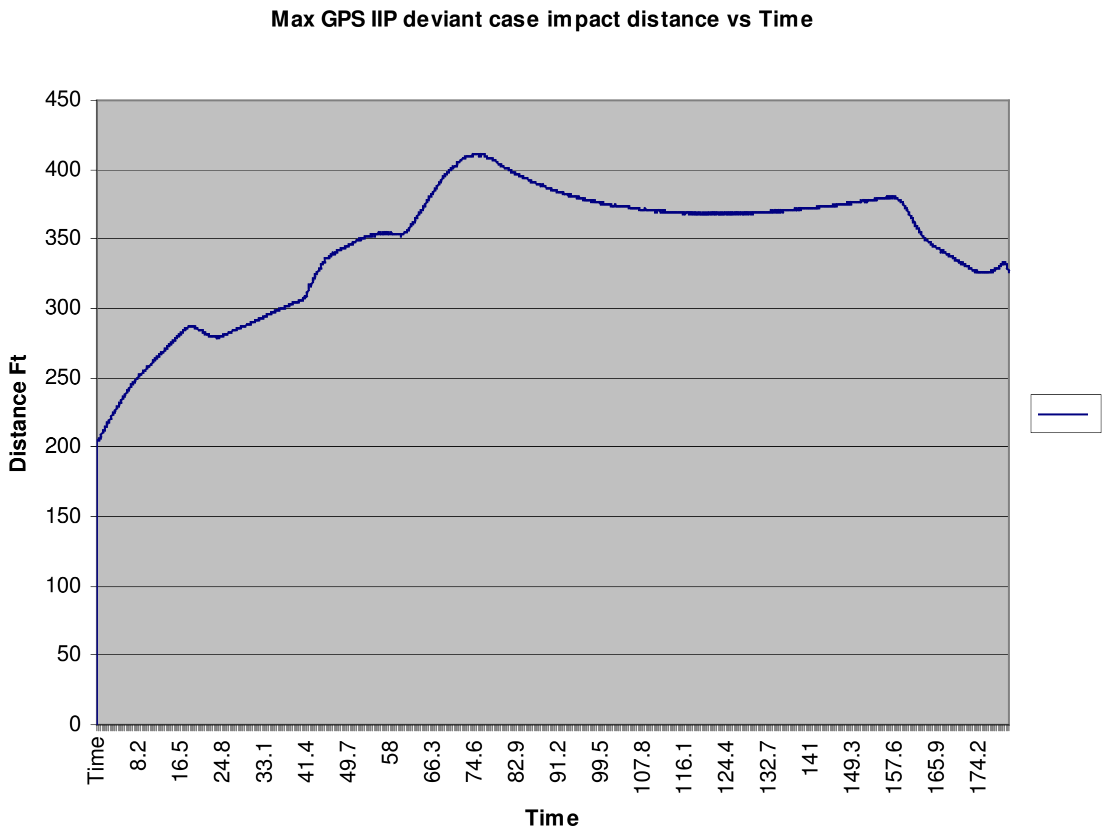


Figure 12 Deviant case maximum distance

3.3.2. GPS IIP system flight termination results

Assuming: Safety Clear Zone and maximum Blast radius. 300 ft.
GPS IIP Hard Abort limit Lines as shown in Figure 11.
GPS IIP delay of 1 second.
Maximum altitude abort of 200M.
And Iteratively using our maximum distance tool We calculate a maximum impact distance from the course center line of 411 ft for the GPS IIP system. Add 300 ft blast radius and our flight hazard zone extends out to 711 feet when the flight is terminated via the GPS IIP system.

3.3.3. Visual command abort system flight termination results.

If we assume the Visual Flight termination Line is the same as the hard abort limits shown in Figure 11 and that the operator takes 3 seconds to activate the abort after the vehicle crosses the abort line we get a distance from the course centerline to the Vehicle aborted impact point of 1812 ft. Adding 300 feet for the blast radius and we get a flight hazard distance of 2112 ft.

