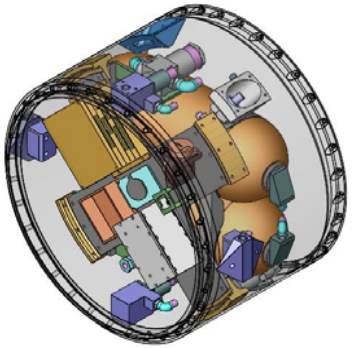
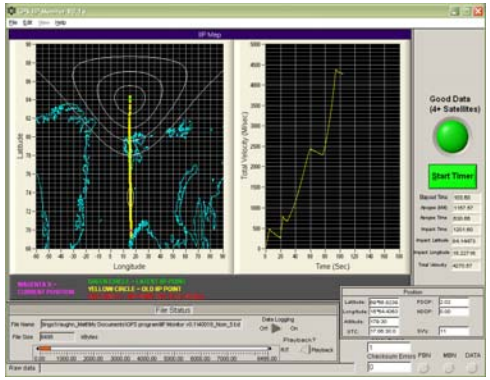


Sounding Rocket Working Group
July 1, 2008

NASA Sounding Rocket Operations Contract (NSROC)



Wallops Flight Facility

SRWG Agenda - NSROC

NSROC State of Affairs	Rob Maddox
Director of Engineering	Ricky Stanfield
Electrical Engineering	Shelby Elborn
Mechanical/Vehicle Engineering	Giovanni Rosanova
Guidance, Navigation & Control	Ron Kiefer
Conclusions	Rob Maddox

Program Manager

Rob Maddox

NSROC Programmatic

- Contract Status
  - Approaching mid point of year 10
  - Preparing for NSROC II
  - Proposal activities will not disrupt operations
  - NGTS fully supportive of this program
- Financial Accounting Status
  - NGTS transitioned to One Source SAP financial accounting system in January 2008
  - Most issues are now resolved, however a few minor issues still emerge and are quickly corrected
- ITAR
  - Most TAA's are progressing well
  - We are closely tracking a few TAA's for missions integrating in July

NSROC Programmatic

- Subcontract Status
  - Bristol
    - Black Brant motors being delivered now
    - Recently placed additional order for Black Brants and Nihkas
  - Saab
    - S-19 Refurbishments are on track
    - Possibly more S-19L conversions in FY 09
  - Univ. of Wisconsin – Ongoing support for ST5000
  - PSL – Ongoing support for instrumentation and ground stations at WSMR
  - Anderson Metals –Significant orders placed for nosecones and ancillary hardware
  - Working closely with NASA contracts and SRPO to assure adequate hardware inventories available for contract transition
    - Received contract mod to deliver hardware up to 1 year beyond end of contract (evergreen clause)

NSROC Programmatic

- New Business Opportunities
  - US Navy Aegis JFTM 2 – Two Terrier Oriole missions
  - US Navy Aegis PAC-BLITZ – Two Terrier Orion missions
  - USAF Airborne Laser – 10 BBIX missions, Black Brant motor procurement
  - USAF Airborne Laser – Five Terrier Lynx missions
  - US Navy Aegis ARAV C – One Talos/Castor I mission
  - US Navy SCSC Fleet Training Rockets – WFF launch opportunities
  - Langley/ATK – Hybolt mission support
  - US/Australian HIFIRE 2 and 6 Missions
- NSROC new business marketing efforts have slowed due to the end of NSROC contract. Most reimbursable work realized now is from returning customers

NSROC Programmatic

- Student Outreach/Intern & Co-op Programs
  - 2007 (Spring 5; Summer 10; Fall 4)
  - 2008 (Spring 4; Summer 12; Fall 5)
  - 83 students from 10 universities have participated in this program (filling 71 intern and 34 co-op positions); many have worked 9-15 months with NSROC. NSROC has hired 8 Intern/Coop graduates as full time engineers; 2 have achieved Doctorates; 10 have achieved Masters Degrees; 9 others are currently pursuing Masters Degrees and 2 are pursuing a Doctorates.
  - ESCC Intern Program: 6 ESCC students have been hired as interns; 3 have been hired as FTE Techs. 2 of the FTE's are pursuing BSE degrees.

