Sounding Rocket Working Group
January 14, 2004

NASA Sounding Rocket Operations Contract
(NSROC)

NASA Wallops Flight Facility

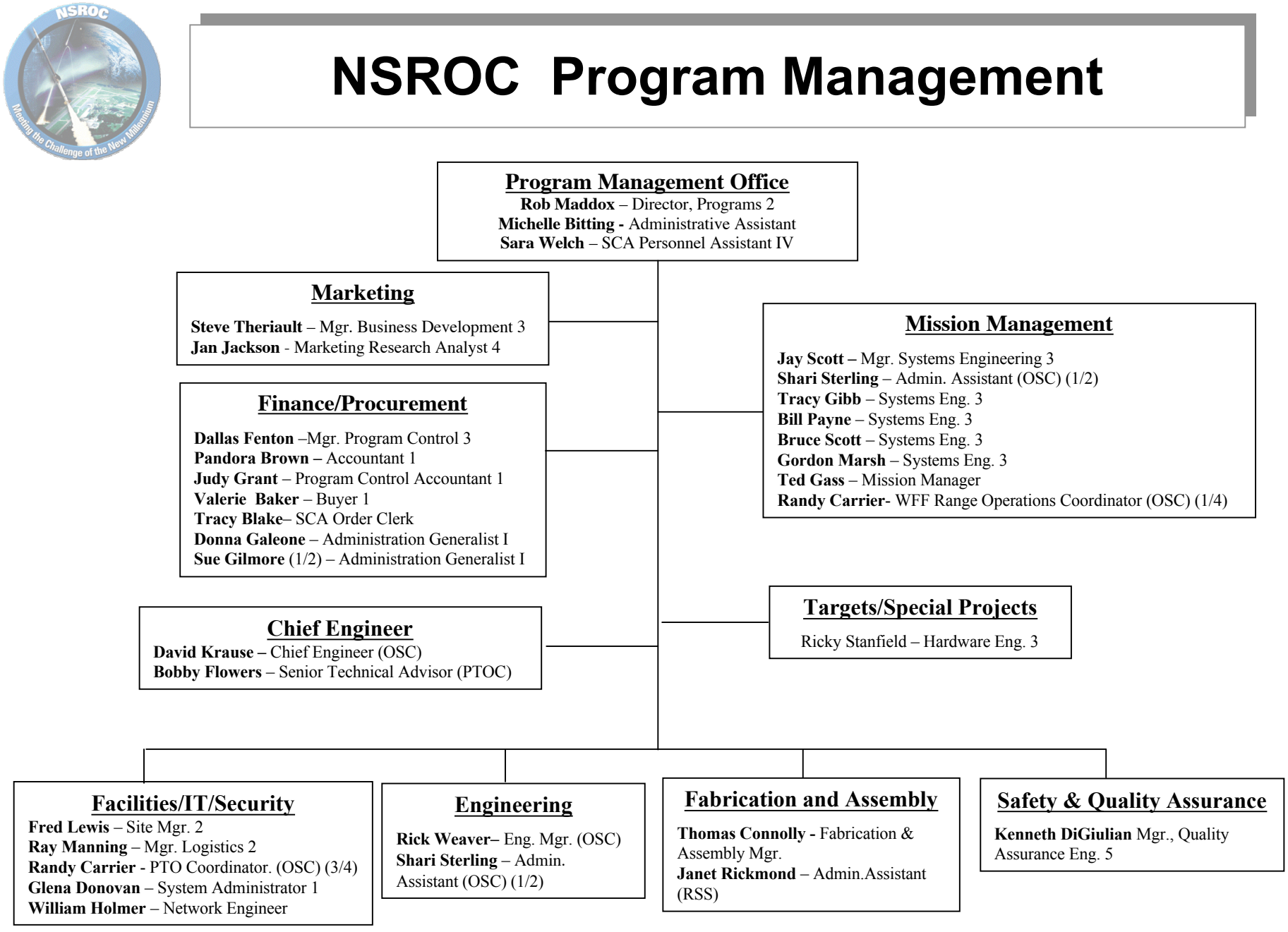
SRWG Agenda - NSROC

Introductions **NSROC State of Affairs** **Organization**	**Robert Maddox**
2003 Events of Note	**Dave Krause**
Engineering Efforts	**Rick Weaver**
Electrical	**Charles Lankford**
GN&C	**Walt Costello**
Summary	**NSROC**

Programmatic

- Contract Status
  - Completing 1st year in 1st option. 10 year contract is at the half-way mark.
- Subcontract Status
  - No significant issues. Plan to minimize Space Vector efforts in the coming year.
- Facilities/Plant Equipment
  - Increased capacity of milling centers with 2 new CNC milling machines
  - Upgraded thermal vac and vibration capabilities in the Test Lab
- Outreach
  - Developed and implemented Co-Op plan. Continued participation and support of the intern program and student missions.
- New Business
  - Continue marketing Wallops' assets. Several new missions and fabrication work is planned for FY04 and FY05.

NSROC Program Management

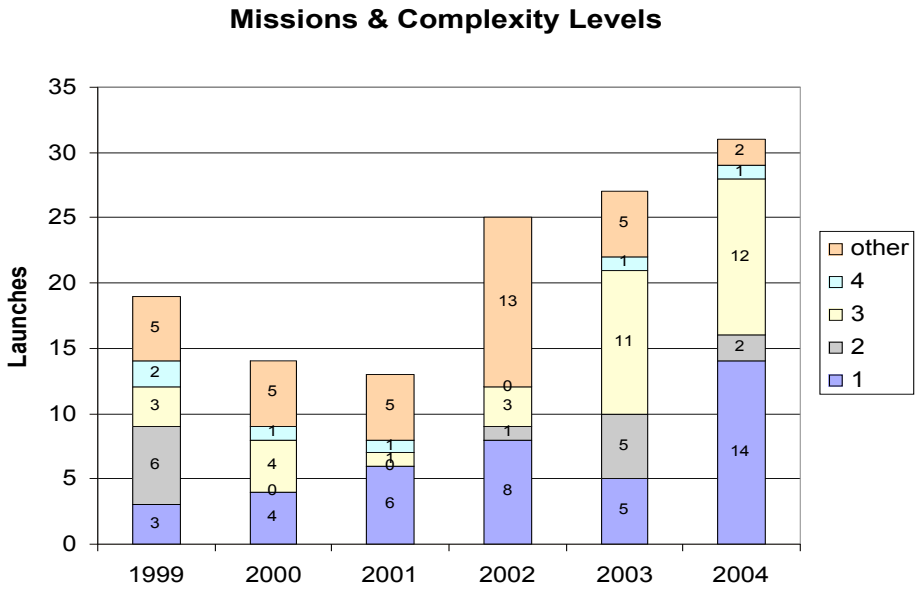


Programmatic

- Last Year's Accomplishments
  - Received Finalist Award for Goddard Contractor of the Year
    - Will submit application again this year
  - Received Goddard and NASA Group Award for 39 straight successful missions
  - Achieved registration to the new ISO 9000-2000 standards
  - Demonstrated New Technical Capabilities
  - Very High PEB Scores