3.3.4. Double failure worst case no abort system flight distance results.

Using a very simple single angle departure and running at max thrust continiously until fuel exhaustion we calculate a maximum distance of 34,977 feet or 6.6miles.

3.4. Key flight safety event limitations. (Section G-4d)

All flight events will be with in the box shown in Figure 11.
The vehicle does not stage or change configuration so the primary safety events are as follows:

Event	Uninvolved party clearance	Comments
Transport	None needed vehicle inert.	
Fueling	Safety Clear Zone	
Pressurizing	Safety Clear Zone	All personal clear of vehicle.
Ignition	Flight Hazard Area	
Liftoff	Flight Hazard Area	
Vertical Climb	Flight Hazard Area	
Translation	Flight Hazard Area	
Hover	Flight Hazard Area	
Descent	Flight Hazard Area	
Landing	Flight Hazard Area	
Vehicle Safing	Safety Clear Zone.	Vehicle will depressurize before personnel approach.
Transport	None needed vehicle inert.	

3.5. Landing and impact point locations. (Section G-4e)

During nominal operations all Landing locations will be the two pads shown in Figure 11. During abnormal operations leading to an Abort all impact locations will be within the Flight Hazard area as defined in section3.3.
This is insured by the dual redundant abort systems and the calculations discussed in section 3.3.1 on page 37

3.6. Agreements (Section G-4f)

Unreasonable rocket has executed a master team agreement with the Xprize cup, but has not executed an agreement specifically describing the operations at the selected air force base. Unreasonable rocket will provide this agreement to the AST as soon as it receives a copy from XPC.

3.7. Tracking Section (G-4g)

The Unreasonable rocket LLC vehicle will have a real time report of the
GPS latitude, Longitude and Altitude provided over the telemetry link.
This data will be recorded by the ground station computer or the other hardware on the ground. This data will be archived in compliance with the operating rules of part 437 and made available to the FAA.The vehicle will also be visually tracked by the safety observer.

3.8. Flight Rules Section (G-4h)

Flight will not be initiated if there is lightning in the area.
Flight will not be initiated if the flight visibilities are less than 1 mile.
Flight will not be initiated if the ceiling is less than 1000 ft.
Flight will not be initiated if the winds exceed the limits determined during flight testing TBD.
The flight wind limit will be the maximum wind velocity demonstrated during the flight test series at FAR MTA.

3.9. Collision avoidance Section (H-8)

N/A. A collision avoidance analysis is not required from United States Strategic Command or Federal launch range since our maximum altitude of 100 km is lower than the FAA threshold of 150 km.

3.10. Mishap response requirements (G-4i)

Paul T Breed or alternatively Paul A Breed will be the point-of-contact and alternate for all activities associated with accidents, incidents, or other mishaps related to operations at the 2007 Xprize Cup. He will:

- Represent Unreasonable Rocket as a member of the Emergency Response Team (ERT) and support the Holloman AFB Emergency Response Coordinator (ERC) by participating in the activities of the ERT during accidents, incidents, or mishaps.

- Ensure that the consequences of a mishap are contained and minimized.
- Assure that all data and physical evidence related to any accident, incident, or mishap is impounded to preclude loss of information essential to subsequent investigations.
- Identify and adopt preventive measures for avoiding recurrence of the event.
- Through the Spaceport ERC, report to and cooperate with FAA and National
- Transportation Safety Board (NTSB) investigations and act as the vehicle operator point of- contact for the FAA and NTSB.

The Unreasonable Rocket accident/emergency operational checklist is attached in as part of our operational checklists in Appendix C.

4. Environnemental Impacts. (Section G-1c)

Unreasonable rocket is using only environmentally benign propellants and pressurization agents. We are using

- Liquid Oxygen less than 450 lbs total per flight.
- Ethanol and Water less than 300 lbs total per flight.
- Gaseous Helium less than 1000 liters at STP.
- Gaseous Nitrogen. Less than 1000 liters at STP.