Director of Engineering

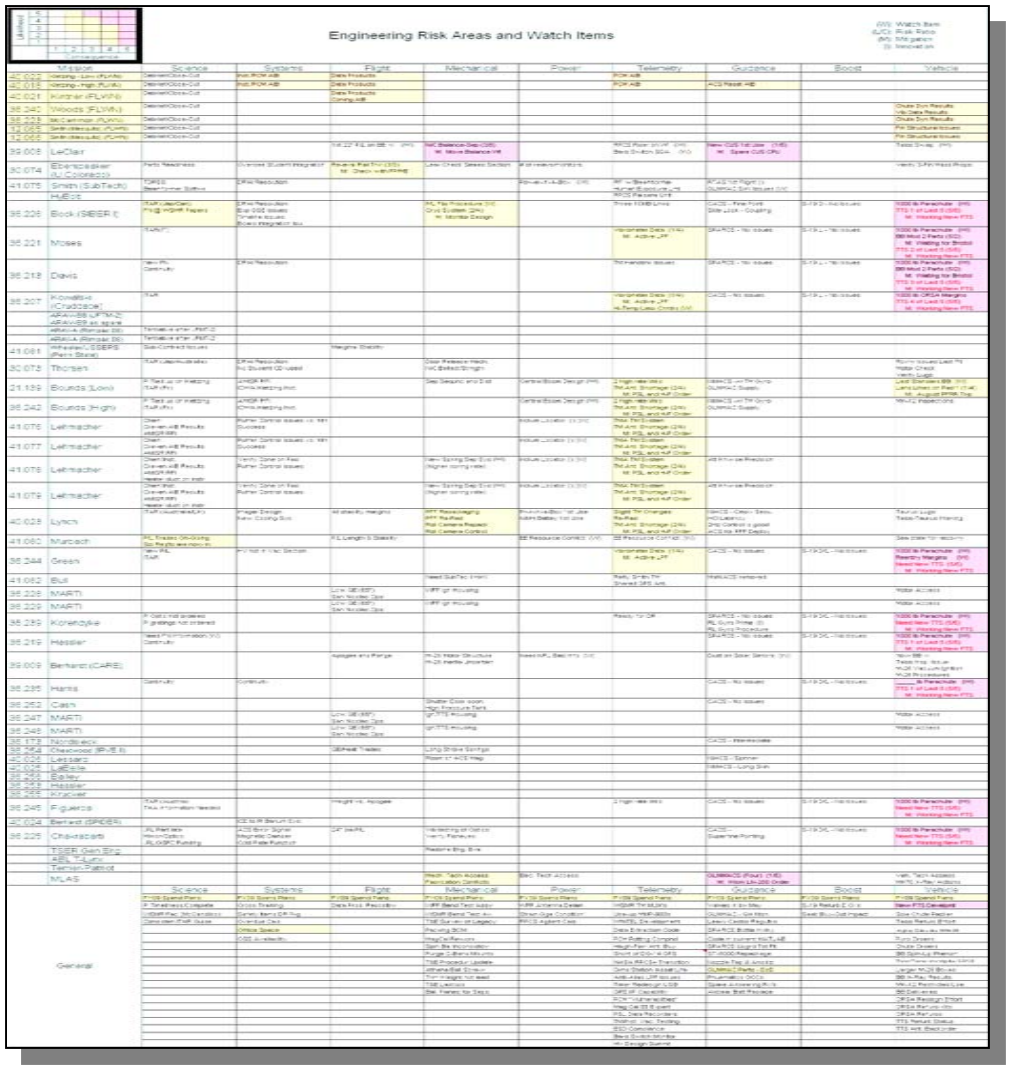
Ricky Stanfield

“Corporate Memory” and Engineering Robustness

- The NSROC Team, SRPO, and the Scientists are united in the pursuit of successful missions and payloads
  - Complete and timely understanding of requirements
  - Experienced engineers, technicians, and machinists
  - Knowledgeable and engaged Principal Investigators and Scientists
  - Effective design and analysis tools
  - Solid experience driven design practices
  - Good use of configuration management, knowledge base, and lessons learned
  - Effective communication within NSROC and with the Science community
  - Continuity and focus of the entire mission team
- The NSROC Contractor Team is continuing to work towards these objectives
  - Effective use of Requirements Matrices to define expectations and track approaches
  - Recruiting, training, and retention of engineers and technicians
  - Timely and continuous interaction with the Science Team, with an open invitation to be of assistance with design or implementation challenges (e.g. Bound PDR)
  - Recent upgrades to SolidWorks and Virtual NASTRAN Analysis Tools, and pending upgrades in OrCAD
  - Continuing to implement our Risk Tracking Summary and Lessons Learned processes to anticipate and mitigate errors, and prevent repeated mistakes
- Working together, we can keep projects on schedule for the stability of the entire staff, and to maintain technical continuity, focus, and “inertia”

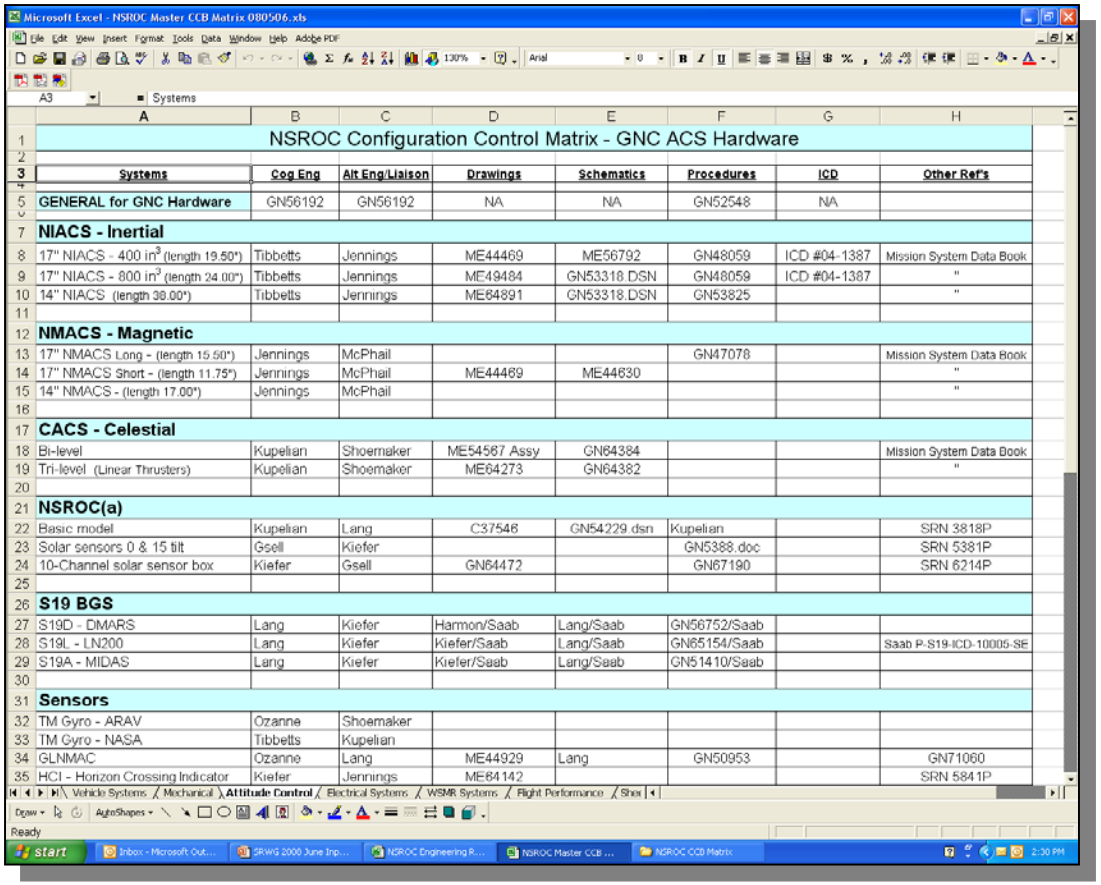
Risk Identification and Tracking

- Continued to use the NSROC engineering risk summary as a risk identification and tracking tool
  - Used to identify risks by mission and engineering discipline
  - Tracks issues to closure
  - Tracks trends by department across all missions
  - Brief and concise
- Matrix is updated after weekly Technical Staff Meetings
  - Reviewed with engineering leads monthly
  - Provided to SRPO as reference
- Proven to be an effective summary to maintain situational awareness
  - Expanded to include likelihood consequence ratio and mitigation plan



