# Northwest Indian College Space Center

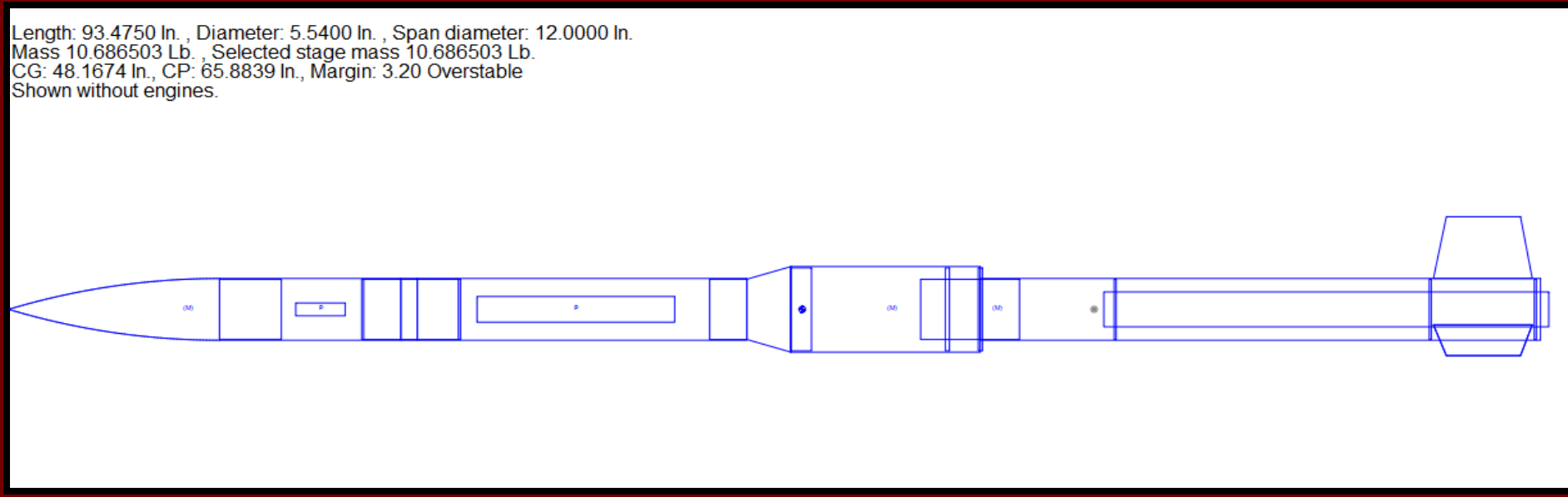
## The RezRiders and the rocket, Frankenstein

Critical Design Review – January 24, 2011

# Mission statement

Through the USLI program the Northwest Indian College Space Center’s RezRiders Team enhances its involvement in science, math, engineering and technology and encourages others in Tribal communities to do the same.

# Frankenstein




Kyle Koos with Frankenstein

# Motor Selection

- relatively slow burn time
- not exceed 17 g’s of acceleration
- provide sufficient thrust-to-weight for a safe launch rail exit speed.

Cesaroni K660-17A motor meets these requirements.

