



NG-LLC 2008 90 Second Vehicle
Experimental Permit
Application.

Revision: 1.02

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1. Program Description (Section G-2)

Unreasonable Rocket is developing two vehicles to compete at the Xprize Cup Northrop Grumman Lunar Lander Challenge in 2008. Unreasonable Rocket is a very small father and son team located in Solana Beach California. The vehicles will be tested under amateur rules off the Cohen dry lake bed or the FAR rocket test facilities near Cantil CA. This application covers the 90 second vehicle.

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 teams. Toward that end Unreasonable Rocket is developing a vehicles to compete in the Northrop Grumman Lunar Lander Challenge. Unreasonable Rocket will be building two very similar vehicles, one to compete in the 90 second challenge and one to compete in the 180 second challenge. The operations, and safety systems for the two vehicles will be almost identical. The vehicles will use identical safety systems to manage operating area containment. They will differ in some structural, and propulsion details. This document covers the 90 second vehicle.

1.2. Vehicle Description

1.2.1. 90 Second Vehicle 3 view Photograph (Section G-2b)

For size reference the Sphere is ~30 inches OD.



Figure 1 90 Second vehicle Photograph view



Figure 2 Other Side vehicle photograph

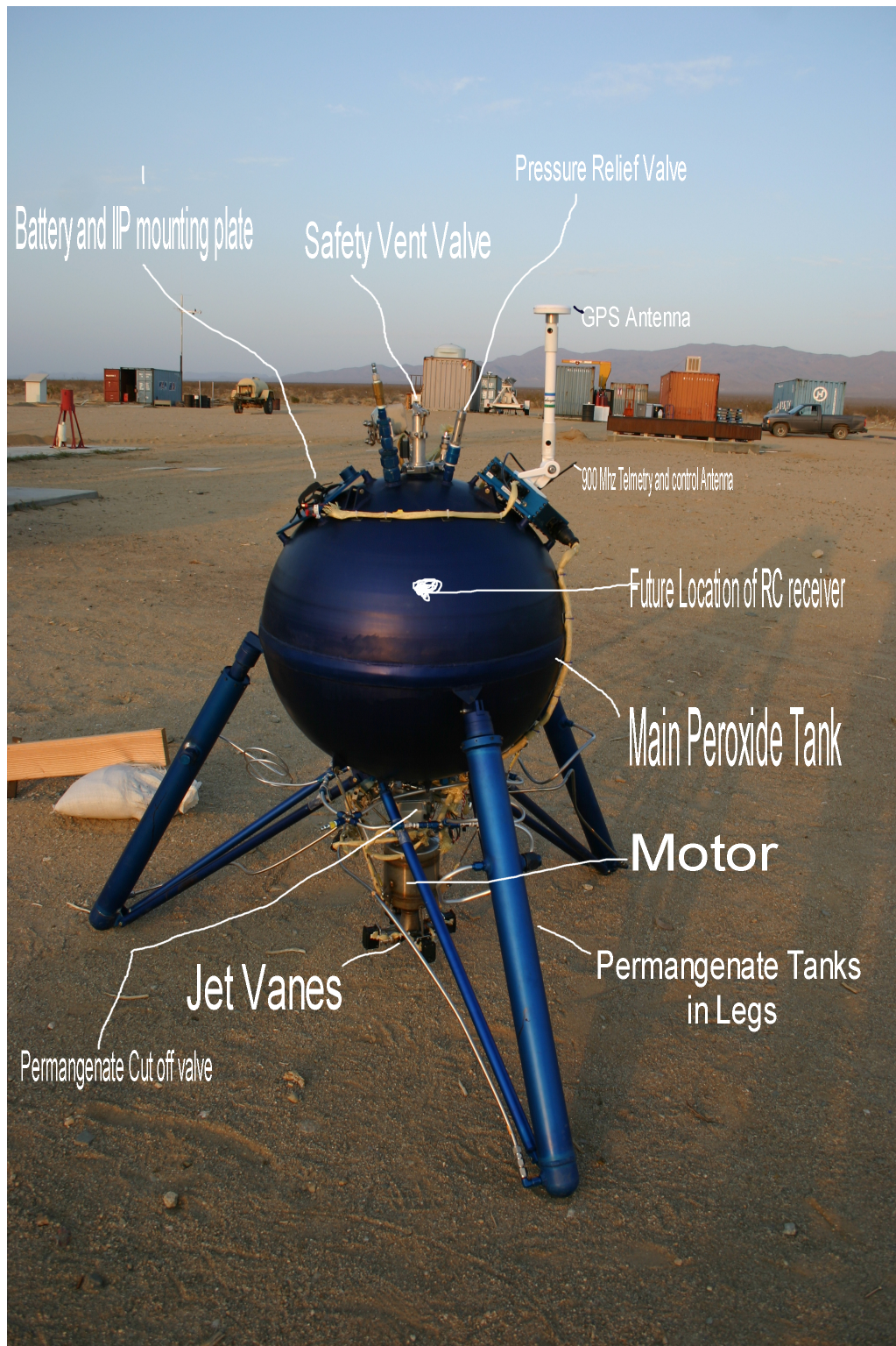


Figure 3 Vehicle Components.

1.2.2. 90 second Vehicle Mass properties and thrust profile. (Section G2-c)

Empty weight ~ 104 Lbs (estimated)

GLOW ~550lb for 90 second flight.

Propellants:

- 85% or 90% Hydrogen peroxide.

- The vehicle will nominally carry less than 350lbs of peroxide.

- 40% Saturated solution of sodium permanganate used as a liquid catalyst.

- The vehicle will nominally carry less than 18 lbs of sodium permanganate.

Pressurization:

The vehicle will use blow down pressurization utilizing approximately 50% of the tank capacity for gas storage. This 50% will be pressurized remotely from external high pressure DOT gas cylinders that are part of the ground operations equipment.

Thrust 1X 650 lb radiation cooled stainless steel mono-propellant peroxide motor.

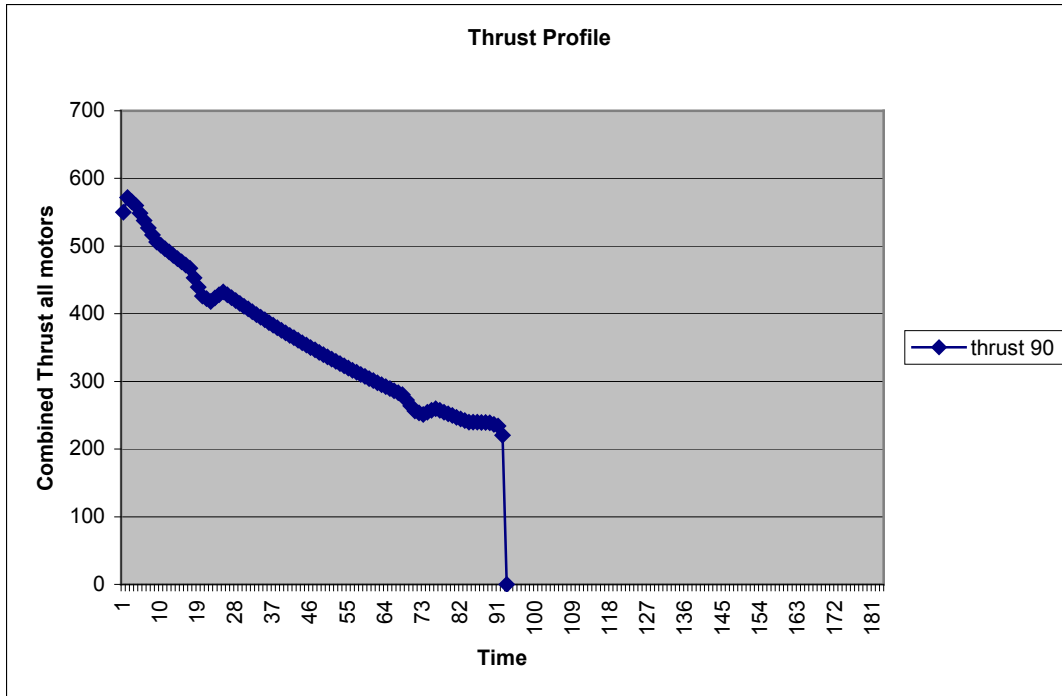
Estimated ISP 100 to 110

Tanks

- 30" diameter 5086 0.160 thick Aluminum sphere peroxide tank.

- 3x 3" diameter x 36" long catalyst tank contained in the landing gear.

Payload 25Kg XPC payload.



The total impulse is 33160 lb sec +/- 10% for the 90 second flight.

1.2.3. Vehicle Systems (Section G2-d)

1.2.3.1. Structural

Please refer to Figure 3 Vehicle Components. When reading this section.

The primary vehicle structural element is the aluminum peroxide tank.

This pressurized tank is hydrostatically tested to 1.25 its maximum operating pressure.

It is designed to burst at 2x its maximum operating pressure. The primary propellant tank is welded 5086 aluminum fabricated from spun hemispheres. The motor and landing gear loads are transferred directly to the tank via welded brackets.

The landing gear consists of hollow aluminum tubes with o-ring sealed sliding sections at the top. The sliding landing gear both provides shock absorption and storage for the sodium permanganate.

Both the primary tank and the landing gear are anodized to reduce the corrosion.

The 55lb payload is not shown in any of the figures. The payload will be attached to the sides of the vehicle in soft fabric saddle bags strung between the landing gear attachments and the fitting weldments at the top of the vehicle. Parts of the payload may also be mounted on the landing gear to reduce the sprung weight.

1.2.3.2. Flight control

The vehicle flight control will be accomplished with a throttled main valve for altitude control and four stainless steel actuated jet vanes.