Programmatic

- Next Year's Challenges
  - Implement new technology
    - Attitude Control Systems
    - New Vehicle Configurations
  - Demanding schedules
    - Remote campaigns
  - Complex missions
  - Budget



Quantity and complexity of missions increased in FY 03 and FY 04

2003 Events of Note – Dave Krause

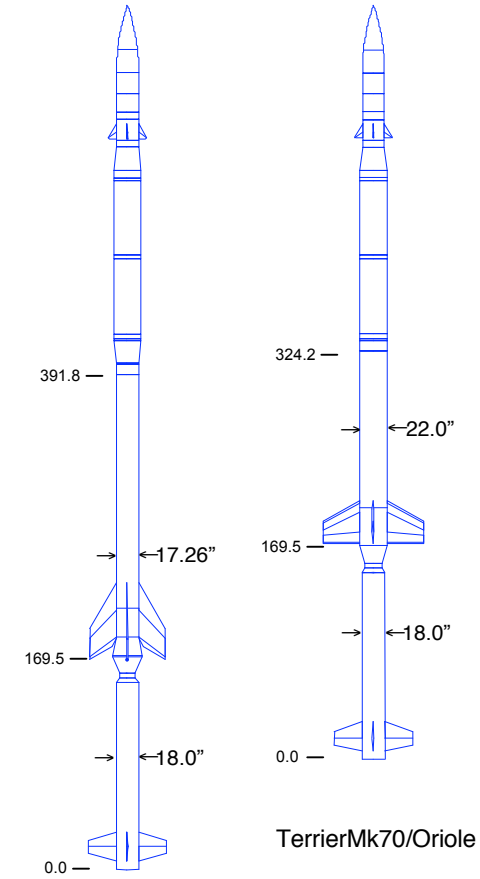
Missions Summary

Launch Vehicle Discussion

Technology Thrusts

2003 Anomaly Review

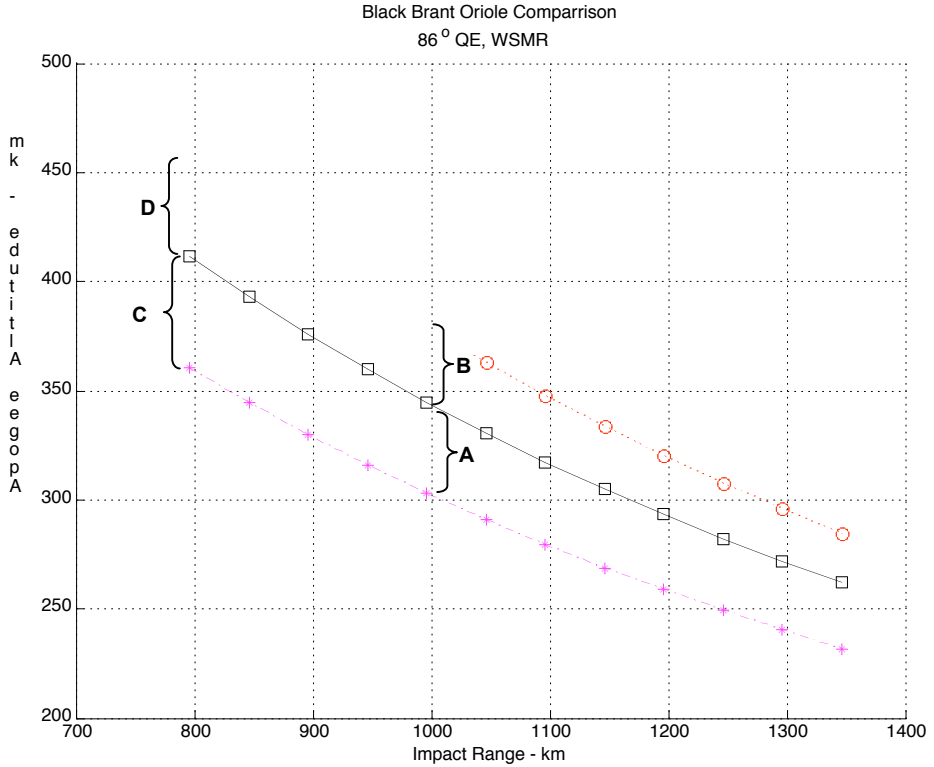
WSMR Launch Vehicle Comparison



Terrier Mk70/BB Mod2

Terrier Mk70/BB Mod2 Mk1

TerrierMk70/Oriole

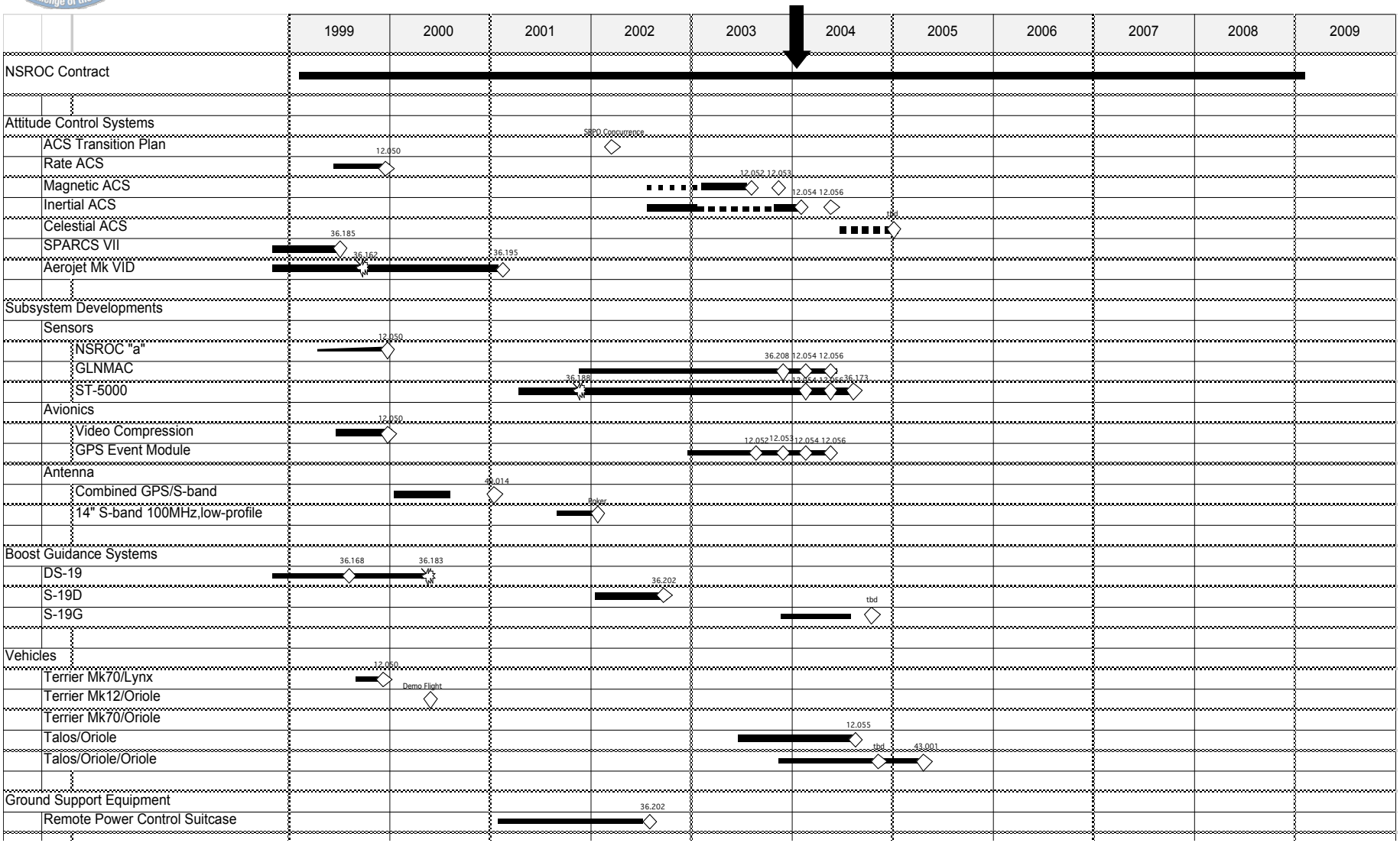


	Apogee	Time above 100 km
A	13.9%	21 sec
B	9.9%	10 sec
C	13.9%	23 sec
D	11.4%	29 sec

Efforts Required Prior to Oriole WSMR Flight Commitment

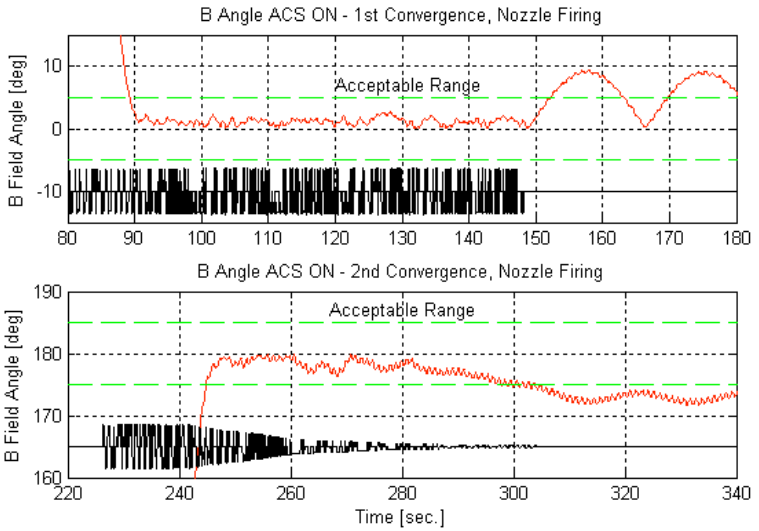
- **New FTS System Requires Qualification and Acceptance**
- **Boost Guidance System Requires SAAB Verification (or redesign to larger diameter envelope)**
- **Recovery System, ACS repackage (if larger diameter)**

Technology Thrusts



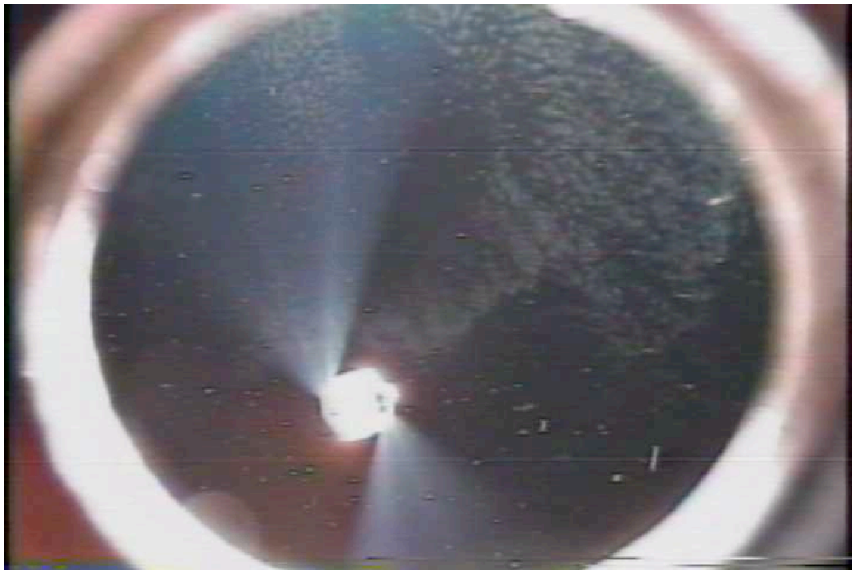
12.052 Mission Summary

- NSROC Magnetic Attitude Control System Technology Demonstration Mission
- Mission Objectives Achieved