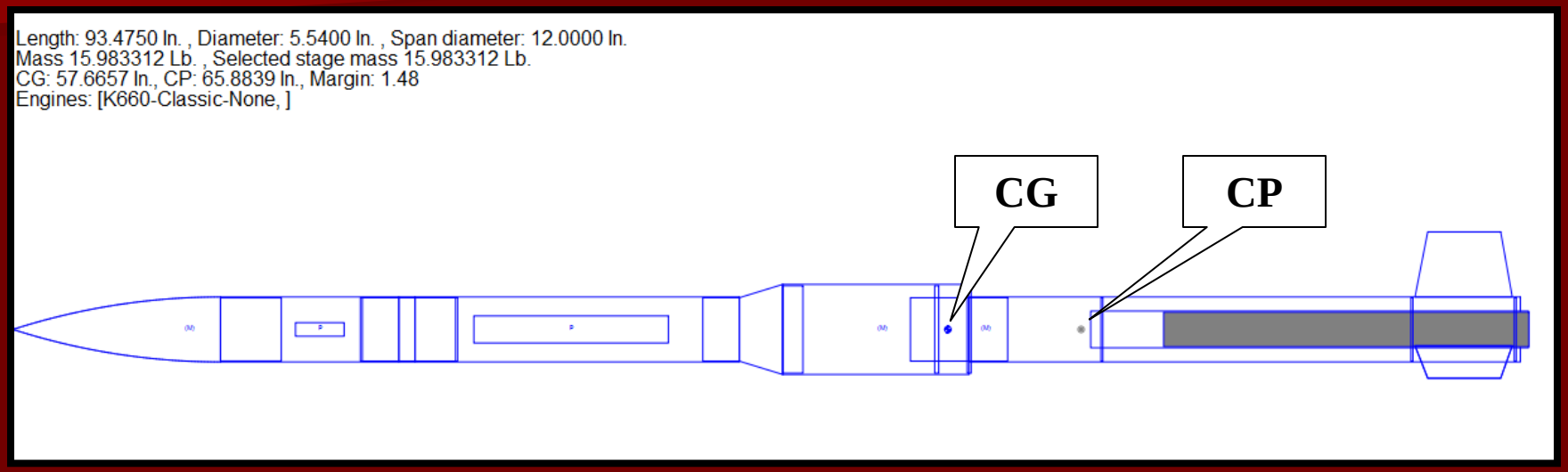
# Motor Selection

- We used RockSim to analyze several motors for our use
- All of our potential motors are commercially produced
- The primary considerations for the motors were the average thrust and total impulse to move Frankenstein to 5,280 feet
- The average thrust was used to determine if the motor would provide the necessary thrust to weight ratio for stable flight
- Once that was determined, motors were tested in RockSim to find the predicted altitudes

# Cesaroni K660-17A motor

| | | | |
|---|---|---|---|
| **Single-Use/Reload/Hybrid** | **Reloadable** | **Motor Dim (mm)** | **54.00 x 572.00 mm (2.13 x 22.52 in)** |
| **Loaded Weight** | **1949.00 g (68.22 oz)** | **Total Impulse** | **2437.00 Ns (548.33 lb/s)** |
| **Propellant Weight** | **1177.00 g (41.20 oz)** | **Maximum Thrust** | **1078.90 N (242.75 lb)** |
| **Burnout Weight** | **734.00 g (25.69 oz)** | **Avg Thrust** | **659.00 N (148.28 lb)** |
| **Delays Tested** | **17 - 7 secs, infinitely adjustable** | **ISP** | **211.10 s** |
| **Samples per second** | **1000** | **Burn time** | **3.69 s** |
| **Notes** | **Classic Propellant** | | |

# Static Stability Margin




***Static Stability Margin*** = Center of Pressure – Center of Gravity / Diameter of Rocket*

*Calculations use the maximum diameter of 5.54”

Margin with no motor: 3.20

Margin with motor: 1.48

# Thrust to Weight Ratio

| Average Thrust | | Ratio | Motor | Rocksim Alt | Case | Lift Off | G's |
|---|---|---|---|---|---|---|---|
| Newtons | Pounds | | | | | | |
| 660.537 | 148.495 | 12.703:1 | K660-17A | 5,381 | 6 Grain | 72.6 f/s | 15.04 |

- **Thrust-to-Weight Ratio = Pounds of Thrust/Weight of Frankenstein**
- We have chosen the CTI K660 Classic

# Mariya Williams Weighing the Fin Can

# Launch Pad Stability Test


Paul Ballew & Keyin Gorman testing the stability and weight capacity of our launch pad

# Launch Guide Data

- Launch guide length: 72.0000 In.
- Velocity at launch guide departure: 72.6120 ft/s
- The launch guide was cleared at : 0.199 Seconds
- User specified minimum velocity for stable flight: 43.9993 ft/s
- Minimum velocity for stable flight reached at: 27.0614 In.

# Stand off - Aft Rail Button

Standoff mounted through-the-wall to motor mount. Standoff necessary because of 5.54” science payload bay.