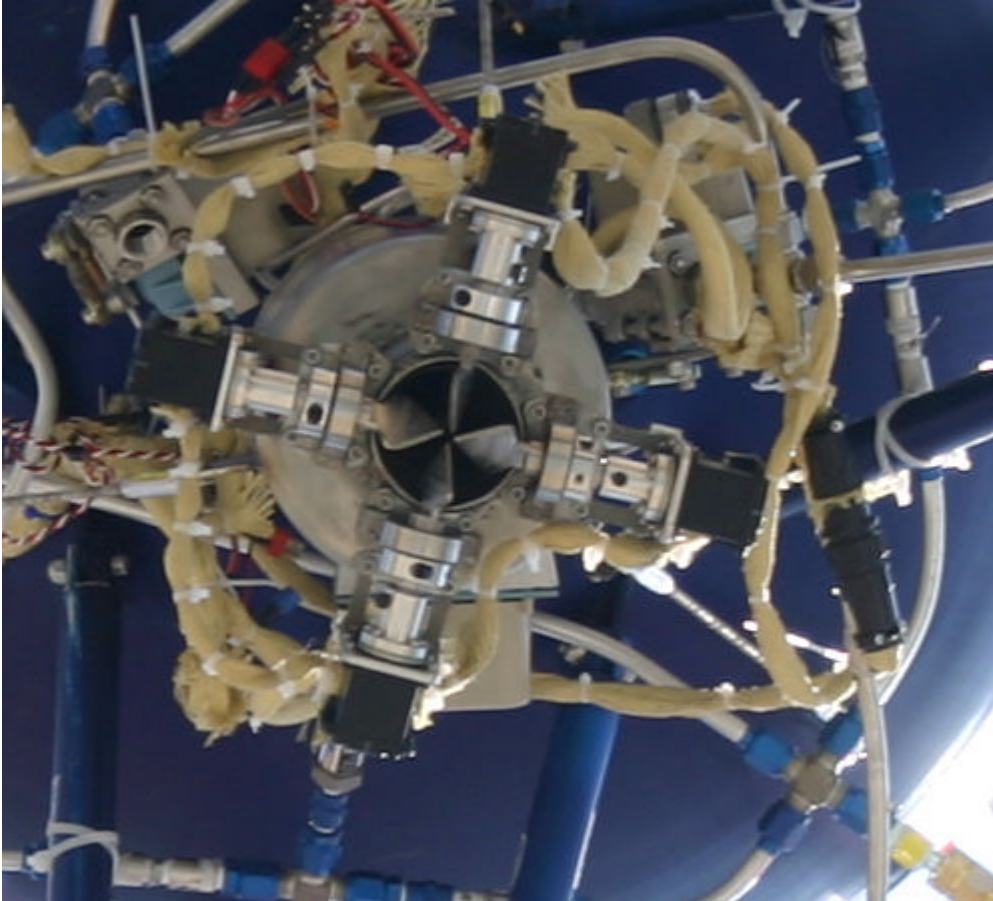


Figure 4 Jet Vanes

Each of the four jet vanes will be independently or collectively actuated for control of pitch, roll and yaw. These actuation commands will be generated by the primary flight control computer.

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 No pneumatic systems are found 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. 90 Second Propulsion(revised)

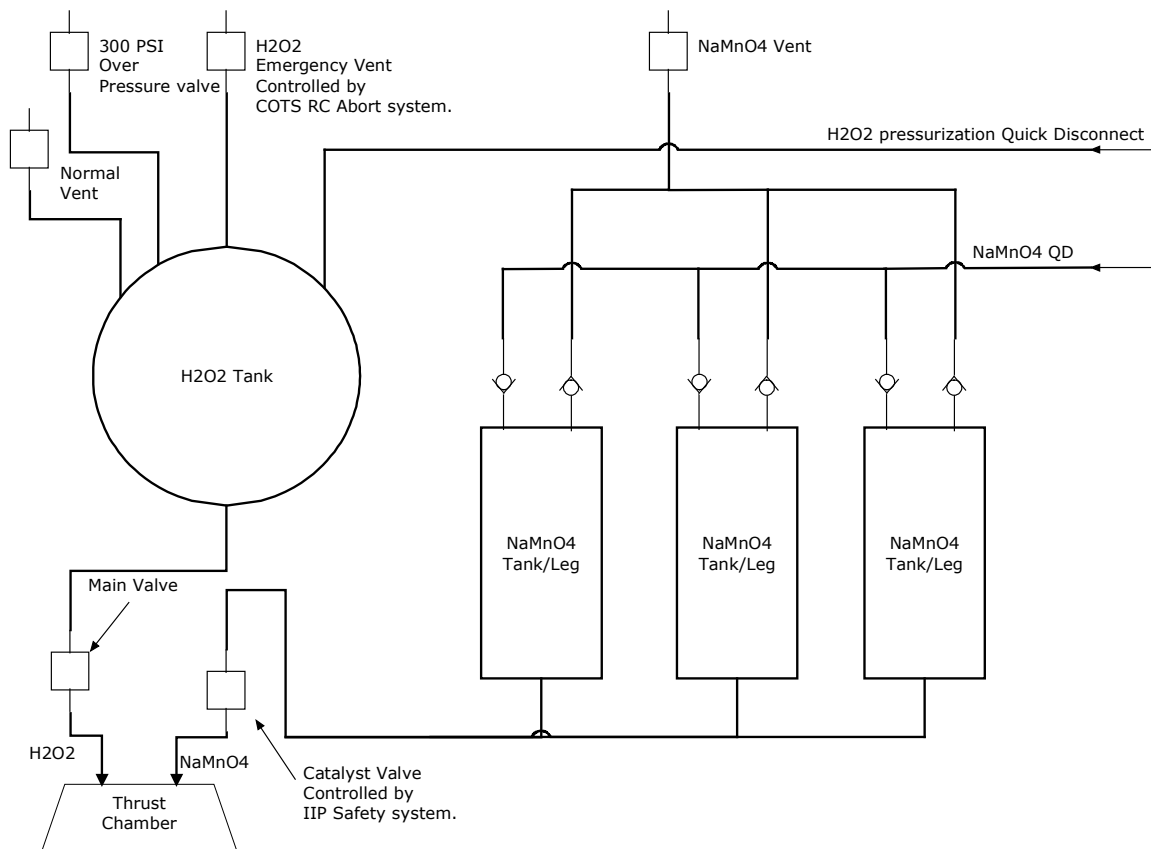


Figure 5 Basic 90 second Plumbing and Propulsion

Propulsion will be provided by a single 650 lb thrust mono-propellant hydrogen peroxide motor. Propellant will be pressure fed from the main tank. The peroxide decomposition will be accomplished with addition of 2% to 4% saturated sodium permanganate.

Maximum thrust will be roughly proportional to feed pressure. The maximum design thrust is 650 lbf at 300 PSI feed pressure. This pressure may change slightly as testing continues. At this time this motor design has been fired three times. Thrust can be terminated by opening the primary vent valve or closing the low flow catalyst valve. If the catalyst is removed from the reaction the motor instantly (200msec or so) stops producing significant thrust. A proof thrust termination test was performed on 3/16/08 shown in Figure 6 Decomposition Test. The test clearly demonstrates that when the catalyst removed from the reaction at point ~2719 on the graph, the chamber pressure and thrust drop to almost zero. This reduction happens even though the peroxide flow greatly increases due to the lack of chamber pressure