Unreasonable Rocket expects that the rest of the necessary environmental information will be provided by the X-prize cup organization.

Unreasonable rocket is not using any hazardous consumables.

5. Compliance with additional requirements.

5.1. Information required for obtaining a MPL. (Section G1-d)

To be provided by XPC and Holloman personal.

5.2. Identification of Location for Pre-flight and Post-flight operations.

To be provided by XPC and Holloman personal.

5.3. Identification of Facilities Adjacent to the location for Pre-Flight and Post- Flight operations.

To be provided by XPC and Holloman personal.

5.4. Maximum Personal Not involved in the permitted activities.

To be provided by XPC and Holloman personal.

6. Vehicle Inspections (G-1e)

Unreasonable Rocket will make its vehicles and its facilities available for inspection at any time with 24 hours notice.

Appendices

A. Proposed possible changes to the vehicle.

- Substitute composite fuel tanks for the aluminum tanks.
- Add single axis thrust vector controls to the Motors if the throttling does not provide sufficient control authority.
- Replace microstrain IMU with better quality Fiber optic IMU.
- Swap the safety actuation so command actuates safety signal selector and IIP unit activates vent valve.
- Use a COTS vent valve for the 90 second vehicle and a lighter weight Unreasonable Rocket designed safety Vent valve for the 180 second vehicle.
- Substitute 50 MHz PCM RC receiver to 72 MHz RC receiver if the RF environment at the site is cleaner for the 50 MHz unit.
- Substitute a 2.4GHz maxstream radio for 910 MHz Radio if the RF environment at the site is cleaner for 2.4 GHz unit.
- Add a positional feedback path to the throttle actuators if the dead band/ hysteresis is too big for control.
- Add capacitive or other tank level sensors so the flight computer can achieve mixture control for the 180 second burn to minimize unused propellant.
- Add 1% or less of ethyl silicate to the fuel. The book ignition claims that the addition of silicate compounds to fuel can reduce the heat transfer in regen cooled motors by as much as 50%. The silicon deposits on the hot portions of the cooling jacket adding a thermal barrier. Unreasonable Rocket will not use this compound unless we have severe cooling problems. Tests to date indicate that this will not be necessary.
- Change the flight trajectory to reflect possible rules changes in the NG-LLC rules.
- Calculate a more detailed Flight hazard area to take credit for reduced blast radius given reduced propellant payload on maximum impact range. This would be done to try and reduce MPL.
- Change the design of the landing gear from springs to crushable blocks or some other scheme not effecting the primary safety or structural systems..
- Reprogram the main flight computer as it is not a safety critical system.
- Increase the take off weight and thrust from the nominal values stated in this document to the maximum values as stated in section 1.2.2. (~23% increase)

B. Unreasonable Rocket Hazard analysis

**** S – Severity, L – Likelihood, R – Risk**

No.	System	Hazard Description	Results	****Risk Before Mitigation Measures**			Risk Elimination or Mitigation Measures	****Risk After Mitigation Measures**			Verification Evidence
				S	**L**	**R**		**S**	**L**	**R**	
1,2, 3A	Avionics Guidance, sensors, valves, tanks and thrust chambers, and plumbing.	Loss or errors for any of the systems described can cause the thrust from one or more thrust chambers to be wrong.	The vehicle could leave its operating area and cause possible death or serious injury to the public outside the operating area.	I	C	4	– Add a separate redundant IIP calculation system that can abort the flight. – Establish a visually monitored do not cross line with a separate redundant remote abort command capability. – Before every flight the flight director will visually verify the abort line markers are in place and brief the abort safety personal on the use of the abort system. – Abort safety personnel will be trained and practice abort procedures.	I	E	12	– Abort system commanded range verification. – Daily preflight abort valve operational test. – Daily preflight abort valve loss of signal operational test. – Training records for abort personal. – Daily preflight test of IIP abort system. – Daily verification of all system battery levels. – System will fly the mission profile, under amateur burn time waiver and minimum of 5 times without failure before flying under permit. At lease the last 3 flights must be consecutive. – Commanded vent to no thrust time will be measured and used to calculate the size of the operating area. – See Appendix D for a description of our verification schedule