Configuration Control Matrix

- NSROC continues to populate the Configuration Control Matrix
  - Applies to all NSROC standard systems and processes
  - Captures top level defining documents and cognizant engineer
  - Top level documents reference subordinate documents
  - CCB Panel meets once each month to update one engineering discipline
  - Shared with SRPO as a reference
- CCB serves as a forum for focused systems engineering discussion of every standard system



NSROC Configuration Control Matrix - GNC ACS Hardware

Systems	Cog Eng	Alt Eng/Liaison	Drawings	Schematics	Procedures	ICD	Other Ref's
GENERAL for GNC Hardware	GN56192	GN56192	NA	NA	GN52548	NA	
NIACS - Inertial							
17" NIACS - 400 in^3 (length 19.50")	Tibbetts	Jennings	ME44469	ME56792	GN48059	ICD #04-1387	Mission System Data Book
17" NIACS - 800 in^3 (length 24.00")	Tibbetts	Jennings	ME49484	GN53318.DSN	GN48059	ICD #04-1387	"
14" NIACS (length 38.00")	Tibbetts	Jennings	ME64891	GN53318.DSN	GN53825		"
NMACS - Magnetic							
17" NMACS Long - (length 15.50")	Jennings	McPhail			GN47078		Mission System Data Book
17" NMACS Short - (length 11.75")	Jennings	McPhail	ME44469	ME44630			"
14" NMACS - (length 17.00")	Jennings	McPhail					"
CACS - Celestial							
Bi-level	Kupelian	Shoemaker	ME54567 Assy	GN64384			Mission System Data Book
Tri-level (Linear Thrusters)	Kupelian	Shoemaker	ME64273	GN64382			"
NSROC(a)							
Basic model	Kupelian	Lang	C37546	GN54229.dsn	Kupelian		SRN 3818P
Solar sensors 0 & 15 tilt	Gsell	Kiefer			GN5388.doc		SRN 5381P
10-Channel solar sensor box	Kiefer	Gsell	GN64472		GN67190		SRN 6214P
S19 BGS							
S19D - DMARS	Lang	Kiefer	Harmon/Saab	Lang/Saab	GN56752/Saab		
S19L - LN200	Lang	Kiefer	Kiefer/Saab	Lang/Saab	GN65154/Saab		Saab P-S19-ICD-10005-SE
S19A - MIDAS	Lang	Kiefer	Kiefer/Saab	Lang/Saab	GN51410/Saab		
Sensors							
TM Gyro - ARAV	Ozanne	Shoemaker					
TM Gyro - NASA	Tibbetts	Kupelian					
GLNMAC	Ozanne	Lang	ME44929	Lang	GN50953		GN71060
HCI - Horizon Crossing Indicator	Kiefer	Jennings	ME64142				SRN 5841P

Staffing and Retention

- NSROC has been actively recruiting for engineers since December 2007
- Filled 6 of 13 engineering vacancies since December
- Turn-over has been light, only loosing 3 engineers or technicians since October 2007
- Average years of experience holding steady
  - ACS: 9 (+1)
  - FP: 15 (-1)
  - EE: 13 (+1)
  - VSE: 7 (+1)
  - ME: 3 (+0)
- NSROC is continuing to encourage staff engineers to take on more project engineering responsibility
  - Improves Systems Engineering Skills
  - Improves Project Execution
  - Grooms Future Leaders and Mission Managers
- NSROC Senior Management Involvement
  - Mentorship efforts (esp. ME)
  - Direct involvement with all departments

NSROC Engineering Staff

Engineering Staff					
Stanfield	NG	Director		Manager	Administrative
Krause	OSC	Chief Eng.		Vacant/Planned	Part Time
Vacant	NG	Admin		Retiring	Unapproved Plan
				Leave/Disability	~~Resigning~~

Guidance			Flight Performance			WSMR			Vehicle Systems		
Kiefer	OSC	Eng	Simko	OSC	Mgr/Eng	Martinez,	OSC	Mgr/Eng			Mgr
Crippen	RSS	Admin	Onions	NG	Admin	Grzelacho	NG	Admin	------	------	Admin
Jennings	ARC	Eng	Disbrow	OSC	Dynamics	Bower	ARC	Eng	Burkhead	NG	Eng
Kupelian	NG	Eng	Edwards	NG	Analyst	Martinez,	OSC	Eng	Hesh	NG	Eng
Ozanne	NG	Eng	Kilcoyne	NG	Analyst	Hoxworth	OSC	Eng	Owens	NG	Eng
Tibbetts	OSC	Eng	Power	NG	Data	Harmon	OSC	Tech	Wroblewsk	NG	ME
Shoemake	OSC	Eng	Melvin P/	NG	Data	Maldonado	NG	Tech	Christense	OSC	Eng
McPhail	NG	Tech							Evans	OSC	Tech
Lang	NG	Tech							Evavold	OSC	Tech
Doyon	OSC	Tech							Vacant	NG VurV	Eng-Chute
Benton	OCS	Data							Vacant	NG VurV	ME
Snyder P/	NG	Tech									
Gsell P/T	OSC	Data									
Miller P/T	NG	Tech-Gen									
Vacant	NG VurV	EE									
Vacant	NG VurV	Tech-Gen									
Vacant	NG VurV	Tech-Pne									

Electrical			Mechanical			Environmental			Information Technology		
Elborn	OSC	Mgr/Eng	Rosanova	OSC	Mgr/Eng	Maxfield	NG	Mgr/Tech	Donovan	NG	Mgr/Tech
Nock	OSC	Admin	Weidner	RSS	Admin	-------	------	Admin	-----	-----	Admin
Lankford	OSC	EE-TM	Fleming	NG	ME	Hudson	NG	Tech	Holmer	NG	N/W Eng
Diehl	NG	EE-TM	Mandigo	NG	ME	Marshall	NG	Tech	Watkinson	NG	Tech
Cranor	ARC	EE	Yacobucci	NG	ME	Sharpe	NG	Tech			
Hesh	NG	EE	Thompson	OSC	ME	Russell	NG	Tech			
Vaughn	NG	EE	Widmyer	OSC	ME						
Gsell	OSC	EE	Creighton	OSC	ME						
Murray	OSC	EE	Hinton-Lee	NG	ME						
Starr	OSC	EE	Reese	NG	ME						
Brooks	OSC	EE	Hylbert	NG	Drafter						
Malaby	OSC	EE-Pwr	Walthall	OSC	Drafter						
Bradley	NG	EE-Pwr	Paschak	ARC	Drafter						
Johnson	OSC	EE-Pwr	Daughton	ARC	Drafter						
Banks	NG	EE	Vacant	NG VurV	ME						
Bowden	NG	EE									
Blake P/T	NG	EE									
Vacant	NG VurV	EE (Orosz)									