# Parachute Calculations

The drogue parachute is an 18” in diameter which results in a calculated 82-85 feet per second descent rate. The main parachute is 72” in diameter. The descent rate after the main is deployed is calculated to be 21 feet per second.

| PARACHUTE SIZE CALCULATION | | | | |
|---|---|---|---|---|
| Rocket Weight | 10.68 | pounds | | |
| Parachute Drag Coefficient | 1.5 | | | |
| | **Vastsas Chute Calculator Program** | | | |
| | **Drogue (50-100 f/s)** | | **Main (17-22 f/s)** | |
| Descent Rate | 85 | feet/second | 21.2 | feet/second |
| Diameter | 18.01 | inches | 72.1 | inches |
| Shroudline length | 12 | inches | 50 | inches |

# ...Parachute continued

| Rocksim PARACHUTE SIZE CALCULATION | | | | |
|---|---|---|---|---|
| Rocket Weight | 10.68 | pounds | | |
| Parachute Drag Coefficient | 1.5 | | | |
| | **Rocksim** | | | |
| | **Drogue (50-100 f/s)** | | **Main (17-22 f/s)** | |
| Descent Rate | 82.4 | feet/second | 21 | feet/second |
| Diameter | 18 | inches | 72 | inches |
| Shroudline length | 15 | inches | 53 | inches |

Supplied with this information, we are confident that our parachute selection will bring Frankenstein safely to the ground.

# Test Plans and Procedures

# Airframe Mission Criteria Results

| Mission | Criteria as of 1/24/11 | Completion or Test Date | Data Recovery % | Success % |
|---|---|---|---|---|
| Scale rocket | Complete | 20-Oct | N/A | 100% |
| Scale rocket flown | Yes | 6-Nov | N/A | 100% |
| Altitude prediction | 3000’ | 6-Nov | 100% | 72% |
| BP test | Eject drogue & main | 3-Nov | N/A | 100% |
| GPS tracker test | Track rocket | 6-Nov | 100% | 100% |
| Competition rocket built | Yes | 19-Nov | N/A | |
| Competition rocket launch | Yes | 12/5/2010 | N/A | |
| Competition altitude prediction | 2,890’ | 5-Dec | 100% | 49% |
| Competition rocket launch | Competition motor | 2/5/2011 | | |
| Altitude prediction | 100% | 29-Jan | | |
| Competition rocket launch | Competition motor | 26-Feb | | |
| Altitude prediction | 100% | 29-Jan | | |
| Competition rocket launch | Competition motor | 12-Mar | | |
| Altitude prediction | 100% | 12-Mar | | |

# Science Payload Criteria Results

| | Atmospheric temp | Atmospheric pressure | Humidity | UV | Solar Irradiance | Interior temp | Rocket roll |
|---|---|---|---|---|---|---|---|
| Prototype science modules built: | 95% | 80% | 100% | 100% | 100% | 90% | 75% |
| Prototype science module tested: | 90% | 50% | 100% | 100% | 100% | 80% | 75% |
| Actual science modules built: | 0% | 0% | 0% | 100% | 100% | 25% | 25% |
| Actual science modules flight tested | 0% | 0% | 0% | 0% | 0% | 0% | 0% |

# Procedures

- Preflight and post flight checks via checklists with ensure that our rocket remains structurally sound.
- Ground tests will determine the amount of black powder necessary to ensure that the calculated black powder quantities shear the pins consistently and that there is enough force to eject the drogue and main parachute bays.
- We will also make sure that the motor casing gets cleaned immediately and thoroughly after use and is carefully inspected to ensure that there is nothing to cause problems and potential catastrophic failure of the motor.
- Continuous weighing and entering the weights into Rocksim will ensure that our predictions are made on the best information available.