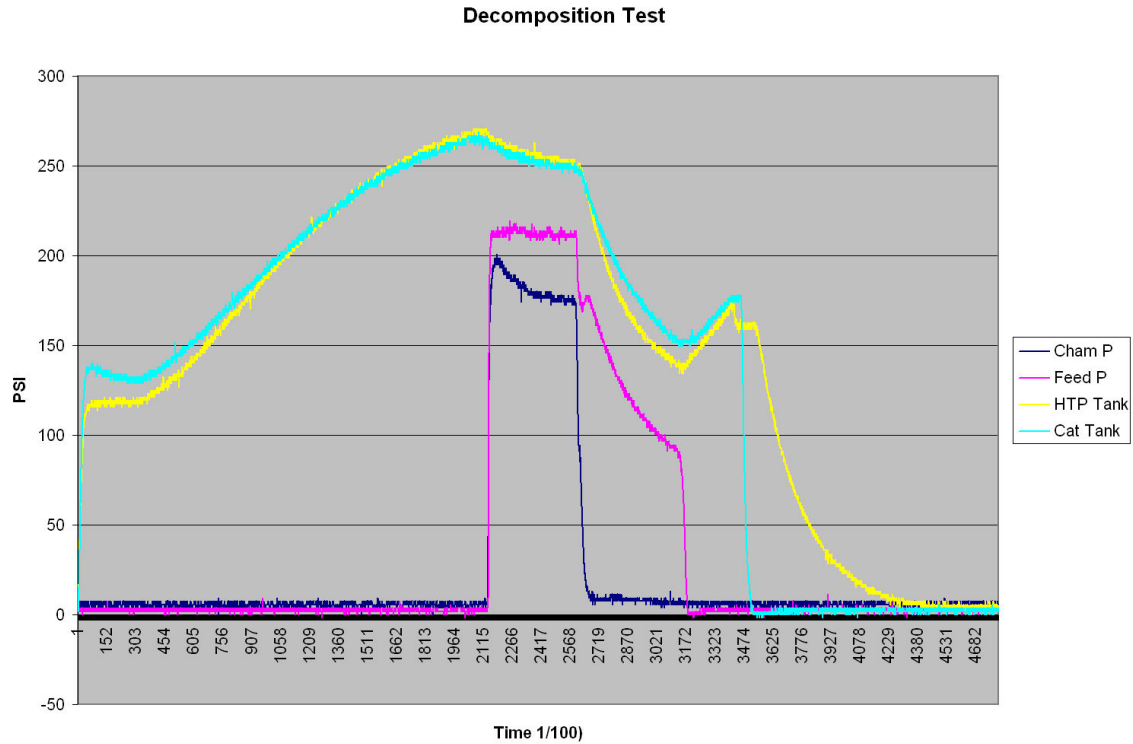


Figure 6 Decomposition Test

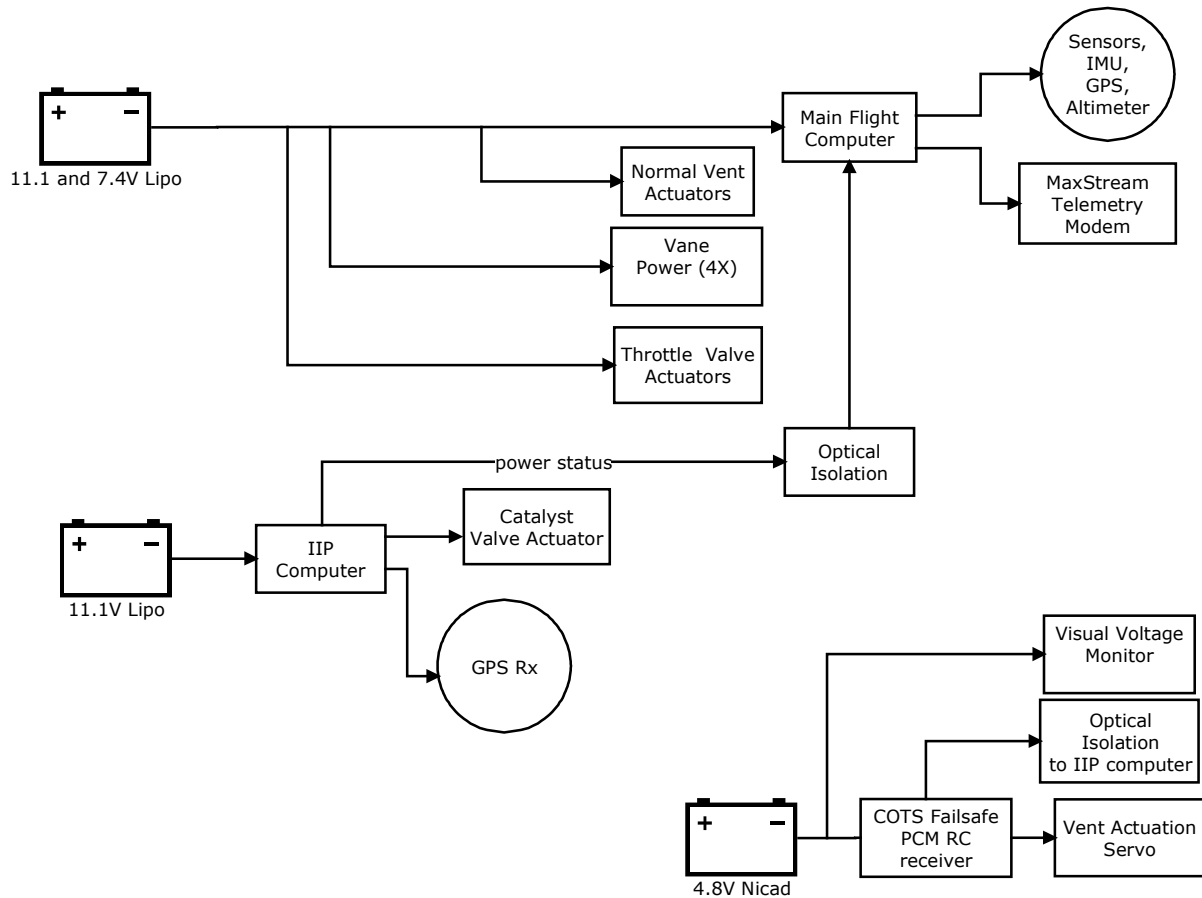
. The current calculated maximum flow rate is corresponds with about 700lbs of thrust at a feed pressure of 300 psi. and chamber pressure of 250 psi. The theoretical ISP for 90% peroxide at 300 PSI with this expansion ratio is about 125 via Cpropep. We expect the actual measured value to be in the 105 to 110 range. We expect actual data on ISP and max flow rate to be available in late June.

All of the active valves in the system are servo actuated. They do not automatically return to any particular position. They freeze in place with loss of power. The 5 actuated valves are shown in the following table

Valve/State	Safe/Fill	Pressurize	Run	Power source
Emergency Vent	Open	Closed	Closed	RC abort system battery
Normal Vent	Open	Closed	Closed	Main Flight computer
Permanganate Vent	Open	Closed	Closed	Main Flight computer
Permanganate Feed	Closed	Closed	Open	IIP computer battery
Main Valve	Closed	Closed	Open/Throttled	Main Flight Computer

The system pressurization will be manually achieved by manual valve actuation from remote bottles over two separate pressurization fill lines of 75 to 100ft. These will be remotely disconnected before flight.

1.2.3.7. Electrical



System electrical power distribution

Figure 7. Electrical power distribution

The electrical power distribution is shown above. There will be 3 separate power sources. The system can be automatically or remotely shut down with the failure of any battery.

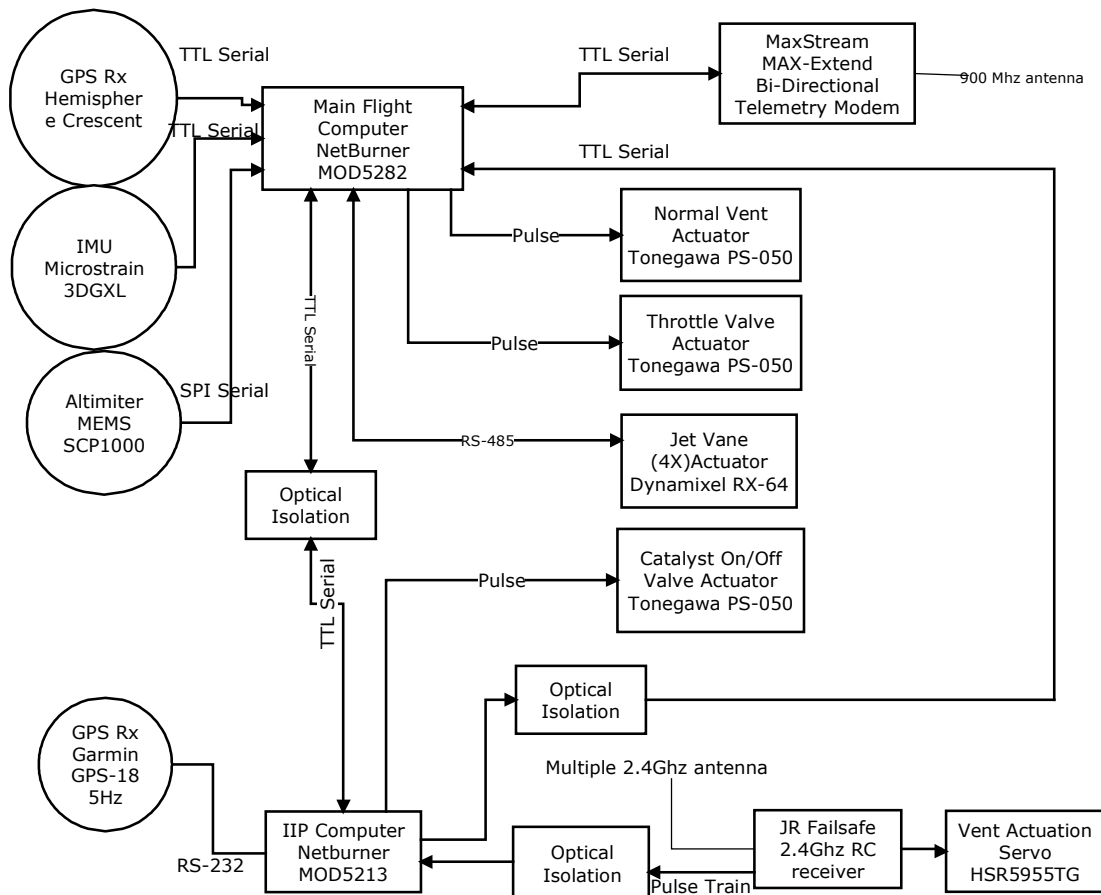
All battery power will be switched with the removal and installation of connectors. During operation the two primary safety systems and the flight computer are all optically isolated. No electrical fault will be able to propagate from one system to another.

During operation the main flight computer battery voltage and the IIP battery voltage 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. The COTS RC receiver battery indicator will be checked as part of each flight preflight.

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 8 Avionics components and signal paths.

All interfaces between safety systems and other components are 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. The command abort RC receiver tells the IIP computer to shutdown, it also directly controls the abort vent valve.

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.