Engineering Resources

- NSROC Engineering is a lean organization
  - Must live within staffing levels defined by SRPO and external offsets
- Mission manifest is growing and payload complexity continue to increase… these are good things!
  - Our focus is on supporting these flight missions
  - Background engineering tasks sometimes suffer
- NSROC is looking to external providers for specialized engineering support to resolve lingering design or analysis problems
  - Troy 7, Inc. - Attitude solutions and data analysis
  - Invocon, Inc. - Electrical component design
  - VibrationData, Inc. - Vibration consultation
  - TGV Rockets, Inc. - Vehicle thermal and fluid mechanics services
- The small business engineering providers can be used to resolve short term design and analysis issues without a permanent increase in staff

NSROC Engineering is continuing to learn, improve our level of coordination, and to improve our services to Science Community

Electrical Engineering

Charles Lankford

Mesquito PCM

Program Benefits

- Low cost by fabricating system in-house.
- Small size (2” x 2” x 1.75” for 32 analog & 2 serial/asyncronous)

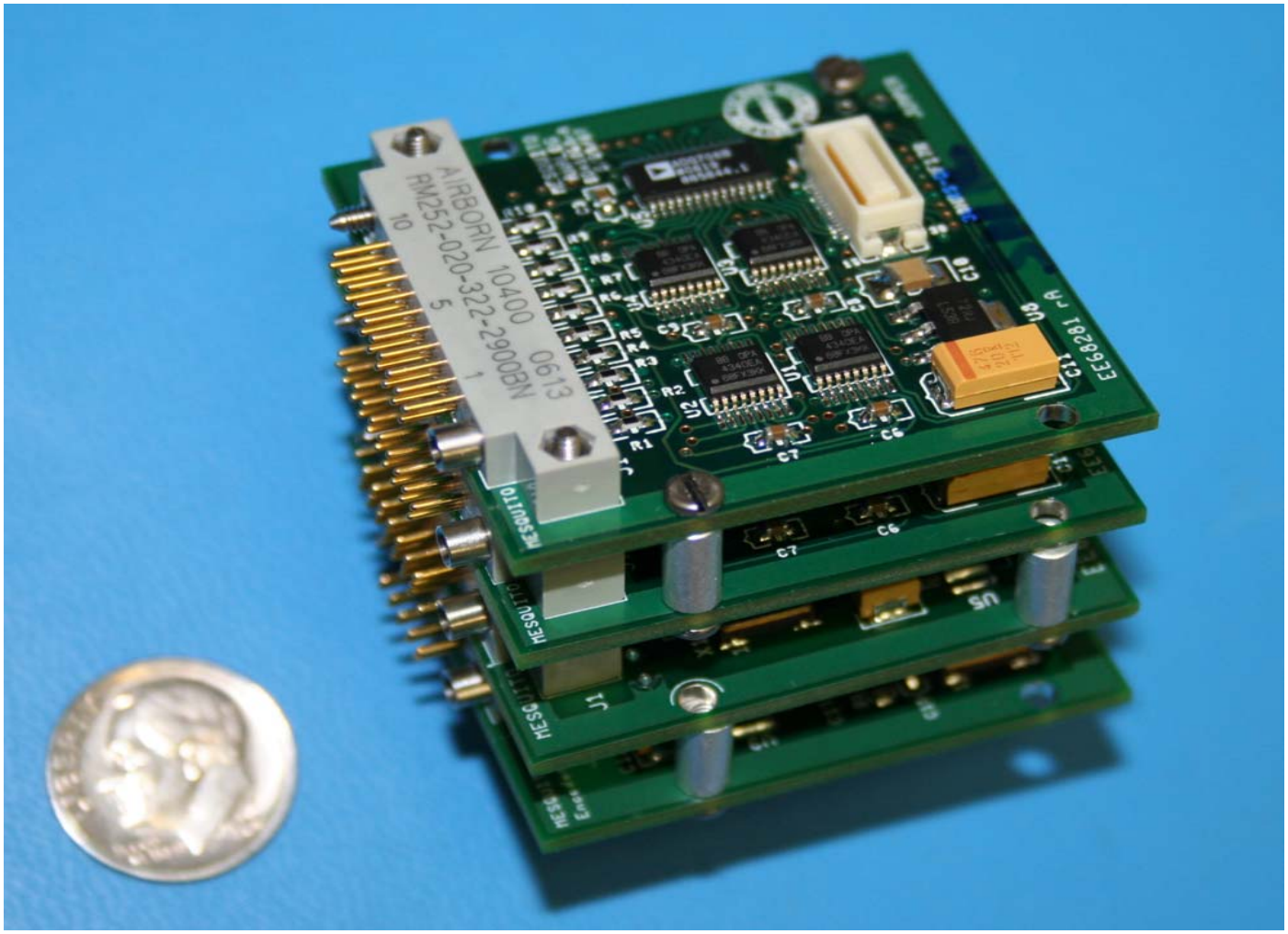
Implementation

- Designed with a modular approach with stackable add-on data modules.
- Presently targeting 16 analog inputs per module with 48 channel max and serial digital / asynchronous data module with 2 inputs each.

Status

- Extensive electrical testing performed at 2 MBPS with 32 analog and 2 asynchronous and synchronous channels
- A PCM unit has been assembled, programmed, bench tested, installed into 41.075 Smith and successfully subjected to payload vibration testing.
- The FPGA configuration/programming has been modified and will now allow up to 1024 Words per PCM frame.

Mesquito PCM



Mesquito Power Switching

Program Considerations

- Mechanical relays are too large for use in the extremely space and weight limited Mesquito payload
- Mechanical relays may not survive the 100-120 G's acceleration.