- Payload aligned to Magnetic Field within 3° during all maneuvers during 1 Hz spin rate
- NMACS depleted gas supply following apogee alignment due to rate gyro anomaly
- Gyro Anomaly caused by excessive vibration induced during I&T
- Vibration sensor suite was included to assess flight dynamics for test specification analysis
- Iridium Piggyback was intended to lock and communicate with the Iridium satellite constellation



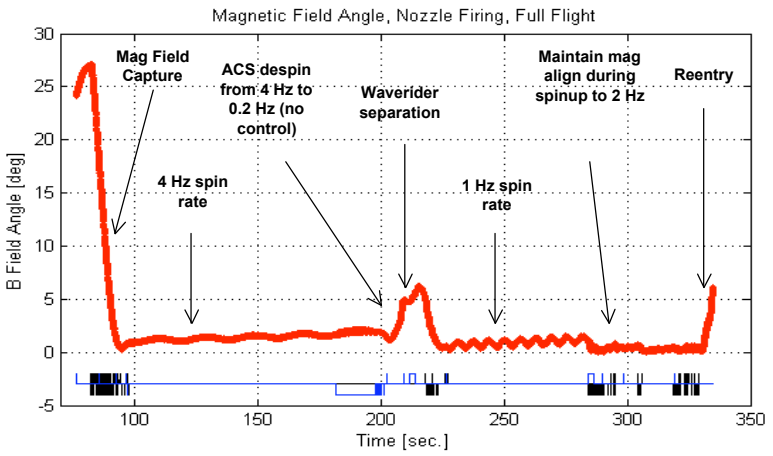
12.053 Mission Summary

- Primary Objective was NMACS alignment to mag field during multiple spin rates and control configurations (4Hz w/ I_r=78 & 1 Hz w/ I_r=6)
- Additional maneuver included spin-up from 1 to 2 Hz while maintaining mag field alignment
- All Mission Objectives Achieved
- NMACS Flight Qualified



- Vibration sensor suite was included to assess flight dynamics for test specification analysis

- NASA Ames Waverider vehicle was released at apogee



36.184/Moses Mission Failure

- Launch Date: December 5, 2003
- Location: White Sands Missile Range, NM
- PI: Dr. Daniel Moses, NRL

- Mission Anomaly: Early Indication is that the Optics Rotating Filter Mechanism Failed. The Mechanism has a Long Flight Heritage on Sounding Rockets and Satellites.