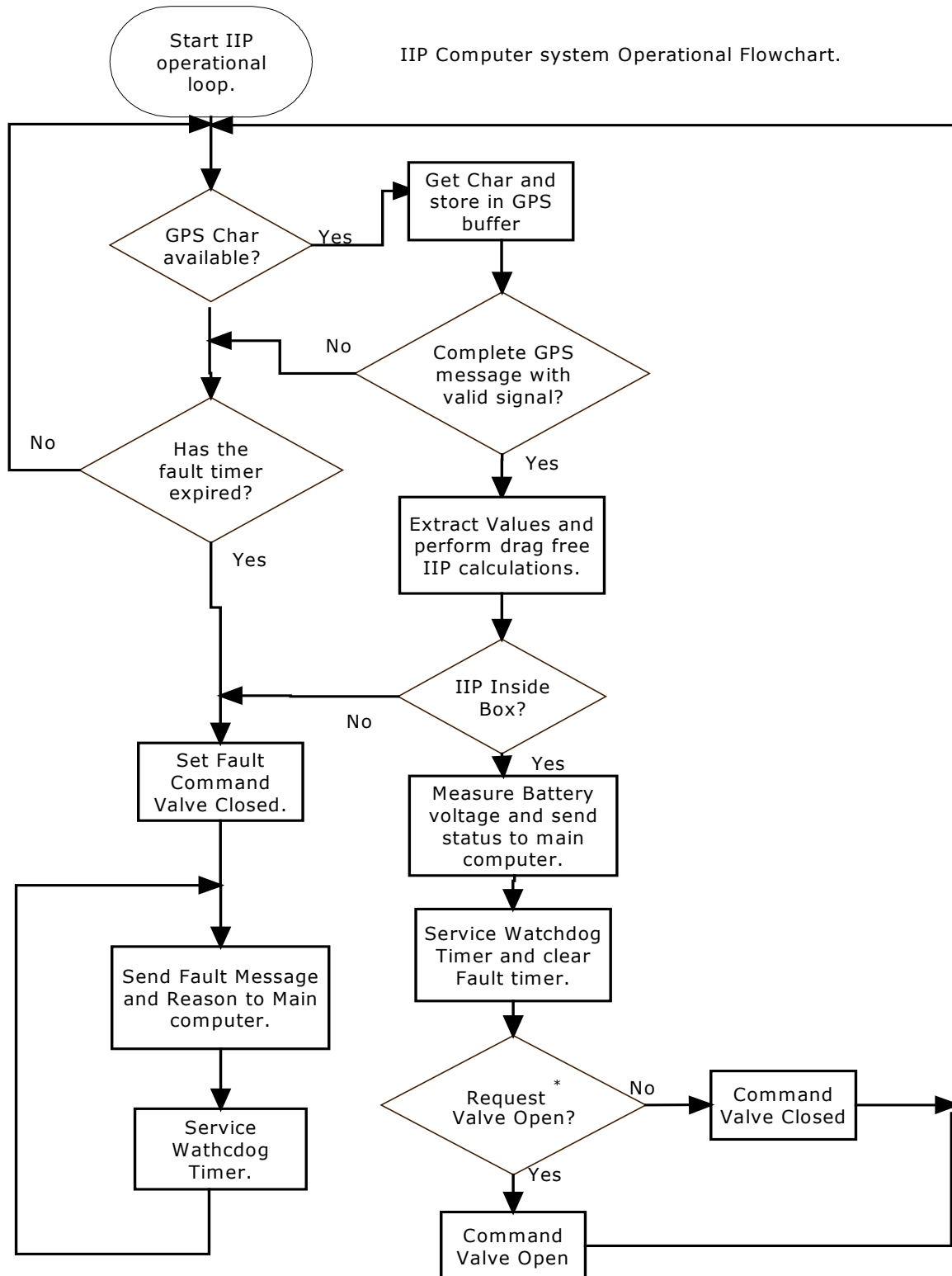
If the signal is lost it will revert to outputting its signal lost programmed position in about 1 second. This preprogrammed position will actuate the vent valves terminating the flight. This will be tested in preflight checks by turning off the command transmitter.

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 the emergency vent to open. 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.



*The Request Valve open is a logical and of the requested valve state and the COTS RC receiver signal. As a result the valve is enabled only if the main flight computer, the IIP computer and the RC system all agree it should be open.

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 meters rather than feet in the IIP calculations. 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/sec² (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.

$$\text{Altitude}(t) = 0.5 * g * t^2 + VVs * t + \text{altitude}.$$

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

$$\text{Field Elevation} = 0.5 * g * t^2 + VVs * t + \text{altitude}.$$

$$0 = 0.5 * g * t^2 + VVs * t + \text{altitude} - \text{Field Elevation}.$$

This can be solved with a simple quadratic equation.

$$T0 = -VVs / (-\sqrt{VVs^2 - (4 * g * -\text{field elevation})} / (2 * g))$$

So given the time till impact

We calculate the new latitude.

$$\text{IIPLat} = Vns * T0 * ns_m_2_d + \text{Lat}$$

$$\text{IIPLon} = Vwe * T0 * ew_m_2_d + \text{Lon}$$

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

1.2.3.9.3. Ground based Avionics

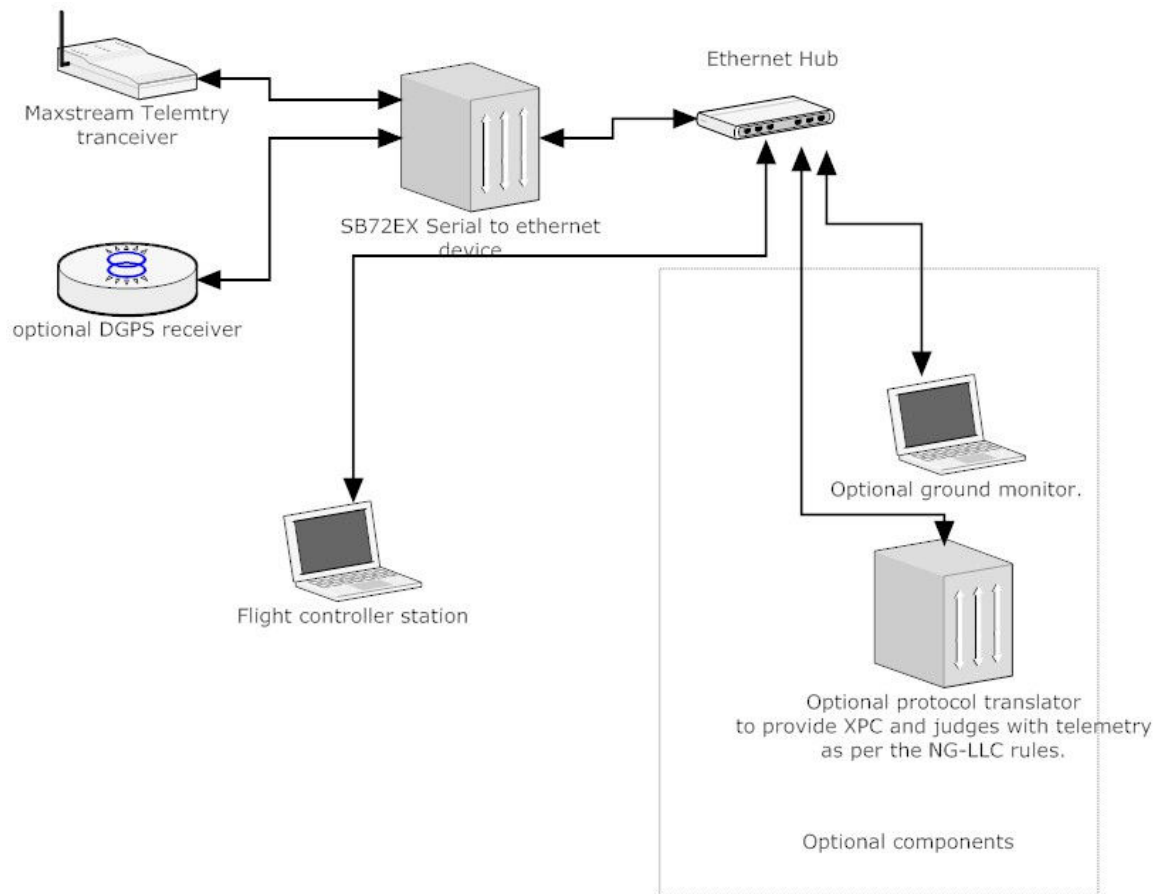


Figure 9 Ground avionics

The vehicle will be operated from the flight control station.

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

- All monitored 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 catalyst valve slightly off closed stop)
- 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 of main engine and depressurization of the vehicle.

| In addition to the ground avionics shown in Figure 9 Flight operations will use a JR XP9303 2.4Ghz 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 box will consist of a GPS receiver, IIP computer with modified software and an added switch. The box will be used to learn / measure navigation points mentioned throughout this document such as the boundaries of the operational area and the points A and B that the vehicle will fly between. The use of this box is described in detail within the flight operations section.

1.2.3.9.4. 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 2.

- RF Abort receiver 2.4Ghz MHz or possible 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 personnel are not used to an environment where their wireless cameras and wireless microphones could cause physical hazards.

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 waiver for burn time. The location of our tethered and unwaivered flights tests will be on Friends of Amateur Rocketry property 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.

The flights under a burn time license waiver will be done on the Choen dry lake bed as described in section 2.2. 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 vehicle 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 bolted or strapped to the ground. The engine 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. Reliable catalyst based ignition of the main motor.
- 2.1.1.1.2. Verify Motor shutdown on loss of GPS signal.
- 2.1.1.1.3. Verify Motor 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 tether attached to a crane or other durable structure. The vehicle will ignite the motor and rise approximately one meter under rocket power to a stable hover and then descend to full support by tether, or full landing. This will require a minimum of 1 flight. More 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 motor 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 staying 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 motor 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 seconds 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 motor and will rise to 50 meters (165 feet), achieve a stable hover, translate 50 meters (165 feet), and then descend to landing. This will require a minimum of 2 flights with no incidents. This series of flights will require a burn time waiver of at least 60 seconds and preferably 100 seconds. Unreasonable Rocket may substitute the following flight profile for this test: Rise to 50 meters translate 15 meters and stop, translate 15 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 Second Hover Duration Test

The vehicle will start resting on a concrete pad. The vehicle will ignite motor and the vehicle will rise to 50 meters to a stable hover remaining aloft for 68 seconds before descending this flight will 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 100 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 burn time wavered un-tethered flight tests prior to the flights of 2.1.7 will be done near the Friends of Amateur Rocketry site. We intent to fly from the edge of Cohen dry lake bed. Friends of Amateur rocketry has a letter of agreement with the BLM to fly from this site. This is at 35 19' 55.24" N and 117 51' 10.15" W

This site is at least 2.1 miles from any uninvolved third party. 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 F.A.R. the test flights in series 7 at Holloman will be flown within the confines of the operating area defined for the NG-LLC. (TBD) The wavered

flights at the Cohen dry lake bed will overlay the operating area and flight hazard areas as defined for Holloman, over the take off and landing area at Cohen. Please note that the flight hazard dimension of 2600 ft give the Cohen site a dimensional safety factor of at least 4.