No.	System	Hazard Description	Results	**Risk Before Mitigation Measures			Risk Elimination or Mitigation Measures	**Risk After Mitigation Measures			Verification Evidence
				S	L	R		S	L	R	
1B	Avionics & Guidance	Loss of GPS signal due to hardware failure or excessive environmental conditions, resulting in erroneous data being uploaded to the vehicle's navigation system.	The consequence is a reduction in the capability of this major safety-critical system to function properly.	II	B	5	– Calculate minimum acceptable GPS constellation availability, do not fly with less than 5 GPS sats above 15degrees. – Before each launch verify the PDOP and GPS signal strengths are above required levels.	II	E	15	– GPS and associated hardware will be flight tested during our initial flight test program (prior to permitted tests) – Daily GPS constellation availability predictions will be printed and verified prior to each flight.

1D	IIP calculation abort system	Failure of the IIP abort system to properly calculate and abort and terminate the flight. This can be the result of software, hardware or mis-entry of abort limits.	The consequence is an inability to terminate an errant flight	I	D	8	– Qualify abort software with the software test plan in accordance with the appendix E. – Qualify the IIP abort system hardware with the environmental tests in appendix E. – Test the abort system operation in flight while mounted to an RC plane or Helicopter. – Enter the abort system limits by physically carrying the abort system to the abort limit points.	I	E	15	-Daily preflight procedures check the battery condition of the GPS IIP system. – Daily preflight checks cover the GPS antenna with an RF opaque shield and verify the abort valves are operated. – Before each flight the GPS IIP system reports GPD DOP and battery condition through telemetry as a check just prior to flight. – Production flight test of IIP system on RC plane or Helicopter shall verify proper operation. – IIP system shall be tested with the GPS simulator as described in the IIP software qualification tests described in appendix E, after coordinate entry m program changes or hardware replacement.

1F	Avionics & Guidance	Failure of telemetry system due to antenna or other hardware fault	The system will continue without GPS corrections and operate a reduced accuracy, but not in a hazardous way	III	C	11	The vehicle flies a preprogrammed path and does not require telemetry for hazard free flight.	III	C	11	-Mitigation not needed.
1G	Avionics and guidance.	Failure of the Command system telemetry causing inadvertent flight.	The consequence is the possible death or serious injury to the public.	I	D	8	– Provide a system safe vent. Will prevent propellant pressurization.	I	E	12	– The system safe vent plug(s) will be the last item(s) adjusted by pad personnel after airspace is cleared and telemetry correctness is verified by the control operator. – The correct implementation of this procedure will be part of the training program.
1H	Command abort operator.	The command abort operator is distracted and fails to immediately notice flight deviation.	The consequence is the possible death or serious injury to the public.	2	B	5	Calculate Command abort distance to include a 3 second delay, 3 times the delay typically measured by an attentive operator.	2	E	15	– Command abort distance for the flight hazard zone are increased.
2A	Flight Control Systems	See item 1A		I	C	4	See Item 1A	I	E	12	See Item 1A
2B	IIP Flight control shutdown.	Wiring fault in IIP system.	The consequence is an inability to terminate an errant flight	I	D	8	– Design system so that no single broken or shorted wire will fail to shutdown all engines. – Specific LOX and Fuel valve actuators	I	E	12	– Inspection verification that the vehicle matches the schematic design documents. – Production test individually verifying that system can shutdown each engine with all