# Frankenstein

Maiden Flight – December 5, 2010
1,429 feet altitude

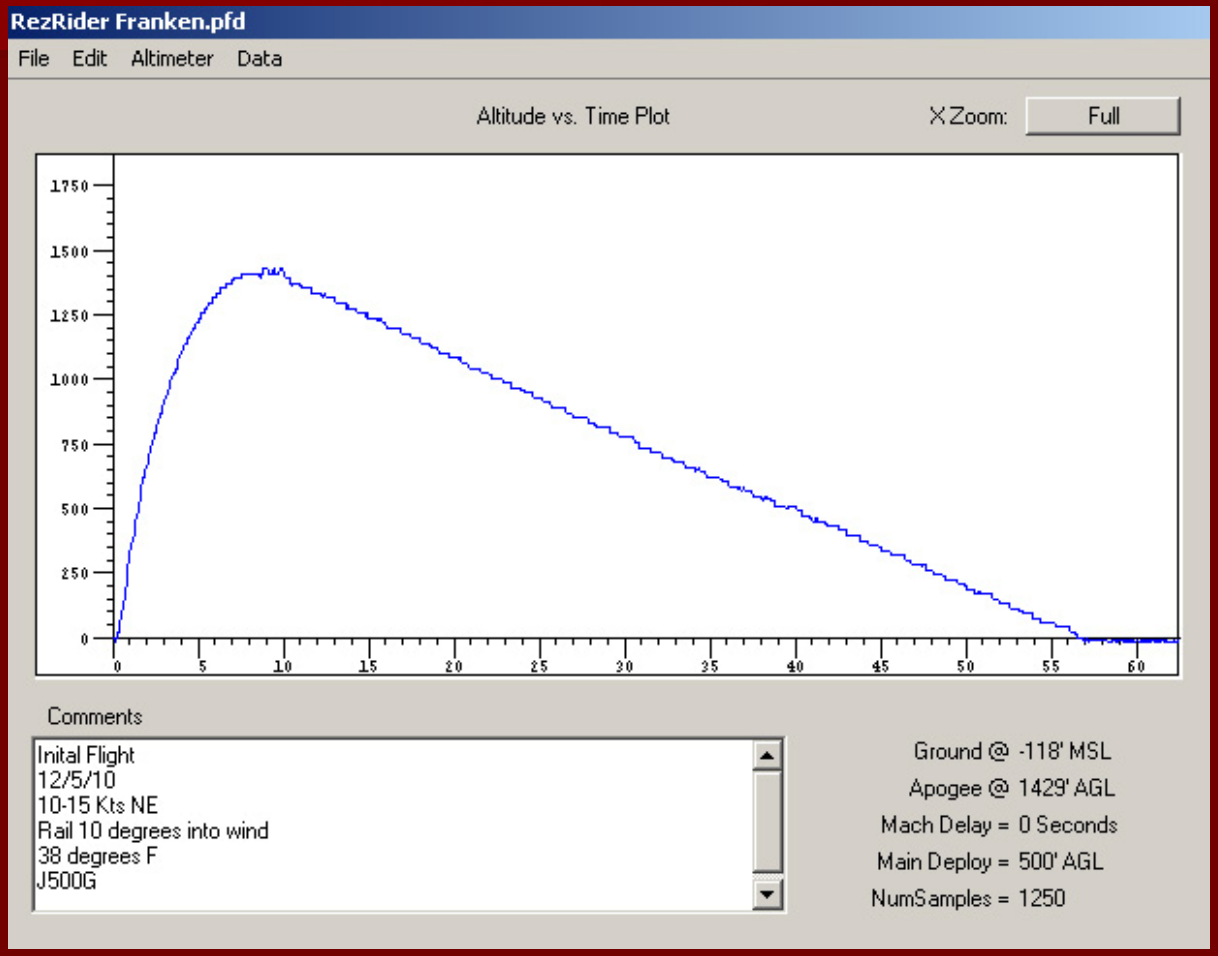
# Flight Test

- Our design is a bit unusual in that our rocket, Frankenstein, had 7.67 inch science payload section on a 4 inch airframe.
- On December 5, 2010, the Northwest Indian College RezRiders launched its full-scale USLI competition rocket.
- We used an Aerotech J500G with a 54mm to 38mm motor adaptor.
- We chose this motor to ensure that we had enough thrust-to-weight ratio and liftoff speed to establish stability prior to leaving the pad.
- 1,429 feet altitude

# Test Results - Predicted Altitude vs Actual Altitude

- 2,890 feet predicted altitude with an Aerotech J500G with simulated wind set to 8-14 Kts and the launch rail angled 10 degrees into the wind.
- 1,429 feet actual altitude with an Aerotech J500G with wind mostly at 15 kts and launch rail angled 10 degrees into the wind.