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 personnel.

- Flight controller.
- Manual safety abort person.
- Pad operations person.
- If containment requires it we will also have a line judge. The presence or absence of the line Judge will be dependant on the tradeoffs discussed in 3.3.4

This section will reference the following areas.

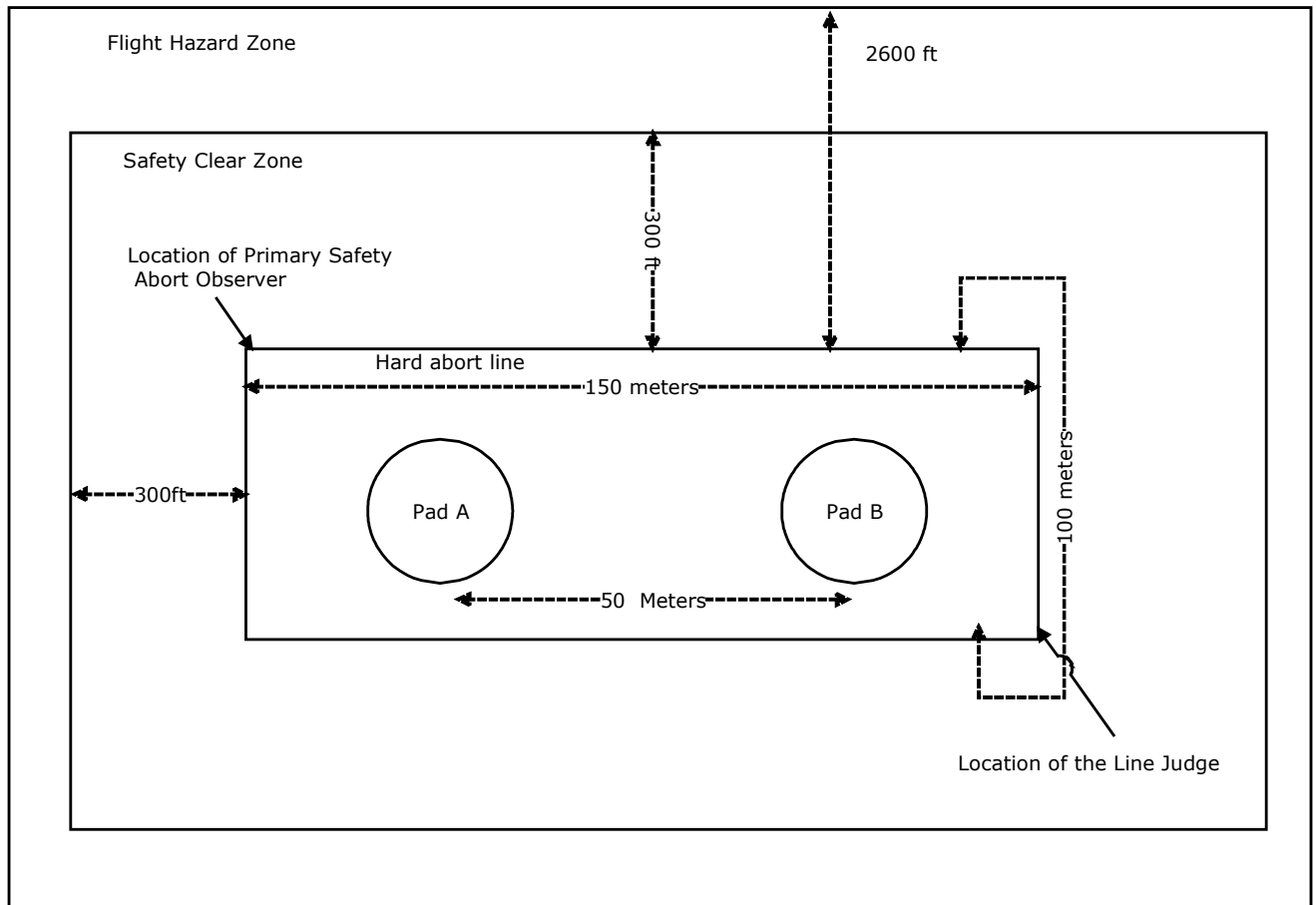


Figure 10Flight hazard zones

The figure above shows the dimensions and shapes of the different hazard zones. These distances are derived in section 3.3 containment.

The areas of concern are :

- Safety Clear zone. This is the area that needs to be clear of uninvolved personnel when the vehicle is in a hazardous state on the ground.
- Flight Hazard Zone. The area that needs to be clear of uninvolved personnel when the vehicle is in flight or capable of flight.
- The diagram also shows the hard abort limits.

The checklists and procedures in all of section 3.1 are designed to verify the readiness and condition of the vehicle before during and after flight to achieve compliance with 437.71.

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 navigational and area restriction coordinates. Since the operating area is derived from the land pad positions both functions abort limits and navigation locations are derived from the same 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.
- The Thrust chamber 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 GPS satellite availability with a mask angle of 15 degrees will be calculated for the day and location.
- The team leader and or the flight control operator (currently expected to be Paul T Breed) will brief the operational personnel on the flight rules and checklist procedures for the day.

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 AFB 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 personnel 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 personnel will ask the flight operations for IIP valid signal verification.
- Pad Operations will visually verify that catalyst valve is closed.
- Pad Operations will request that the computer be put into safety test mode.
- Pad Operations will visually verify that catalyst valve has moved from its 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 catalyst valve is 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 ask the safety abort operator to command an abort.
- Pad Operations will then manually close the safety vent valve and ask the abort operator to command normal operation latching the abort valves.
- Pad Operations will now verify with the flight controller that the IIP system has rebooted and is reporting valid GPS data and position.
- Pad Operator will request that flight operations command the vehicle to safe.
- Pad Operations will visually verify catalyst valve closed, and vent valves open.
- Pad Operations will now fill the vehicle with Permanganate.
- Pad Operations will verify no visible Permanganate.
- Pad Operations will command that all uninvolved personnel to clear the safety clear area.
- Pad Operations will connect the Peroxide fill line(s).
- Pad Operations will verify that all uninvolved personnel are clear of the safety clear area.
- Pad Operations will ask event control for permission to fill Peroxide.
- Pad operations will visually verify that all uninvolved personnel are clear of the safety clear area.
- Pad Operations will fill Peroxide.
- During Peroxide fill Pad Operations will audibly verify that Peroxide vents are open.
- Pad Operations will connect the N2 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 in the pad vehicle 100 ft away and prepare to pressurize.
- Flight control will ask event control to verify the safety clear area is clear.
- Flight control will visually verify that the safety clear area is still clear of personnel.
- Flight control will ask event control for permission to pressurize.
- Pad ops will pressurize the vehicle from 100 ft away.
- Flight control will verify battery voltages, IIP status and pressurization pressures are nominal.
- Flight control will request command the pressurization lines be disconnected
- Pad Ops will disconnect the pressurization lines and verify them disconnected.
- Pad Ops will seek shelter.
- 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 visually verify that the abort operator is in place.
- Flight control will advise all on the operation net that we are cleared to launch.
- The line Judge will verify that the abort operator can hear him on the radio.
- The abort operator will acknowledge the abort operator radio call.
- Flight control will remind everyone on the radio net that the line judge is the only one that may speak while the vehicle is airborne.
- 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.

Flight Rules for the safety abort operator.

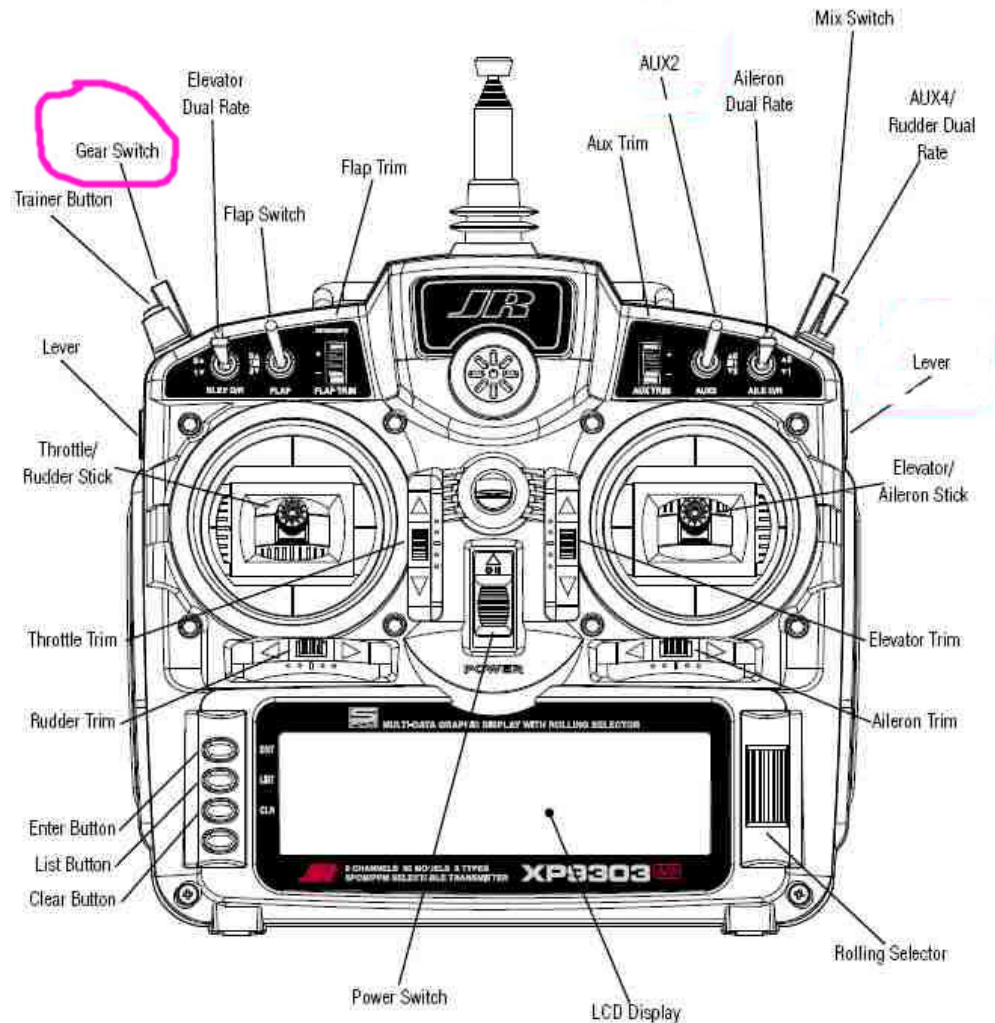
In parallel to the above procedure the Safety abort operator will do the following:

- Once pad ops and or flight control requests that the Safety Clear zone and or the Flight hazard zone be cleared the safety abort operator will observe any change in the clear /not clear status and announce it on the radio net.