							for each engine are optically isolated from the system and powered via an independent power source.				IIP system connectors disconnected one by one.
3A	Electrical System	Failure of primary power source (i.e. battery) due to design inadequacies or excessive environments leading to safety-critical system loss and crash of the vehicle.	The consequence is the possible death or serious injury to the public.	I	C	4	– Dual lithium-ion batteries will power both the command abort and GPS IIP system controllers. – Separate battery systems will power the actuators for each of the LOX and fuel valves for each engine. –Safety batteries will be sized to operate the system for 12 hours. – All batteries will be preflight tested by personnel. – All batteries will have continuous monitoring by the telemetry system,	I	E	12	– Daily preflight will manually measure each vehicle battery under load and verify its operation. – All batteries will have real time telemetry reporting and no flight will be initiated with any battery out of tolerance. – A copy of our training program has been included with this application (Appendix C).
3B	Electrical System	Electrical system short circuit resulting in loss of vehicle safety-critical systems and crash of the vehicle.	The consequence is the possible death or serious injury to the public.	I	C	4	– The redundant safety systems share no hard connections or power sources. All Safety systems will report status to the telemetry system via optically	I	E	12	– Verify galvanic isolation between all safety systems with an ohm meter after and electrical modifications or maintenance.

							isolated connections.				
3D	Electrical System	Electromagnetic interference (EMI) causes failure of systems to operate in flight and crash of the vehicle.	The consequence is the possible death or serious injury to the public.	I	E	12	N/A → → → Risk is acceptable				
4A	Software and Computing Systems	Improper GPS coordinates entered for operating limits	The consequence is the possible death or serious injury to the public.	I	C	4	– Enter the abort limits data by physically carrying the GPS IIP box to the abort limits on the ground. – Each set of programmed limits will generate a cryptographically unique MD5 sum. – Additional non-GPS based abort provided by the command abort system.	II	E	15	-Daily preflight will require verifying the MD5 coordinate sum for the GPS IIP system is equal to the value recorded in the log book for that location.
4B	Software and Computing Systems	Improper GPS coordinates are entered for flight navigation.	The consequence is the possible death or serious injury to the public.	I	C	4	– The command abort and GPS IIP system will provide redundant flight abort. – Navigation points will be entered by physically caring the vehicle to the pad locations.	I	E	12	
5A	Structures	Structural Tank failures	The consequence is the possible death or serious	I	D	8	– Tanks designed to a safety factor of more than 1.5 (Design Factor 1.5).	I	E	12	– The tanks will be hydrostatically tested to 1.5 MOP during production. – The following FAA/AST

			injury to the public.								guidance document has been used to determine the appropriate verification safety factors for all structures: *FAA/AST Guide to Verifying Safety-Critical Structures for Reusable Launch and Reentry Vehicles* – See Appendix D for a description of our verification schedule
5B	Structures	Structural failure of the tank retention system	The consequence is the possible death or serious injury to the public.	I	D	8	The system is designed with large common vents for all tanks. If any one set of tanks/engine leave the vehicle this will require the disconnection of the large vent line venting all tanks and causing shutdown of all engines.	I	E	12	–Vent to engine shutdown time is one of the verification tests. – See Appendix D for a description of our verification schedule
7A	Propulsion System	Thrust chamber burn through due to design inadequacies resulting in a vehicle explosion. The consequence is the possible death or serious injury to the public.	The consequence is the possible death or serious injury to the public.	I	D	8	See Item 1A	I	E	12	See item 1A
7B	Propulsion System	Inability to shutdown propulsion system due to failure of leading to loss of control of the vehicle, and the vehicle leaving the	The consequence is the possible death or serious injury to the public.	I	C	4	– Redundant safety systems. See Item 1A	I	E	12	– See Appendix D for a description of our verification schedule

		operating area.									