- Root Cause: Unknown, AIB at NRL underway

- Corrective Action: tbd

36.205 Recovery System Anomaly

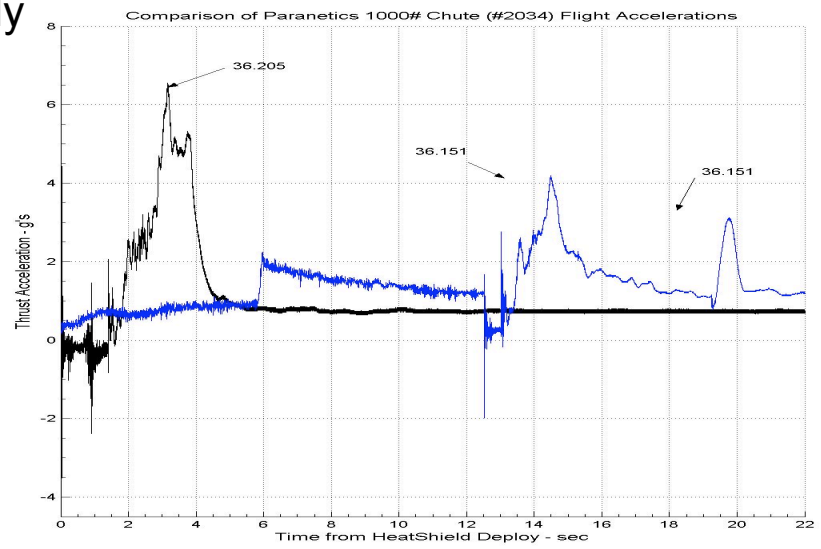
- Launch Date: December 5, 2003
- Location: White Sands Missile Range, NM
- PI: Dr. Thomas Woods, University of Colorado

- Mission Anomaly: Complete recovery sequence occurred in ~5 seconds. Payload was recovered undamaged (payload weight was 799 lbm)

- Root Cause: Staging line cutter(s) prematurely actuated releasing the main along with the drogue

- Corrective Action:

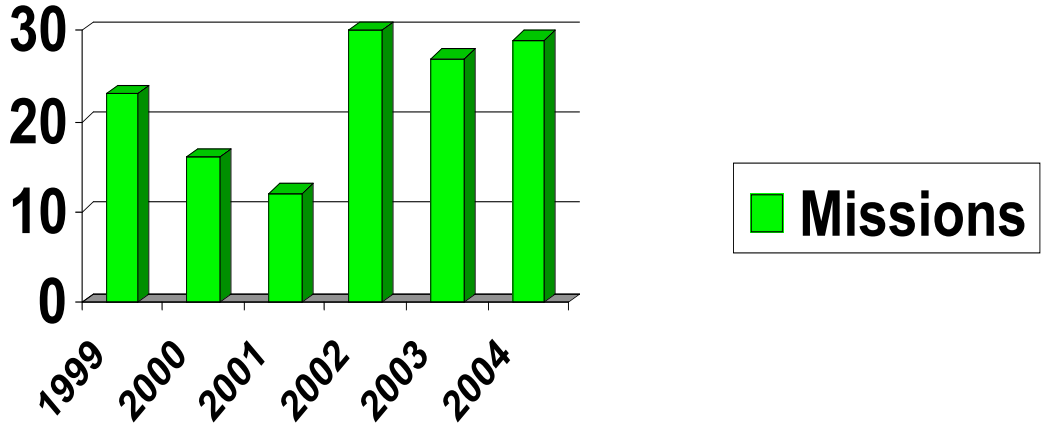
1. X-ray recovery systems at WSMR prior to flight.
2. Restrict handling to final install only. All I&T activities accomplished with dummy system.



Engineering - Rick Weaver

Mission Scheduling

Mission Manifest



- FY 03 missions that have slipped launch by 1 month or more 6/26 = 24%
- There was previous concern about resource conflicts due to missions slipping in small increments. This was reduced tremendously as four of the six missions slipped long-term, and the total number of slips decreased.
- FY04 should be the same as seven missions have launched and fourteen are scheduled for the Kwajalein campaign.
- Most are meeting or ahead of mission schedule.
- Only one FY04 mission has not had a Design Review.

Staffing

Contract Staffing Level

Current	168 FTE 5 Part time
Feb 1999	152 w/ 12 vacant positions
2003 Hires	20, increased total by 5.

The current launch operation schedule is busy, however OT has been minimal. This should continue through the Kwajalein campaign as long as Integration and Testing does not slip on the schedule.

We have 4 vacant positions that we have delayed filling.

Outreach Program

- In 4 years, program participation has grown from 2 interns from one university in 1999 to 12 interns from 7 universities in Summer of 2003, a Co-op Program began in January 2004 (5 students from 3 universities) and plans to expand the program to White Sands next summer. As part of this program, UVA, Penn State, Virginia Tech, Clemson and UA/F students are currently participating in our NSROC Intern/Co-op Program.
- PR from the first UVA Launch resulted in front page coverage in newspapers across Virginia – a major plus for NASA Wallops, NSROC, NGIT and UVA.
- The intern and co-op programs provide students a long-term opportunity to experience first hand and to make knowledgeable choices when they graduate. Some graduates of this program currently work for aerospace leaders, 4 are full time employees of NSROC Engineering.
- The NSROC Outreach Program supports the NASA/WFF SEM and Sub-SEM programs, provides presentations to 4H, Scout, and community groups from Pennsylvania to South Carolina; participates in job fairs and career days in Delaware, Maryland and Virginia; and represents NASA WFF at Science Fairs, Forensic Groups, and wherever else a WFF presence is required.

Performance Rating

- NSROC is graded on it's deliverables; Requirements Definition Meeting, Design Review, Mission Readiness Review, and Mission Closeout Report. The rating is on a scale of 1-5. Below is for FY03
- RDM – averaged slightly above a 4.5 (91%)
- DR - averaged slightly above a 4.5 (91%). One mission rated a 3.
- MRR - averaged a 4.4 (89%). One student mission rated a 2.
- MCR - averaged a 4.6 (92%).
- Science Requirements Packages are being completed, providing more concise information.
- Preliminary Design Reviews were held on complex missions.
- The SRP's and PDR's have helped the design process as they have identified design concerns and actions needed.