After flight has begun the safety abort operator will observe the vehicle for the following conditions:

- The vehicle is on track and not crossing and hard abort limits.
- The vehicle is stable and not exhibiting any anomalous dynamic behavior.
- If the vehicle exhibits and anomalous dynamic behavior the safety abort operator will command a landing over the radio voice net.

- If the vehicle exhibits rapid anomalous behavior or crosses the hard abort lines the safety abort operator will command an immediate shutdown with his RC transmitter.
- The safety operator will listen tfor radio abort call from the far corner line judge. Once the vehicle has landed the safety abort operator will resume his duties observing the Safety clear zone and the flight hazard area and notifying people of any change in status.



The safety abort operator activates an immediate hard abort and shut down by flipping the GEAR switch on the RC transmitter.

Flight rules for the line judge (If required)

The line judge will watch the hard abort lines and if the vehicle crosses these lines he will announce ABORT ABORT ABORT on the radio net. It is explicitly not up to the line

judge to make abort decision based on dynamic behavior unless he also meets the experience requirements for safety abort operator codified in the flight rules section 3.8..

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 refueling.
- 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 valve 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)



The permitted flights will be carried out from the east or west pad sets as described in the Xprize Cup Appendix B operating areas and locations document. We have provided the 2007 version of the document to the FAA under separate communications. It is expected that the Xprize cup will generate a 2008 version of this document that should be identical. Please note we are only using the locations of the pads in this document. Our hard abort limits, safety clear zone and flight hazard zones are all smaller than the Xprize document indicates.

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 D.o.D. 6055.9, using the vehicle propellant weight of 550 lbs. Using table C9.T18 plus note 4 we get an equivalent explosive weight

of $0.2 * 550$ or 110lbs. To be conservative we will use a weight of 300 lbs . Taking a K factor of 40 we calculate a blast standoff off radius of 300ft.

We will apply the following as an operating area overlay on the HAFB pads as described in the Xprize cup operating area containment document.

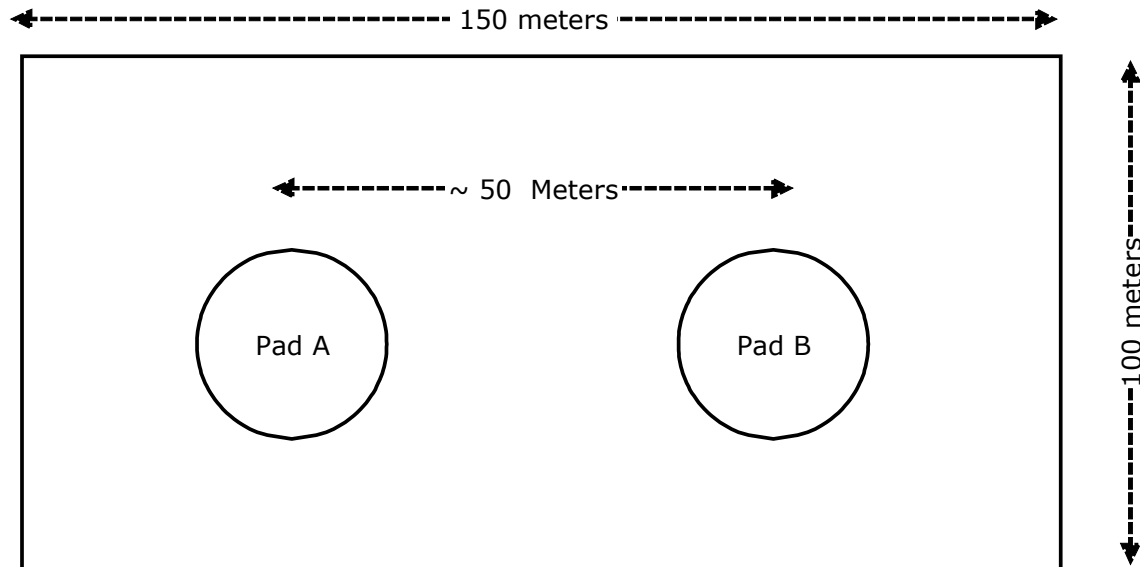


Figure 11 Assumed hard abort limit lines.

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 90 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 billion possible trajectories. We then report the worst case. Below is an example of worst deviant case impact distance from the course centerline for the 90 second flight vs. time into the flight. This graph assumes a 3second delay from crossing the boundary to triggering the abort. The GPS based IIP version of this yields about 3 times less distance.

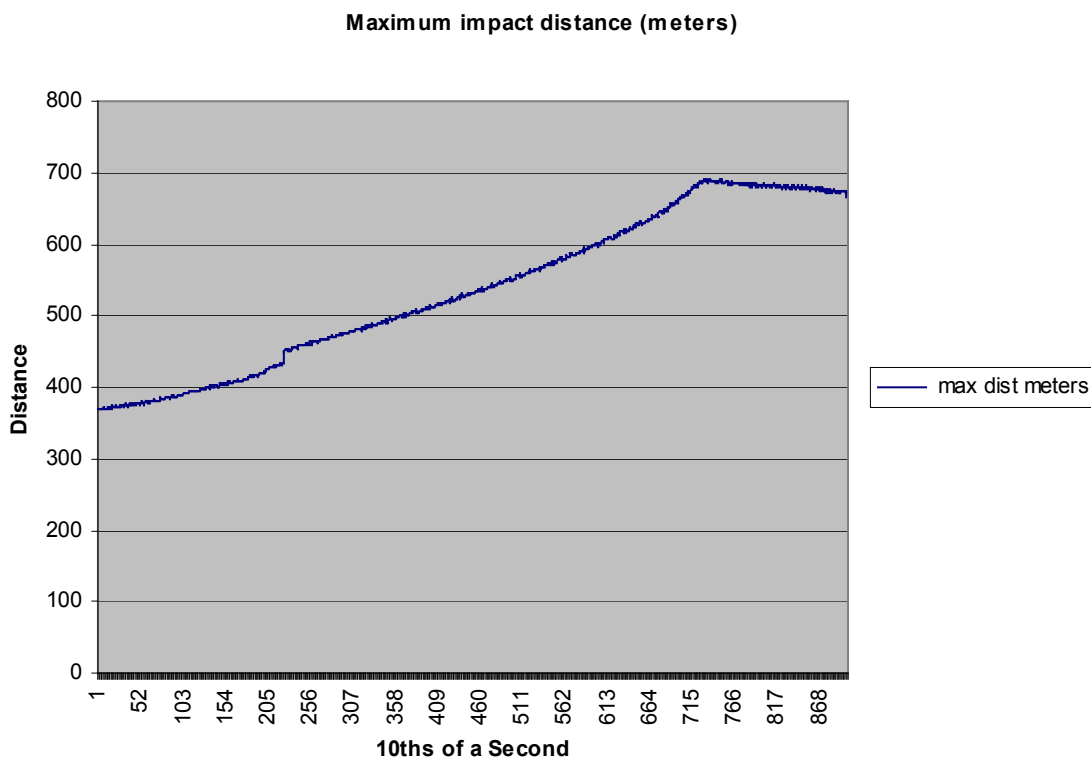


Figure 12 90 Second Vehicle maximum distance with 3 second boundary crossing delay

3.3.2. 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 690 meters or 2263 ft. Adding 300 feet for the blast radius and we get a flight hazard distance of ~2600 ft.

3.3.3. Triple failure worst case no abort system flight distance results.

We calculate the maximum distance the vehicle can travel given running at max thrust continuously until fuel exhaustion and a CD of 0.2 at about 6.2 miles.

We arranged to have CFV done to determine a Cd number for the vehicle in the most streamlined direction. The results of this were a Cd at 200Knots of about 0.25 the number used in the calculations of maximum range are conservative.