Implementation

- Surface mount circuit technology
- Device selected rated for 4.5 Amps

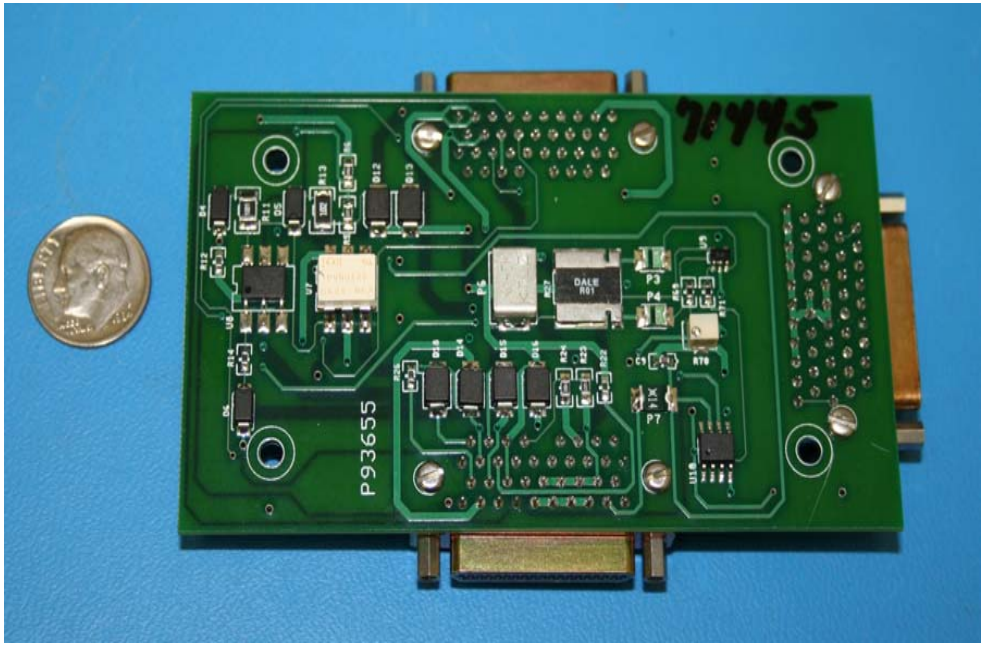
Breadboard Test Results

- Tested at 4 Amps continuous for 4 hours
- Tested 2 hours while switching on and off at 1 Hz while loading to 4 Amps

Status

- Test box and cable designed and fabricated .
- One unit has been installed into 41.075 Smith and successfully subjected to payload vibration testing.

Mesquito Power Switching



Mesquito Nose Cone Pyro Firing/Monitoring Circuitry

Program Considerations

- Traditional pyro CDI systems are too large for use in the extremely space and weight limited Mesquito payload.

Implementation

- Surface mount circuit technology using solid state switches and high capacity storage capacitor plus integration of failsafe and squib current monitoring circuitry

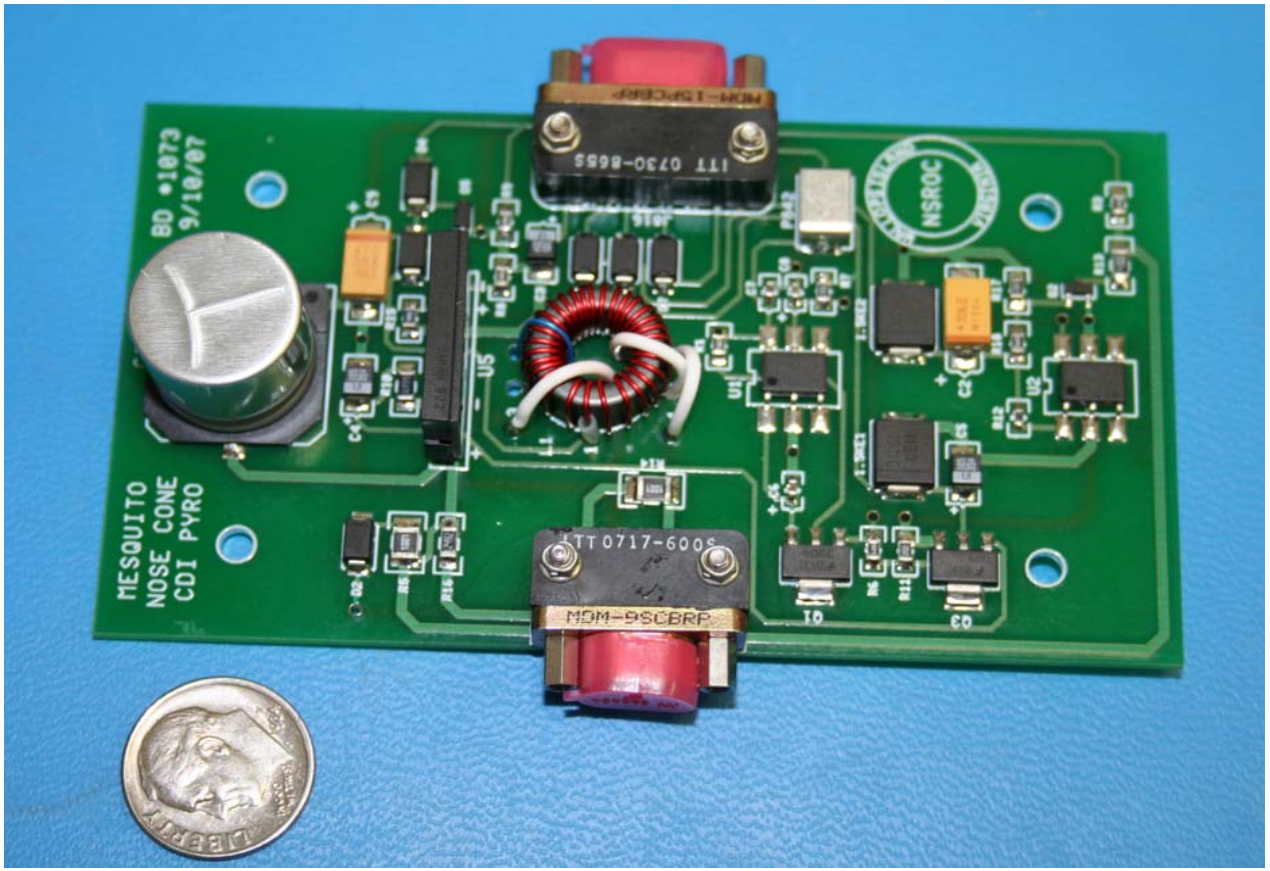
Breadboard Test Results

- 2200 Microfarad storage capacitor has over 2 x energy to fire dual bridge wire at minimum supply voltage and 4 x at maximum voltage.