Performance Rating

- NSROC has internal performance tools.
- Electrical inspection acceptance average rate was 94.1%.
- Mechanical inspection acceptance average rate was 95.97%.
- 334 NCRs were generated. Most mission related NCRs were closed out prior to the affected mission's MRR. Very few were kept open after missions were completed.
- Significant NCRs that affect other payloads or refly payloads are elevated to the Corrective Action Tracking System (CATS)
- The CATS process has demonstrated a positive improvement in utilization. 30 Corrective Actions were created.
- These tools lead to a more efficient, effective quality product.

Electrical – Charles Lankford

Program Enhancements

GPS Event Module (GEM)

System Capabilities

- 15 Programmable Events with 12 Event Input Backup's
- Upleg, Apogee and Downleg Control
- 1 KM or Better Altitude Accuracy
- Flight proven micro-controller and driver electronics used

System Status

- Unit 1 Incorporated in 12.052 and successfully flown on August 1st
- Unit 2 Incorporated in 12.053 and successfully flown on October 24th
- Unit 3 incorporated in 12.054 and slated to fly in Feb 04'
- Following successful operation in 12.054 the GEM will be considered fully qualified

Program Enhancements

12.052 GPS Event Module (GEM) Flight Data Results

EVENT	GPS Driven			MFT(B/U)	Latency of GPS Driven Output--Error	
	Time	Altitude	Vertical Velocity	Time	Delta Altitude	Delta Time
GEM Event 1 (50 km)	48.582	? **50.312 km**		58.202	? 312 meters	0.18
Up Leg	48.6	50.343 km	1697.9 m/sec			
GEM Event 2 (60 km)	54.582	? **60.323 km**		64.202	? 323 meters	0.2
Up Leg	54.6	60.353 km	1640.3 m/sec			
GEM Event 3 (70 km)	60.782	? **70.306 km**		75.202	? 306 meters	0.19
Up Leg	60.8	70.334 km	1581.7 m/sec			
GEM Event 4 (80 km)	67.282	? **80.378 km**		85.223	? 378 meters	0.25
Up Leg	67.3	80.405 km	1519.1 m/sec			
GEM Event 5 (90 km)	73.982	? **90.342 km**		95.223	? 342 meters	0.23
Up Leg	74	90.368 km	1457.5 m/sec			
GEM Event 6 (100 km)	80.982	? **100.309 km**		105.223	? 309 meters	0.22
Up Leg	81	100.334 km	1391.3 m/sec			
GEM Event 7 (110 km)	88.383	? **110.344 km**		120.223	? 344 meters	0.26
Up Leg	88.4	110.367 km	1324.4 m/sec			
GEM Event 8 Apogee	231.984	**204.529 km**		235.224	? 0 meters	?0.30
(204.7529 km)@ +231.7	232	204.529 km	-2.498 m/sec			
GEM Event 9 (120 km)	367.585	? **119.747 km**		370.245	? 253 meters	0.2
Down Leg	367.6	119.728 km	-1252.7 m/s			
GEM Event 10 (110 km)	375.386	? **109.690 km**		378.246	? 310 meters	0.23
Down Leg	375.4	109.672 km	-1325.2 m/s			
GEM Event 11 (100 km)	382.786	? **99.622 km**		385.246	? 378 meters	0.27
Down Leg	382.8	99.602 km	-1395.8 m/s			
GEM Event 12 (90 km)	389.786	? **89.622 km**		392.246	? 378 meters	0.26
Down Leg	389.8	89.602 km	-1461.0 m/s			
GEM Event 13 (80 km)	396.486	? **79.617 km**		N/A	? 383 meters	0.25
Down Leg	396.5	79.596 km	-1525.4 m/s			
GEM Event 14 (70 km)	402.886	? **69.665 km**		N/A	? 335 meters	0.21
Down Leg	402.9	69.643 km	-1585.0 m/s			
GEM Event 15 (60 km)	409.086	? **59.662 km**		N/A	? 338 meters	0.21
Down Leg	409.1	59.639 km	-1639.6 m/s			

Program Enhancements

12.053 GPS Event Module (GEM) Flight Data Results

EVENT	GPS Driven			MFT(B/U)	Latency of GPS Driven Output--Error	
	Time	Altitude	Vertical Velocity	Time	Delta Altitude	Delta Time
GEM Event 1 (35 km)	81.263	? **88.33 km***		43.23	? 53.3 km*	47.4*
Up Leg	81.3	88.372 km	+1124 m/sec			
GEM Event 2 (67.3 km)	81.263	? **88.33 km***		66.23	? 16 km*	14.2*
Up Leg	81.3	88.372 km	+1124 m/sec			
GEM Event 3 (100.7 km)	92.983	? **100.896 km**		94.23	? 196 meters	0.19
Up Leg	93	100.913 km	+1016 m/sec			
GEM Event 4 Apogee	202.48	? **156.213 km**		217.25	? 0 meters	?0.30
(156.213 km) @ +202.2	202.5	156.213 km	0 m/sec			
GEM Event 5 (143 km)	255.68	? **142.892km**		302.25	? 108 meters	0.22
Down Leg	255.7	142.883 km	-496 m/sec			
GEM Event 6 (127.7 km)	280.68	? **127.552km**		320.25	? 148 meters	0.2
Down Leg	280.7	127.539 km	-725 m/sec			
GEM Event 7 (122.2 km)	116.68	? **122.343 km**		117.23	? 143 meters	0.18
Up Leg	116.7	122.360 km	+796 m/sec			
GEM Event 8 (141 km)	145.08	**141.128 km**		114.23	? 128 meters	0.24
Up Leg	145.1	141.140 km	+530 m/sec			
GEM Event 9 (70 km)	338.48	? **69.677km**		369.25	? 323 meters	0.25
Down Leg	338.5	69.649 km	-1270 m/s			
GEM Event 10 (20 km)	28.473	? **20.207 km**		30.23	? 207 meters	0.19
Up Leg	28.5	20.237 km	+1105 m/s			
GEM Event 11 (37.7 km)	362.08	? **37.440 km**		390.25	? 260 meters	0.19
Down Leg	362.1	37.409 km	-1405 m/s			
GEM Event 12 (105.5 km)	306.78	? **105.311 km**		341.25	? 189 meters	0.19
Down Leg	306.8	105.289 km	-972 m/s			
GEM Event 13 (200 km)	**	**	**	N/A	**	
Up Leg						
GEM Event 14 (200 km)	202.68	? **156.212km**		N/A	? 43.788 km***	
Down Leg	202.7	156.212 km	*** 0 m/s			
GEM Event 15 (20 km)	376.07	? **19.827 km**		N/A	? 173 meters	0.19
Down Leg	376.1	19.799 km	-900 m/s			

Notes: * Loss of GPS lock from altitude 30.160 km to 88.330 km on ascent.

** This altitude was not reached, so event never fired since it was an up-leg event

*** This altitude was not reached, so event fired at apogee, since it was a down-leg event.

Program Enhancements

GPS Receiver Engineering Test Flight

Test Flight Results

- PSL purchased a Javad model JNS100 GPS receiver for one of their upcoming WSMR supported missions and asked NSROC for possibility of Engineering Test Flight opportunity.
- NSROC was able to incorporate the unit into mission 41.024 Erdman flown at WSMR on July 15th, 03.
- Review of the Javad receiver data indicates data loss early in the flight similar to that experienced with the Ashtech unit. NSROC EE group feels that the Javad GPS receiver **will not improve** our acquisition problems encountered on Terrier-Improved Orion vehicles.