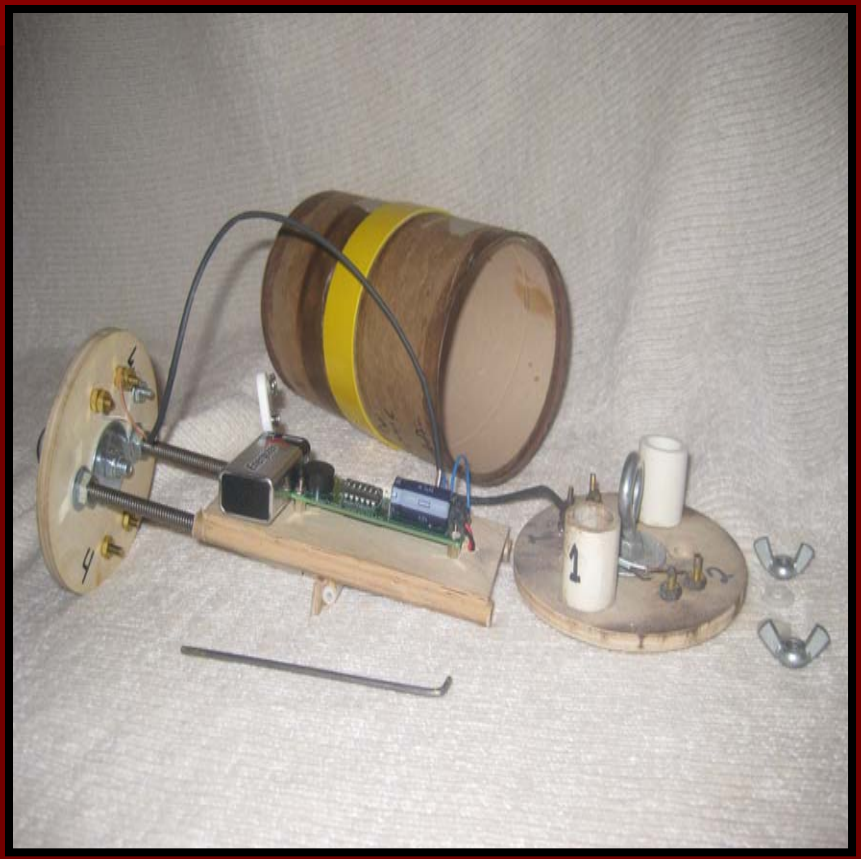
# PerfectFlite Flight Data



# Changes After Data Analysis

- We have worked extensively with Rocksim and changed the Coefficient of Drag to have the simulated launch altitude be very near the actual altitude.
- We matched the weather conditions in the simulation as closely as possible to the actual weather conditions of the flight on December 5, 2010.
- As a result, the CD has been changed to 0.57, which will override Rocksim's calculated CD.

# EBay with PerfectFlite MAWD Altimeter



# Dual Deployment Ground Test

Drogue and nose cone and drogue bay separating

Ground test demonstrated enough BP was used to separate the components but not place excessive stress as indicated by the extended by not stretched shock cord.

EBay (on right) and Main parachute separating

# Black Powder Calculations

| | | |
|---|---|---|
| Desired Pressure = | 15 | psi |
| mass BP = | 1.1 | grams |
| Ejection F = | 188.5 | lbf |

4Fg Black Powder Gas Properties

| | | |
|---|---|---|
| R = | 22.16 | ft*lbf/lbm/R |
| Tc = | 3307 | R |

m=PV/R/T

F=P*(pi/4)*d^2

Drogue Parachute

| | | |
|---|---|---|
| Volume = | 138.23 | in^3 |
| Dia = | 4 | inch |
| Length = | 11 | inch |
| mass BP = | 1.1 primary - 1.3 secondary | grams |