Status

- Test box and cable designed.
- One unit has been installed into 41.075 Smith and successfully subjected to payload vibration testing.

Mesquito Nose Cone Pyro Firing/Monitoring Circuitry



Payload Power System

Status

- First design successfully flew on 12.063 Hickman and 41.068 Seybold.

System Redesign

- The system has been redesigned to incorporate the relay and controller board onto a single board.
- The new box is 1” shorter than the previous unit

Implementation

- The new payload power control system has been designed, board layout completed, PC board ordered and received, PC board populated and has been electrically tested.
- The PCD has been subjected to and successfully passed all prototype environmental testing.

Status

- The new payload power control system has been integrated into 41.075 Smith. The box went through environmental with the payload and sequenced with a variable load up to 10A.

Payload Power System

New Battery Technology

Issues

- Weight critical missions need higher power density power systems
- NiCad battery disposal have environmental concerns

Implementation

- Investigated Nickel Metal Hydride and Lithium Ion battery technologies

NiMH Battery Status

- NiMH batteries have been fully electrically and environmentally qualified for flight and we have 4 different capacity units available in stock
- The Mesquito payload is designed to use 2-12 cell 830 mAH NiMH packs These batteries will be flown on 41.075 Smith

Lithium Ion Battery Status

- Lithium Ion batteries with 4 AH rating have been procured and subjected to full environmental qualification.
- An identical 4 AH pack will fly on 41.075 Smith. It has been successfully charged in the payload and has undergone sequence testing with a variable load of up to 10A.

New Battery Technology

Battery Comparisons

Type	NiCad	NiMH	Li Polymer
Size	C	4/3 FAU	8S4P
Rated Capacity	3.0 Ah	3.6 Ah	4 Ah
28.8 V Pack Volume	35.78 cu. In.	25.3 cu. In.	20 cu. In.
28.8V Pack Weight	4.44 lb.	3.05 lb.	1.37 lb.

New Battery Technology
Lithium Polymer

Next Generation GPS

GPS Receiver Status

- NSROC was notified that Ashtech high dynamics DG16 receivers would not be sold anymore effective immediately
- NSROC has enough DG16 receivers to take us through PFRR in 2009

Javad

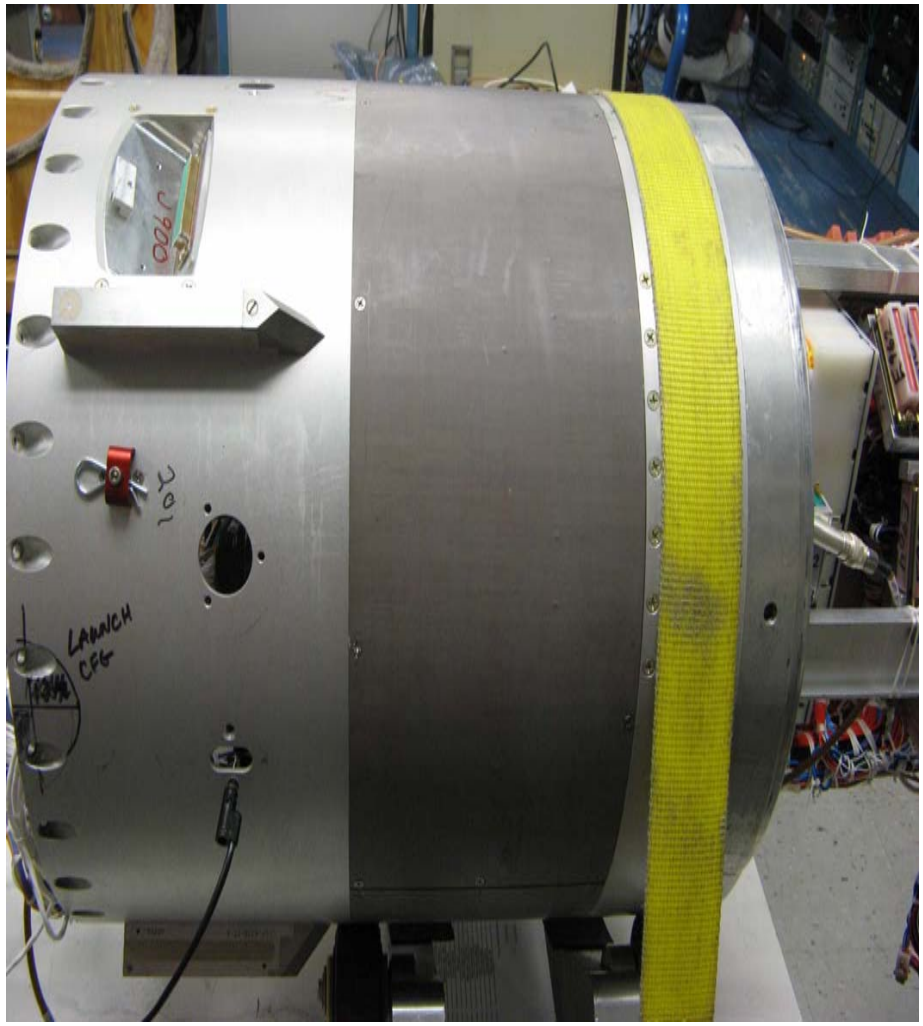
- JNS100 has been chosen as a candidate for Next Generation GPS receiver.
- Interface circuitry, PCB and housing has been designed, fabricated & assembled.
- First unit has undergoing electrical and component vibration testing
- First flight is planned for 41.075 Smith

Combination S-Band / GPS Antenna

History

- NSROC discovered antenna pattern problems with the PSL combination S-Band / GPS 17.25” wraparound units in mid 2007.
- PSL determined the problem to be a fabrication/assembly related issue
- PSL redesigned the antenna
- PSL manufactured a first article on which they performed RDP’s.
- NSROC reviewed the RDP’s and allowed PSL to ship this antenna to Wallops for further testing.
- NSROC generated independent RDP’s.
- This first article antenna was mounted on the 41.075 Smith TM skin and subjected to the normal payload vibration testing.
- Post vibration outdoor GPS testing was performed on 41.075 with nominal results.