7C	Propulsion System	Lox or Fuel leak from line rupture or fitting failure leading to possible fire or explosion of the vehicle.	The consequence is the possible death or serious injury to the public.	I	D	8	–The GPS IIP and command abort systems are on opposite ends of the vehicle. They are unlikely to both be involved in a fire. – The command abort operator is instructed to abort the flight if visible fire has progressed beyond the engine area.	I	E	12	– Production inspection verifies that the command abort and GPS IIP systems are on opposite ends of the vehicle. – See Appendix D for a description of our verification schedule .
7E	Propulsion System	Over pressurization of Lox or fuel tank due to improper pressurization (design inadequacies, pressurization system failure) leading to tank bursting and loss of vehicle.	The consequence is the possible death or serious injury to the public.	I	D	8	– The tank has been designed to a safety factor (burst) of 1.5. – Tank will incorporate a pressure relief valve set to 1.3 times maximum operating pressure.	I	E	12	– The tank has been proof tested to a safety factor of 1.5. The following FAA/AST guidance document has been used to determine the appropriate verification safety factors for all structures: *FAA/AST Guide to Verifying Safety-Critical Structures for Reusable Launch and Reentry Vehicles* – See Appendix D for a description of our verification schedule
7J	Propulsion System	Propellant dump valve fails to open leading to possible fire and explosion if hard landing and fuel on board.	The consequence is not serious enough to cause injury to the public.	IV	D	19	N/A → → → Risk is acceptable				

10A	Natural Environments	The vehicle experiences wind gusts exceeding its control capability. This results in the flight control system inability to control the vehicle. Probable crash of the vehicle inside or outside the operating area.	The consequence is the possible death or serious injury to the public.	I	C	4	– Wind limits on launch commit criteria	I	E	12	– We will not launch if winds are above the demonstrated operating velocity.
10B	Natural Environments	Natural or triggered lightning strikes the vehicle in flight leading to flight - safety system malfunction.	The consequence is the possible crash of the vehicle outside operating area.	II	C	6	– Monitor and report meteorological conditions to the mission conductor prior to launch – Vehicle will not launch if lightning producing meteorological conditions exist	II	E	15	– Description of abort rules are included in the Unreasonable rocket checklist.

C. Unreasonable Rocket operational Checklists

TBD this will be a translation of the steps and bullet points from the operational safety documentation into numbered checklist suitable for use on a clipboard.

D. Unreasonable Rocket Verification Schedule.

Test number	Test Reason	Test description	Acceptable results	Record format
T1	Tank Structure	Hydrostatically test tanks to 500 PSI	Tank does not fail at 500 PSI	Logbook or Tank frame stamp.
T2	Lacing Structure	Test simulated lashings to 800 lbs more than 4x maximum load.	Lashing does not fail	Logbook and or Video.
T3	Landing Gear	Vehicle will be dropped from a height to simulate 1m/sec impact.	Vehicle structure does not fail	Logbook and or Video
T4	Command Abort Delay	Attach command abort valve to static test stand, activate vent while motor is running measure the vent to chamber thrust decay interval.	Adjust abort limits to match delay.	Logbook and computer data.
T5	Command Abort Range test	The command abort range will be tested as per the JR9303 RC transmitter operator manual instructions.	Minimum ½ mile range with antenna extended.	Logbook
T6	IIP system final acceptance test.	TBD	TBD	Logbook.
T6	IIP connector test	Set up IIP computer with throttle valves commanded open. Obscure GPS signal and verify that all throttle valves close. Disconnect each plug in the IIP system wiring and repeat the test verifying that at least one valve on each engine closes.	IIP can shutdown all 4 engines with any signal wiring connector disconnected	Logbook.
T7	Visual inspection of abort wiring	Visually verify that the vehicle wiring for the abort systems is on separate ends of the vehicle to minimize fire damage	IIP systems are separate	Logbook and or pictures.

T8	Galvanic isolation	Use an ohm meter to insure that the galvanic isolation barriers shown in the design details of this document exist	Systems are isolated	Logbook.
F1..FN	Flight tests	Flight tests as described in the flight test area.	See flight test descriptions	Computer Data, Video and Logbook.

E. Unreasonable Rocket IIP computer design details.

TBD this section will include:
Schematic
PCB layout
Component Data sheets
Software design details
Software Code
Software verification test plan.
Final acceptance test plan.
We anticipate that this data will be available in Early July 2007.

F. Unreasonable Rocket Safety Switch design details.

TBD this section will include:
Schematic
PCB layout
Component Data sheets
Final acceptance test plan.
We anticipate that this data will be available by mid June 2007.