Future Efforts

- Available GPS trade information indicates Parthus makes a receiver rated to operate at much higher accelerations and plans to pursue evaluation of such a unit.

Program Enhancements

Low Cost PCM Encoder & S-Band Transmitter

Capabilities/Specifications

PCM Encoder

- 32 Analog Inputs with 16 Bits/Word resolution
- 32 Digital Inputs or Outputs
- 1 Asynchronous Input with rates up to 115.2K baud
- Input power voltage range from +10 to +36 Volts
- Stackable for future expansion

S-Band Transmitter

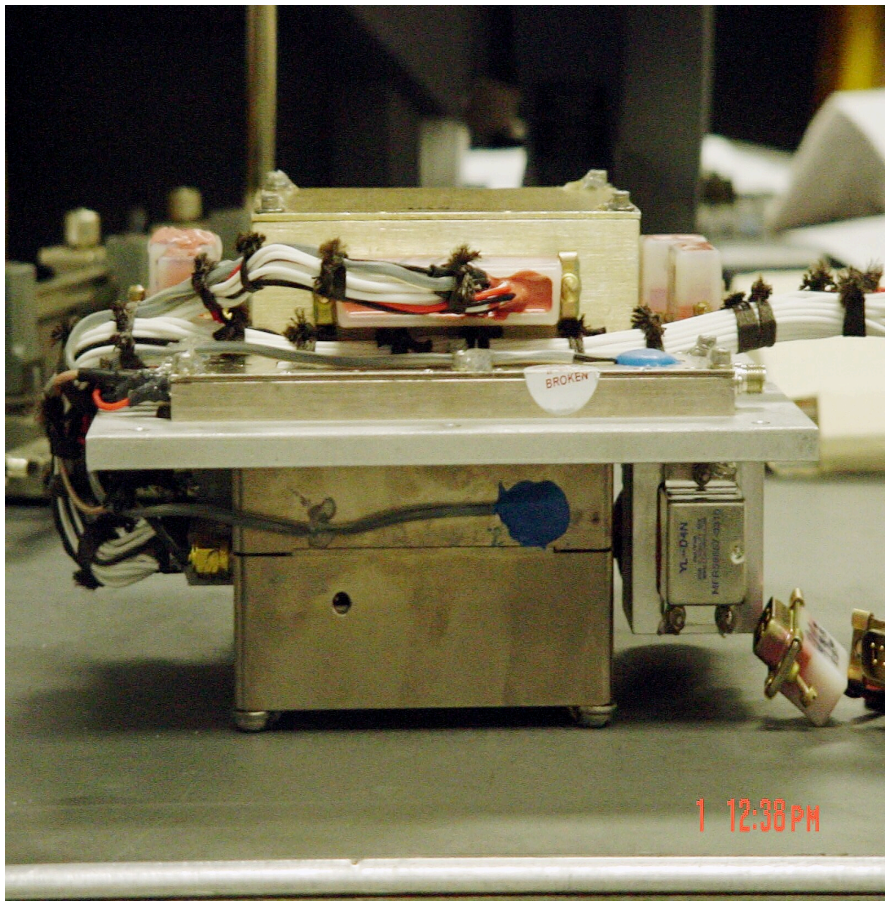
- 1 Watt Minimum RF Output
- 6 MHz Frequency Response
- Input power voltage range from +9 to +15 Volts High Efficiency

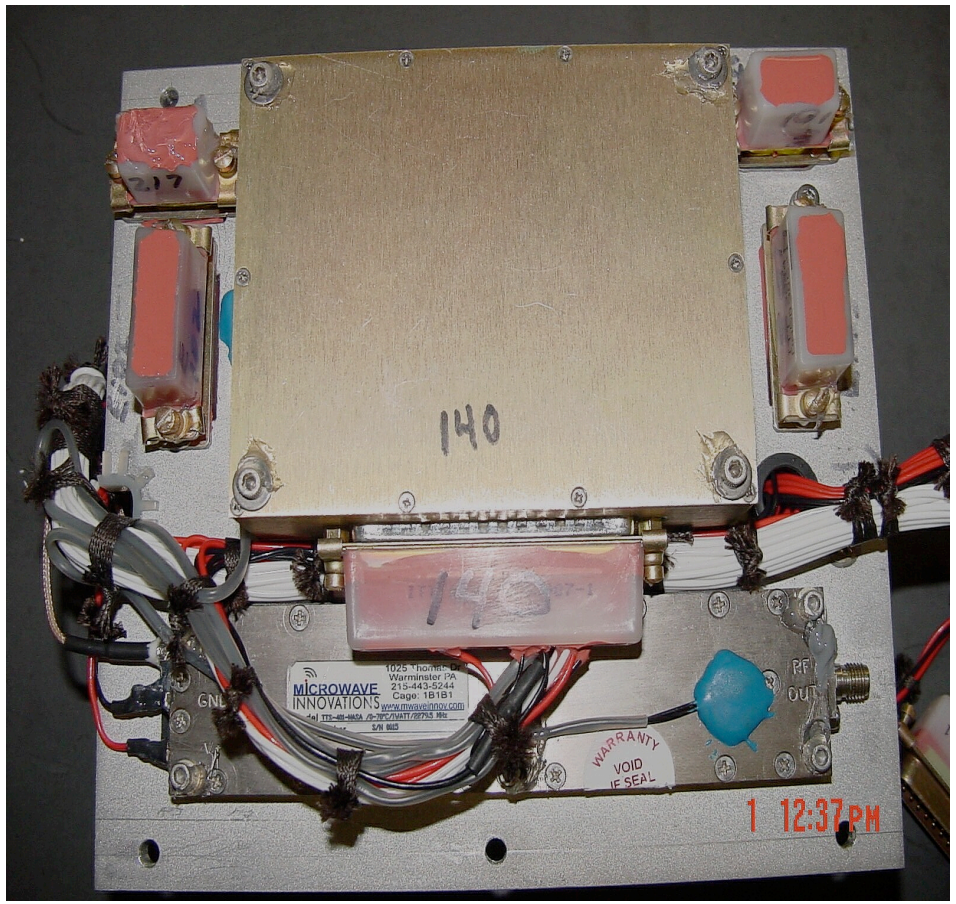
Status

- Incorporated into 12.053 Murbach Waverider system as Engineering Test Flight and successfully flown on October 24th
- Serial Digital and Time Event Input capability being added to existing module
- Add-on expansion capability planned to be completed by June 04’

Program Enhancements

Low Cost PCM Encoder & S-Band Transmitter





Program Enhancements

Low Cost PCM Encoder & S-Band Transmitter

Program Enhancements

Magnetic Test Facility Remote Field Offset Adjust

Problem

- Drift's/changes in Earth's local magnetic field due to magnetic substorms causing problems during magnetometer calibration.