Combination S-Band / GPS Antenna



Mechanical &
Vehicle Engineering

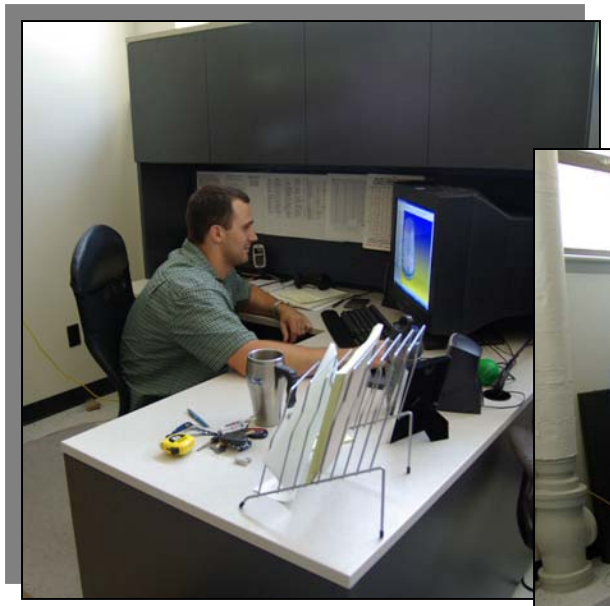
Giovanni Rosanova

Mechanical Engineering

- **Vibration and Shock**
  - Flew shock sensors on WSMR BB Mk1 in BB9 configuration (Woods 36.240) to give confidence to MFS.
  - Data shows that shock environment due to Mk1 ignition well within qualification loads for TTS components.
  - More data may be collected on an upcoming flights.
- **Balancing Payloads with Booms Out**
  - MOI table being modified to allow this
  - Estimate completion this month
  - Anticipate use during Poker I&T
- **Staffing**
  - Two new ME's since last SRWG. Both former NSROC interns.
  - One new Designer/Drafter

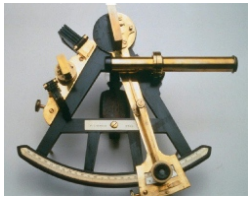
Mechanical Engineering

Working environment rehabilitated!!



Vehicle Engineering

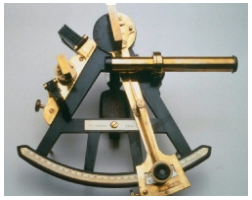
- **Recovery Systems**
  - Update on 1000 lb. parachutes
    - Premature dis-reefing (36.220 McCandliss and 36.241 Rabin most recent)
    - Lab testing of reefing line showed that the line will fray and cut very easily in cutter with sharp edges
    - Reefing line cutters with sharp edges were de-burred on 36.243 McCandliss and parachute staging was nominal during re-entry
    - Older lot of cutters was re-qualified for 36.223 McCammon and parachute staging was nominal during re-entry
  - Going forward
    - New cutters being ordered with requirement of smooth edge around reefing line holes
    - Monitor performance to better understand payload dynamics during parachute staging; e.g., ACS sensors being left on during re-entry to gather attitude data during parachute staging.
- **Staffing**
  - Recruiting full-time parachute expert



NSROC GNC

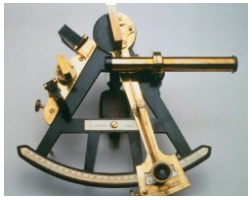
Ron Kiefer

GNC – Ron Kiefer



- Restart of ACS on Kletzing flight
- Sensor hardware – Standard, New
- ACS hardware – Standard, New
- Post-Flight Data Reduction
- Missions – Recent Past, Present, and Near Future

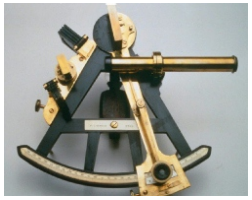
Restart of ACS on Kletzing



- At T+326, the ACS did a Restart which fired Roll Valves
  - The ACS still performed successfully throughout the flight
  - Post-flight evaluation of ACS discovered potentially non-robust circuitry with respect to the microprocessor

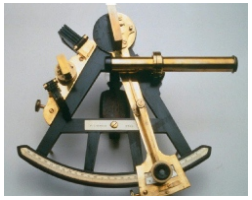
- Robust enhancements identified and implemented
  - TM Analog signals separated from processor by op amps
  - “Enable” circuitry now LoLo
  - ACS grounding isolated from Chassis ground
  - Filtering added to input power bus

Sensor Hardware - Standard



- GLNMAC
  - S/N 050 is being built.
- Solar Sensors
  - SLIT (set contains 4 sensors)
  - Coarse Solar Sensor
  - MASS
  - LISS
- Magnetometers
  - TM Bartington (0-5V)
  - NMACS Bartington (± 10V)
- Star Tracker
  - ST5000 (University of Wisconsin)
  - Ball (single star) no longer used
- Rate Sensor
  - Gyro chip sensor
- Horizon Crossing Indicator
  - HCI by Servo

Sensor Hardware - New

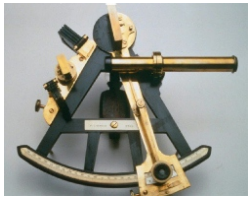


- Micro-IMU
  - Size of a “Hockey puck”
  - Robust – by MEMSense
- Ring Laser Gyro
  - 1 lb unit by Honeywell
  - >10x RIG control
- Digital Magnetometer
  - Honeywell HRM2300
  - Better performance
- ST5000 repackaged (Mark III)
  - Smaller, lighter, more robust

GSE

- Command Uplink System
  - Latest state-of-the-art technology
  - Touch screen control

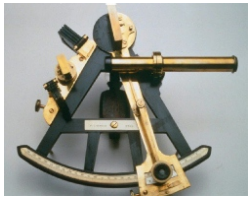
Sensor Hardware - New



- MEMSense Micro-IMU

Accelerations:	**+/-5G's**
High G Accels:	**+/-50-70G's**
Magnetometer:	**+/-1.9 Gauss**
Gyroscope:	**+/-50 & 3000deg/sec**
Input Voltage:	**9-13Vdc**
Weight:	**3.5 ounces**

Sensor Hardware - New

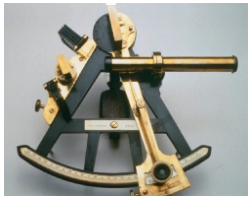


Honeywell Digital Magnetometer

- The Honeywell digital magnetometer has flown on two Costello payloads and the Craven payload.