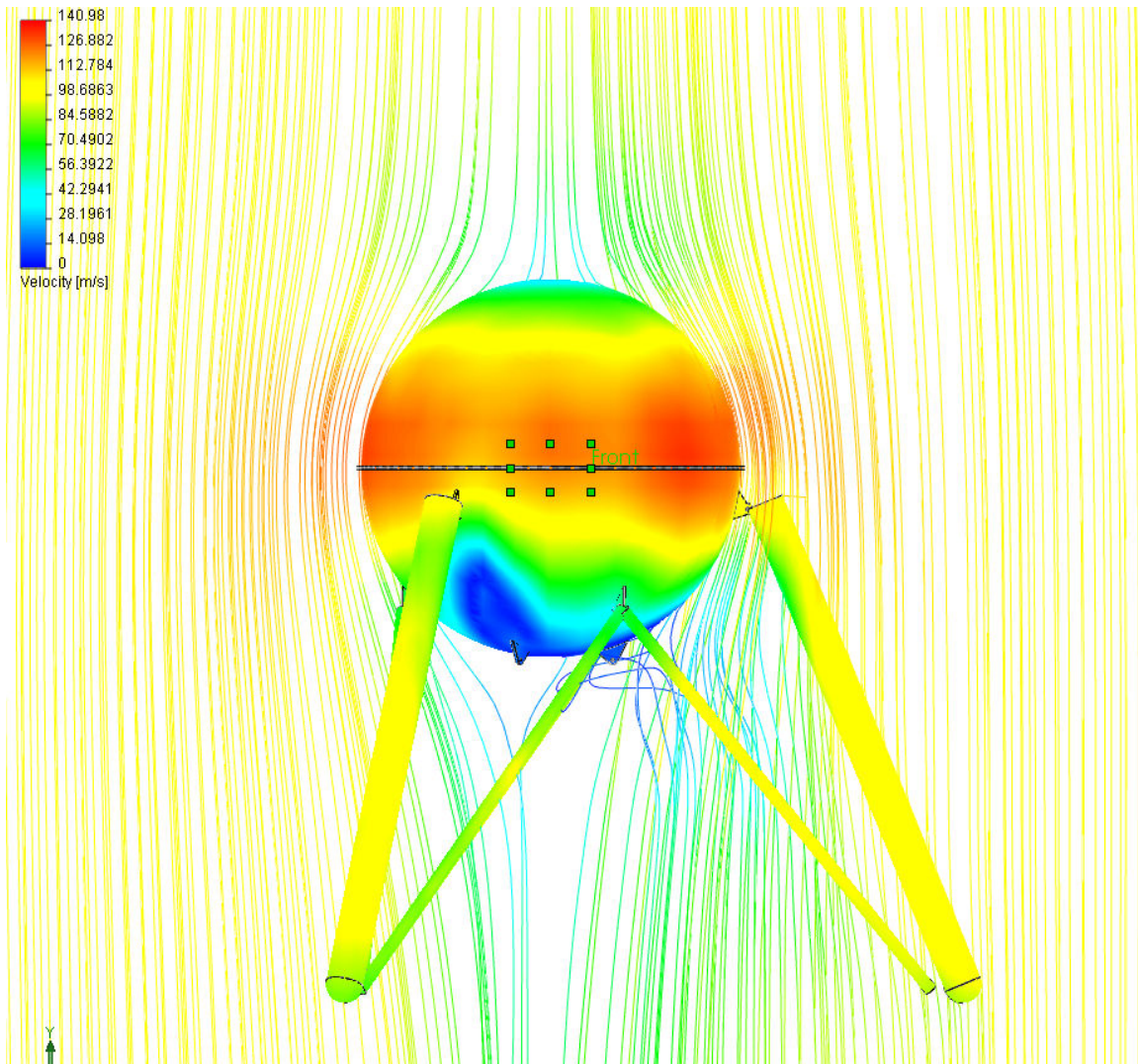


Figure 13CFD Stream lines

3.3.4. Flight termination narrative discussion.

Given the hard abort limits as defined Figure 11 Assumed hard abort limit lines. The IIP computer terminates the flight if the vehicle were to ever to have an IIP outside the hard abort limits. To protect against double failures we are planning to use a manual abort as executed by the abort operator. It is straight forward to calculate the distance the vehicle

can travel from the time it crosses an abort line given an assumed delay interval. If the abort operator is paying attention then this is not completely reflective of reality. All of the maximum calculated distances are the result of the vehicle going from normal flight into some hard maximum acceleration. If this were to occur in flight the abort operator should terminate the flight before it even reaches the abort boundaries. To be able to make this sort of judgment call the abort operator must be familiar with the normal operation of the vehicle. Toward this end we have experience requirements for abort operators that are codified in section 3.8.

Since our architecture presently only supports a single abort operator, we need to choose where the single abort operator positions himself. This will need to be an interactive process that takes into account the direction of the most critical distances. The abort operator should be located on the most critical corner. This makes judging opposite corner more difficult. Unreasonable Rocket proposes the following adjustments to the dimensions given in this section:

A Critical corner can be identified :

We would place the abort operator on the critical corner. For exclusion zones in the direction that would require crossing either of the observers corner sight lines one would add 0 ft to the abort limits. For exclusion zones that would require crossing the abort limits 50 meters away on the short side of the abort box we would propose doubling this distance to 100meters for calculation and using a flight hazard zone distance limit of 2600ft+50 meters or 2780 ft. For exclusion zones on the far side of the area crossing the abort line 150 meters away we would propose adding 150 meters or ~500 ft to the flight hazard zone limits or 3100 ft. total If the non critical corner has exclusion zones that are at all close to the 3100 ft limit we will add a line Judge at the opposite corner with radio contact to the abort operator. From a calculation methodology this probably adds to the cut off time delay, but really only applies if the vehicle slowly leaves the box, as any rapid dynamics will result in an abort regardless of the vehicle position.

A Critical corner can not be identified:

We would place the abort operator in the middle between the two pads. For exclusion zones crossing the 50m dimension of the abort box we would again add 50meters to the line for a flight hazard zone distance of 2780 ft. for exclusion zones past the 150Meter dimension or 75M from the observers point we would add 75 additional meters to the flight hazard zone for a distance of ~ 2900 ft.

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 personnel 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 section 3.3.

This is insured by the dual redundant abort systems and the calculations discussed in section 3.3.1 on page 40

3.6. Agreements (Section G-4f)

Unreasonable rocket has executed a master team agreement with the X-Prize 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 provide a real time report of indicated latitude, longitude and altitude over the telemetry link. This data will be recorded by the ground station and operator. 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.

Proper and complete execution of the checklists and procedures described in 3.1.1 to 3.1.3 are an integral part of the flight rules.

A key element in the safety system is the judgment of the safety abort operator. The task of determining when the vehicle crosses the hard abort limits is straightforward. However we believe that the safety is significantly enhanced if the safety abort operator also activates the safety abort if the vehicle exhibits rapid or significant dynamic deviations from normal flight. Toward that end we will use the following safety abort operator rules: Any person operating as a safety abort operator must have the following experience:

- For wavered operations on Cohen dry lake the operator must have personally witnessed at least one tethered flight.
- For Permitted operations at Holloman the safety abort operator must have witnessed at least three flights.

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 2008 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. Environmental Impacts. (Section G-1c)

Unreasonable Rocket is using only environmentally benign propellants and pressurization agents.

- Hydrogen Peroxide less than 350 lbs total per flight.
- Sodium Permanganate less than 17 lbs total per flight.

- 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 personnel.

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

To be provided by XPC and Holloman personnel.

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

To be provided by XPC and Holloman personnel.

5.4. Maximum Personnel Not involved in the permitted activities.

To be provided by XPC and Holloman personnel.

6. Vehicle Inspections (G-1e)

Unreasonable Rocket will make its vehicles and its facilities available for inspection by the FAA at any time given 24 hours notice.

Appendices

A. Proposed possible changes to the vehicle.

- Substitution of aluminum tanks with composite fuel tanks.
- Replace microstrain IMU with better quality Fiber optic IMU.
- Swap the safety actuation so command actuates safety catalyst valve and IIP unit activates vent valve. The current design has the RC receiver directly operating the emergency vent valve and indirectly operating the catalyst shut off valve through the IIP computer.
- Swap our safety servo actuators from Tonegawa to Dynamixel or other COTS servo actuator.
- Substitute 50 or 72 MHz PCM RC receiver to 2.4Ghz RC receiver if the RF environment at the site is cleaner for the 50 or 72 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.
- 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 and aerodynamic drag on maximum impact range. This would be done to try and reduce MPL.
- 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)
- Replace the Stainless Jet Vanes with a higher temperature alloy.
- Replace Jet Vanes with attitude thrusters.

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 causes the thrust quantity or direction 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	<ul style="list-style-type: none"> – 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 personnel on the use of the abort system. – Abort safety personnel will be trained and practice abort procedures. 	I	E	12	<ul style="list-style-type: none"> – Abort system commanded range verification. – Daily preflight abort valve operational test. – Training records for abort personnel. – 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 without failure before flying under permit. – 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. Test the abort system limits by physically carrying the abort system to the abort limit points.	I	E	15	<p>-Daily preflight procedures check the battery condition of the GPS IIP system.</p> <ul style="list-style-type: none"> – 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 in program changes or hardware replacement.
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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	I	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	<ul style="list-style-type: none"> – The system safe vent plug(s) will be the last item(s) adjusted by pad personnel after airspace is cleared and telemetry 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 the engine.	I	E	12	<ul style="list-style-type: none"> – Inspection verification that the vehicle matches the schematic design documents. – Production test individually verifying that system can shutdown the engine with all IIP system connectors disconnected

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			I	E	12	one by one. – 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 isolated connections.		I	E	12	– Verify galvanic isolation between all safety systems with an ohm meter after and electrical modifications or maintenance.
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	1 2	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 injury to the public.	I	D	8	– Tanks designed to a safety factor of more than 1.2 (Design Factor 1.2).	I	E	12	– The tanks will be hydrostatically tested to 1.25 MOP during production. – The following FAA/AST guidance document has been used to determine the appropriate verification safety factors for all structures: <i>FAA/AST Guide to Verifying Safety-Critical Structures for Reusable Launch and Reentry Vehicles</i> – See Appendix D for a description