Solution

- Locate reference magnetometer outside of magnetic test facility building to sense changes in the local magnetic field.

Status

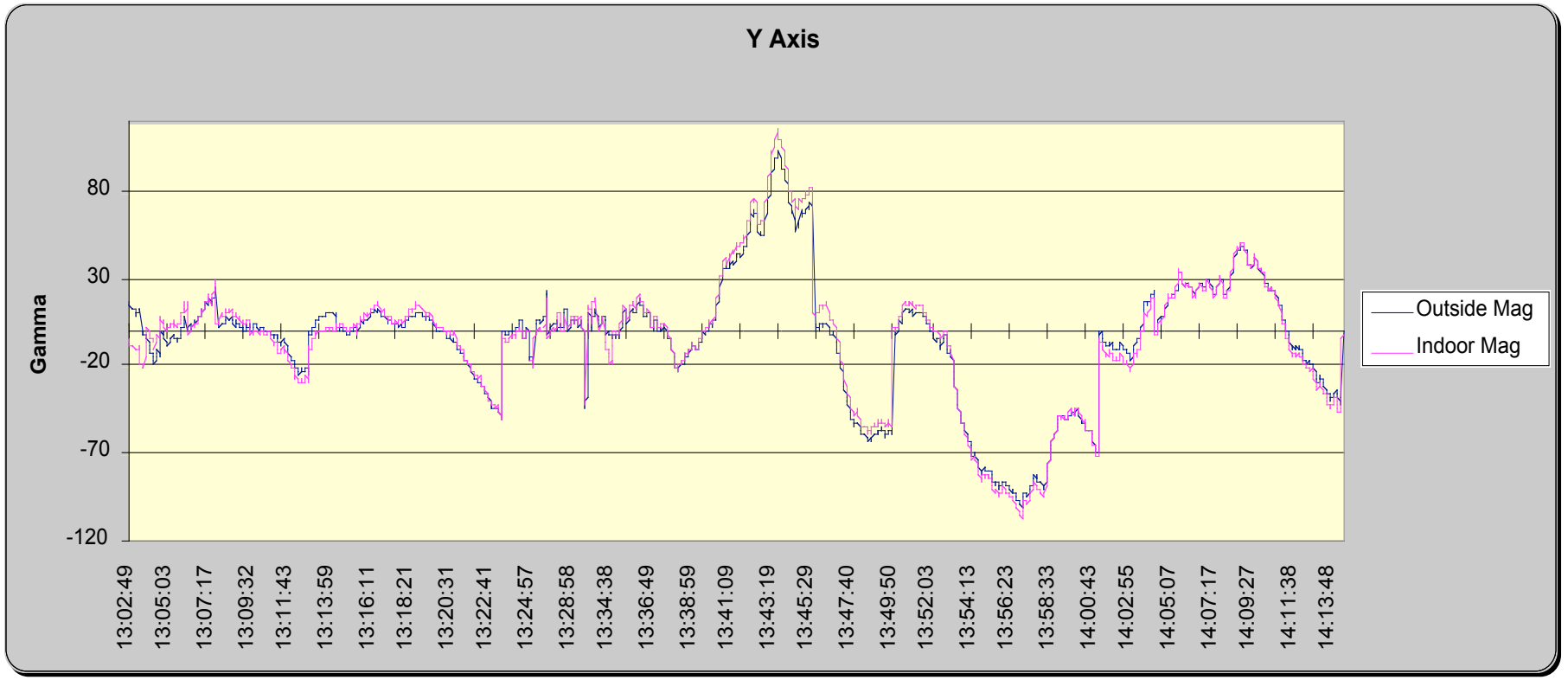
- Hardware and software installed and tested.
- Manual intervention currently required for facility field re-zeroing but can be changed to automatic once NSROC has full confidence in system operation.

Program Enhancements

Magnetic Test Facility Remote Field Offset Adjust

Program Enhancements

Magnetic Test Facility Remote Field Offset Adjust



Program Enhancements

Test Rocket S-Band Beacon

Problem

- Poor TM antenna tracking performance at Poker Flat, Alaska in Winter 2002 as well as similar TM tracking problems at other ranges needs resolution.

Solution

- Provide a low power low cost S-Band radiator in the test rockets (2.75 “) currently used by Radars to verify they are flight ready.

Status

- NSROC worked with a proven RF Engineering firm to develop a 100 milliWatt S-Band Beacon for integration into the test rocket
- NASA tasked via a PTO for NSROC development of the Beacon package
- The RF Engineering firm developed the 100 mWatt transmitter and power regulation system and identified several potential antennas.
- NSROC developed the power supply, control system and PCM system simulator section of the beacon and tested two configurations of antenna mounting.
- The RF Engineering firm integrated and packaged three sets of hardware and shipped to NSROC in November 2003.

Program Enhancements

Test Rocket S-Band Beacon

Program Enhancements

Programmable Timing Signal Buffer Module

Issue

- Some missions require large number of Frame Sync, Minor Frame Sync, Word Clock and Bit Clock signals requiring multiple Time Event PCM decks. Missions 21.132 & 21.133 would require 4 Time Event decks each.

Proposed Solution

- NSROC EE had PSL develop a new programmable timing signal buffer module that can provide up to 16 programmable outputs per deck.

Program Benefits

- On missions 21.132 & 21.133 the new module will replace three Time Event decks saving cost (~$4500 per payload) and PCM system height (1.125”).

Program Enhancements

Airborne Bit Sync and PCM Decommutator

Issue

- Current user uplink command capability is limited to a single channel at 1200 baud communication rate

Expanded & Enhanced Capability

- NSROC EE has purchased new airborne bit sync/decom hardware that will allow up to 4 asynchronous channels (1 ACS command & 3 user channels) at baud rates totaling up to 200 K BPS maximum. ACS command rate is currently 1200 baud thus leaving considerable capability for the remaining 3 data channels.
- NSROC is planning to fly this new hardware on 12.054 and 12.056 later this year.

Program Benefits

- This new capability will allow much greater Experimenter command uplink control of their instruments.

Proposed Program Enhancements

High Efficiency/Small Footprint S-Band Transmitters

Issues

- NSROC EE currently must use a 10 Watt wideband transmitter for any PCM system operating over 2 M BPS
- The current 10 Watt transmitter generates ~75 Watts of heat which must be dissipated typically with more massive decks.
- Current narrowband transmitters (T700 series) are fixed frequency and require stocking of 10 plus different frequencies

Proposed Solution

- Proven RF Engineering company has worked with NSROC EE to develop specs for a high efficiency (~3X improvement) transmitter with either 2 or 5 Watts RF output, support up to 10 M BPS PCM bit rate, frequency agile, smaller footprint than current 2 & 5 Watt units and accept both low voltage or the standard +28 volt power input.