Conversions: 1 lb = 454 grams

1 oz = 28.3 grams

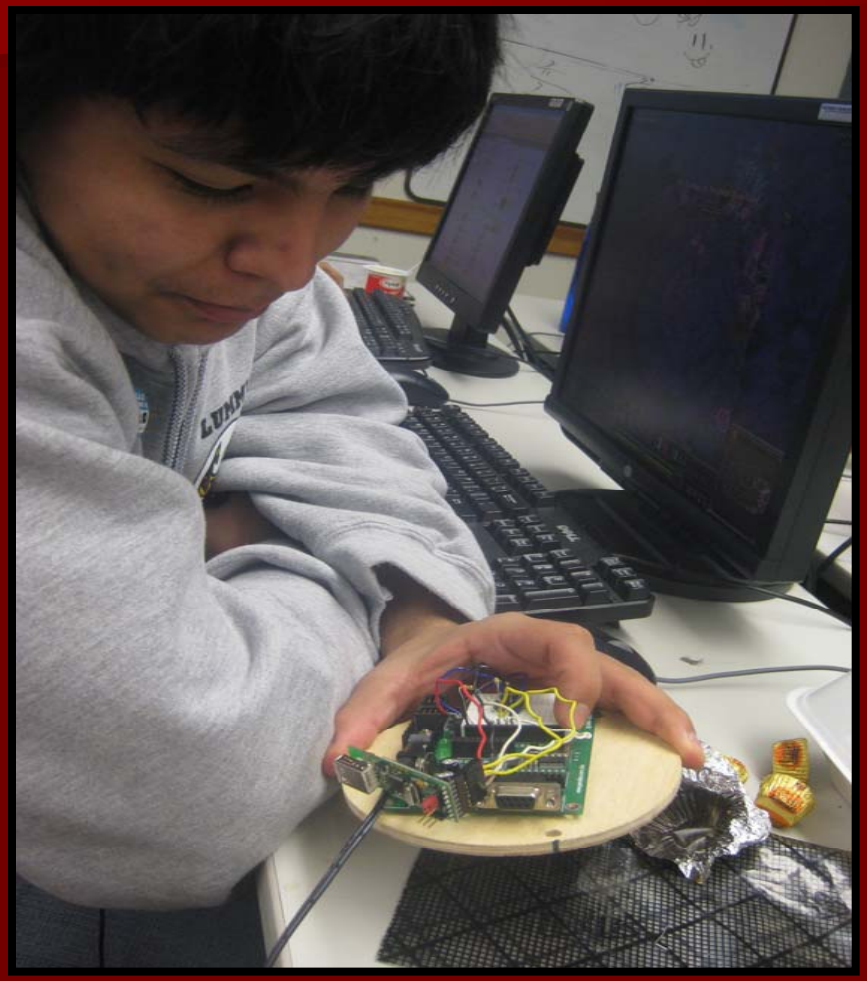
Main Parachute

| | | |
|---|---|---|
| Volume = | 251.33 | in^3 |
| Dia = | 4 | inch |
| Length = | 20 | inch |
| mass BP = | 1.9 primary – 2.1 secondary | grams |

**Black Powder Ejection Charge Calculator**

by Chuck Pierce

# Science Payload



Paul Ballew working on temperature/ pressure module

# Payload Integration Feasibility

- Easily integrated with the other subsystems.
- Each experiment is self-contained and independent of any other experiment.
- Multiple experiments give more students an opportunity to be involved.
- Makes the installation more flexible by making it easier to inspect and install several smaller devices rather than an integrated larger one.
- All of the components can be assembled before launch day.
- Instrument package can easily be installed into the sciene payload bay at any time.


Kiya Gorman working on payload bay

# Educational Engagement Plan Status

- Northwest Indian College Science Department High School students: February 5, 2011
- Lummi Nations School Grades 9-12 Demonstration: February 10, 2011
- Demonstration to Northwest Indian College students: February 24, 2011
- NAR Convention in Seattle, WA: March 12-13, 2011

# THE END