5B	Structures	Structural failure of the tank retention system	The consequence is the possible death or serious injury to the public.	I	D	8				I	E	12	of our verification schedule
													<p>– Vent to engine shutdown time is one of the verification tests.</p> <p>– See Appendix D for a description of our verification schedule</p>
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				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 operating area.	The consequence is the possible death or serious injury to the public.	I	C	4				I	E	12	<p>– See Appendix D for a description of our verification schedule</p>
													<p>– Redundant safety systems. See Item 1A</p>

7C	Propulsion System	Propellant 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	<p>–The GPS IIP and command abort systems are on opposite sides of the vehicle. They are unlikely to both be involved in a fire.</p> <p>– The command abort operator is instructed to abort the flight if visible fire has progressed beyond the engine area.</p>	I	E	12	<p>– Production inspection verifies that the command abort and GPS IIP systems are on opposite ends of the vehicle.</p> <p>– See Appendix D for a description of our verification schedule</p>
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	<p>– The tank has been designed to a safety factor (burst) of 1.25.</p> <p>– Tank will incorporate a pressure relief valve set to 1.1 times maximum operating pressure.</p>	I	E	12	<p>– The tank has been proof tested to a safety factor of 1.25. The following FAA/AST guidance document has been used to determine the appropriate verification safety factors for all structures: <i>FAA/AST Guide to Verifying Safety-Critical Structures for Reusable Launch and Reentry Vehicles</i></p> <p>– See Appendix D for a description of our verification schedule</p>
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

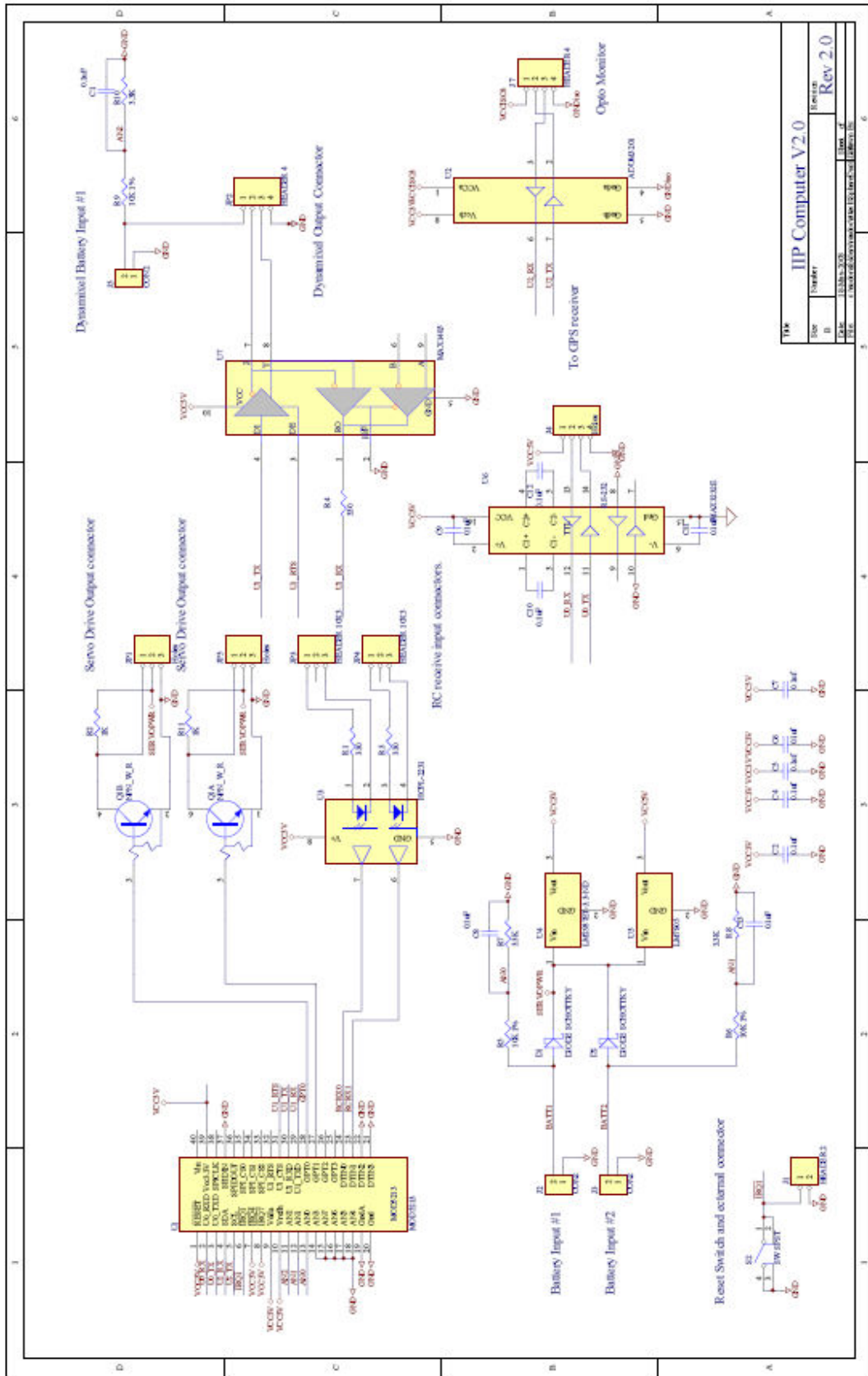
The operational checklists will be a direct transcription from the bullet items in sections 3.1.1.1 to section 3.1.3

D. Unreasonable Rocket Verification Schedule.

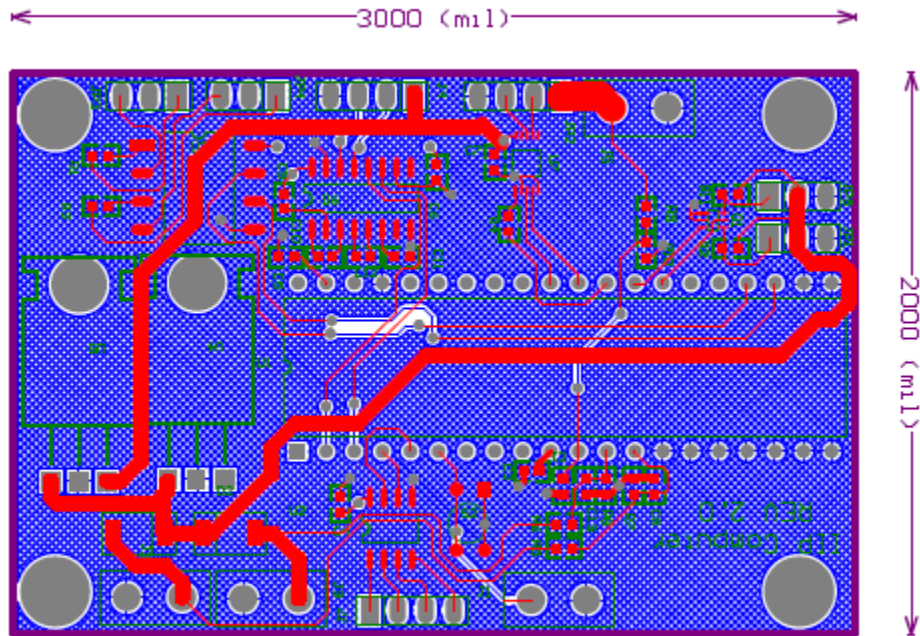
Test number	Test Reason	Test description	Acceptable results	Record format
T1	Tank Structure	Hydrostatically test tanks to 370 PSI	Tank does not fail at 370 PSI	Logbook or Tank frame stamp.
T2	Landing Gear	Vehicle will be dropped from a height to simulate 1m/sec impact.	Vehicle structure does not fail	Logbook and or Video
T3	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.
T4	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
T5	IIP system final acceptance test.	TBD	TBD	Logbook.
T6	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.
T7	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.

Schematic:



PCB layout :



Software design details see section 1.2.3.9.2

Software Code will be provided.

Final acceptance test plan.

We anticipate that this data will be available in Late July 2008.

General outline of my software design for the IIP computer:

It will run on a

MOD5213. http://www.netburner.com/products/core_modules/mod5213.html

The GPS receiver is Garmin GPS18-5Hz an output only device that continuously sends NEMA GPGGA position and PGRMV velocity data at 5Hz. The software will run as a simple loop polling the serial port for GPS data.

It will enable the watch dog timer, and it will only clear that when it has received a valid data frame from the GPS.

The entire program will be written in C

The logical flow is documented in my application 1.2.3.9.2

General outline of the test plan....

1)Generate a series of GPS test data strings....

GPS loss of lock.

GPS failure (no data)

GPS failure gibberish data.

GPS Leaving IIP containment area:

- Level Slowly At 10 points on each edge.

- Level Slowly Exactly at each corner.

- Level Slowly Exactly one LSB to each side of each corner.

- Level Slowly out of the top of the containment box (300M)

- Jumping well out side the box in a single frame.

- Leaving the box at a 2Gee 45 climb for:

 - 10 points on each edge and the corners.

- Leaving the box at a 2Gee 45 descent for

 - 10 points on each edge and the corners.

- From a position outside the box with enough velocity so the IIP lands outside the other side of the box.

GPS normal flight profile.

Test the proper operation of the IIP system with each of these test strings.

2)Additional Testing will test:

- Operation with garbled stored box position data.

- Operation while failing each of the two redundant batteries.

3)Attached to an RC plane or helicopter at FAR and fly around with telemetry recording and reporting status.

Verify that it triggers at the correct points during this test.

4)Once testing begins all source will be kept in a source control system (CVS)

5)A Code checksum will be reported by the box on startup.

All tests will record this checksum.

All tests will have to be passed with this one version.

this checksum value will be recorded and if changes are necessary then all tests will be re-run.

6)I'm also open to a line by line code review publicly or privately with anyone you would like to have review the code.

The code set is not going to be very big, simple probably less than 10 pages printed out .