Program Benefits

- Reduction in battery pack size & weight, reduction in mounting deck mass, capable of supporting small diameter payloads, reduction in number of transmitters required to be stocked in inventory.

GNC – Walt Costello

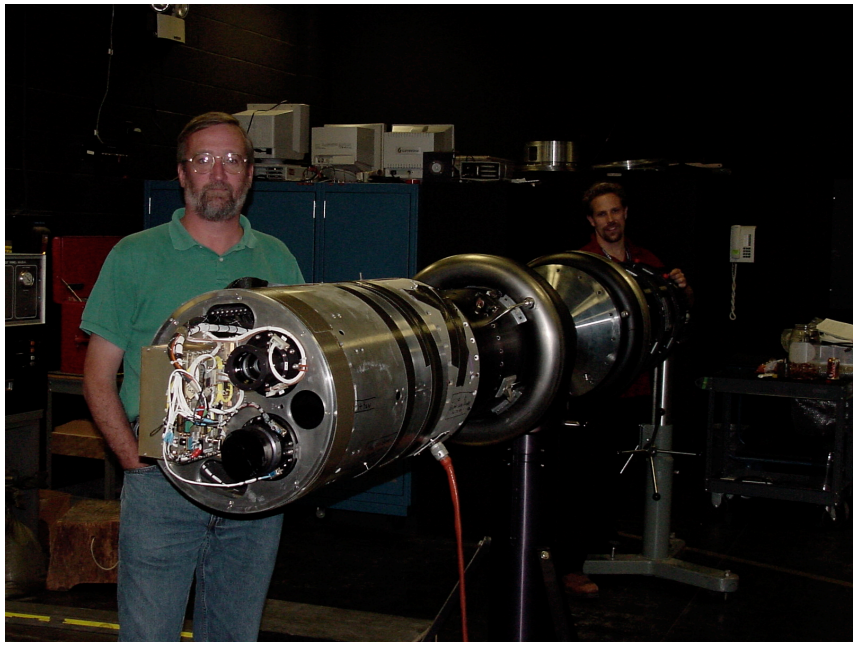
GNC Accomplishments

- Successfully flew two magnetic NMACS
- Successful performance of GLN-MAC on Feldman 36.208
- Successful Closed-Loop ST-5000 Air Bearing Test with AeroJet Mk VI-D ACS System at Wallops Island
- Two GLN-MAC-200 have been manufactured at Wallops Island
- Successful Operational Implementation of “Direct To Guide Star” Maneuver on AeroJet Mark VI-D ACS
- Successful Operational Implementation of NSROC(a) Attitude Determination System

GNC Plans

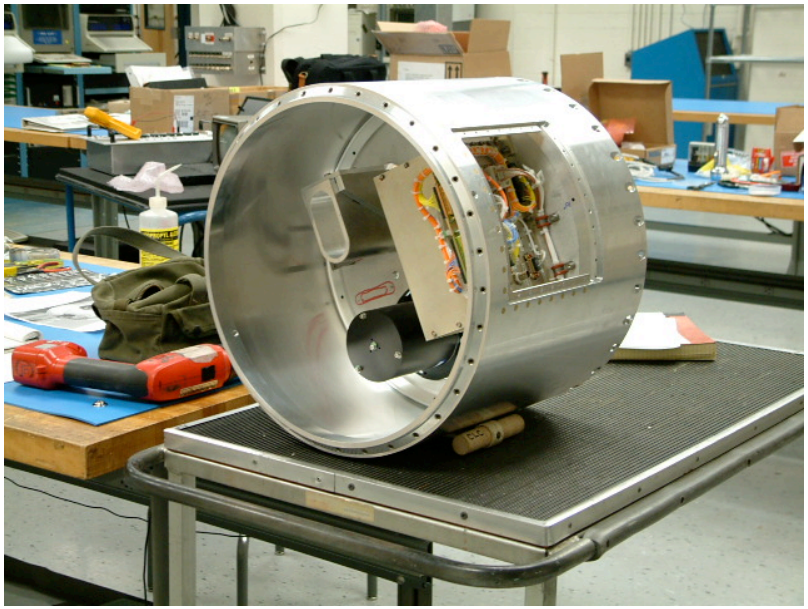
- The First Operational NMACS is now in the field on Kintner 35.035 at Svalbard
- An Inertial NIACS and ST5000 will fly next month at WSMR
- The NIACS and ST5000 will fly again this summer
- A Users Manual for performing Post-Flight Data Analysis is being developed
- The ST-5000 will close the loop next September on Nordsieck 36.173 and on Cruddace 36.207 in 2005

ST-5000 Air Bearing Test



Confirmed AeroJet MK VI-D ACS control using the multi-star ST5000 tracker. Testing also showed ACS nozzle firings were <20% of firings while controlling with the Ball single-star tracker.

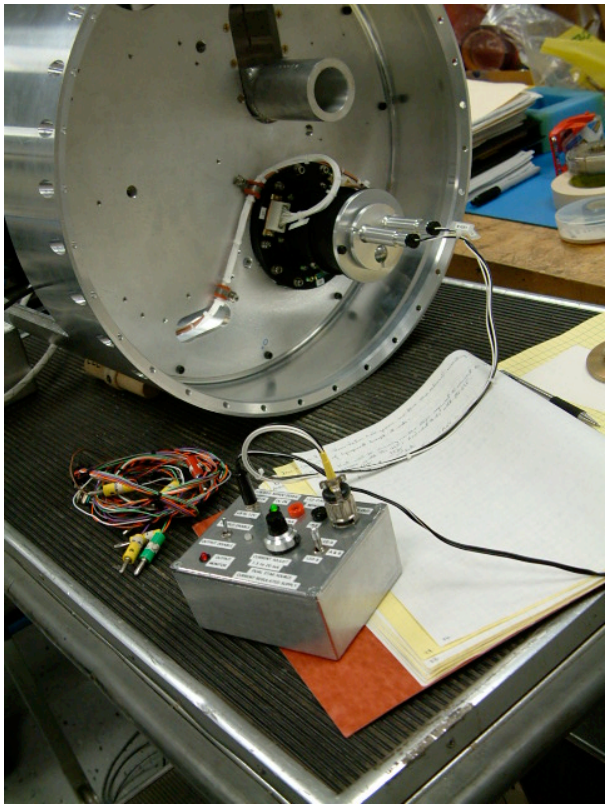
ST-5000 Star Tracker



ST5000 tracker installed in skin for next month's NIACS launch at WSMR.

ST-5000 Star Tracker

ST5000 tracker with
a two-star simulator.



Conclusions

- NSROC Is Committed to Continuing the Mission and Program Successes
- Satisfying the Code S PI Mission Requirements Is Still NSROC's Primary Goal
- NSROC Is Committed in Expanding the Technical Innovations While
  - Maintaining a Cost Effective Environment
  - Meeting the Success Requirements of the PIs
  - Making Effective Use of the In-House Talent and Experience
- NSROC's Receipt of the SRWG Findings Is Important for Future Growth Planning