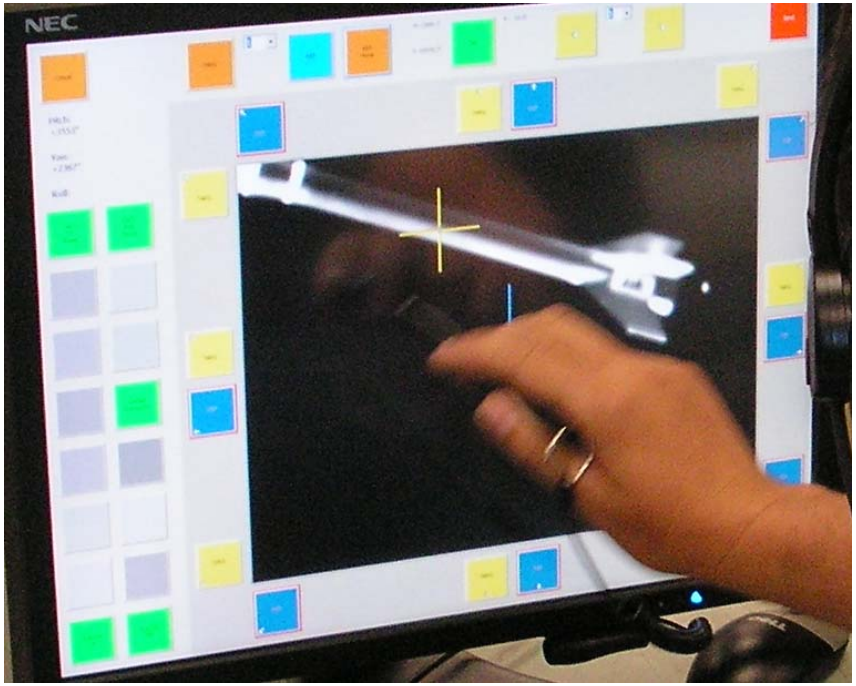
Power: +12 Volts
Magnetometer: +/-1.9 Gauss
Resolution: 67 micro-gauss

Sensor Hardware – New GSE

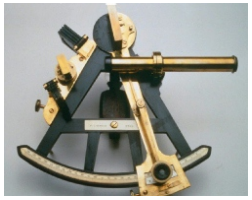


Command Uplink System

- Touch Screen Control - LeClair MDA payload June 26, 2008

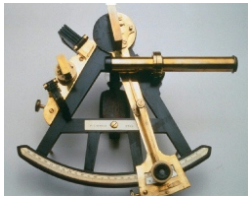


ACS Hardware - Standard



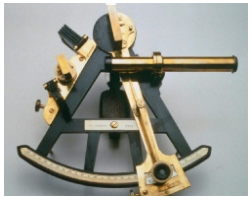
- NIACS
  - Inertial or spinning to 2 Hz
- NMACS
  - Magnetic spinners to 5 Hz
- CACS
  - Fine pointing <0.5 arcsec.
  - ST5000 tracker (no guide stars required)
- SPARCS
  - 4 units available for solar missions
- NSROC(A)
  - Miniature unit used with SLIT solar sensors
- S19 BGS
  - 3 units of S19D with DMARS
  - 4 units of S19L with LN200.

ACS Hardware - New



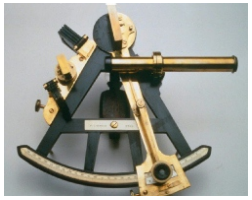
- RTAS
  - Provides payload attitude real-time
  - Uses the micro-IMU and GumStix computer
  - Also uses solar sensors, HCI and digital magnetometer
  - Maiden flight to be Smith 41.075, launch this month

ACS Hardware - Innovation

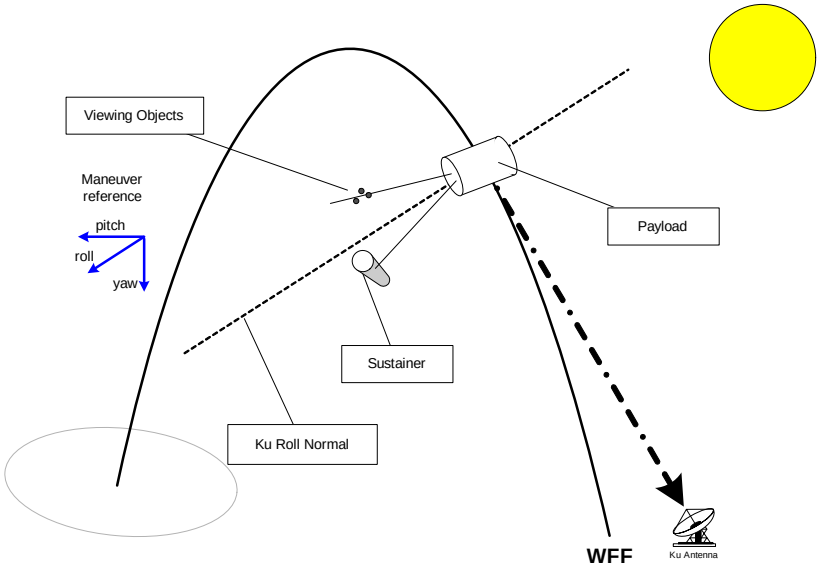


- LeClair 39.008
  - Multiple, simultaneous targeting objectives
  - Multi-body orbit models used for targeting
  - Filtered trajectory solution to improve GPS/velocity vector system
  - Import ACS data into Mission Planning Lab Visualizations
  - Automated launcher box test
  - ACS data display in Range Control

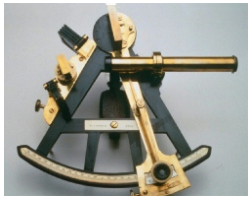
ACS Hardware - LeClair



- Precise pointing of payload.
- Roll payload to best fit secondary target.
- Flight results:
  - ~0.03^{o} pointing
  - Ku lock maintained
  - 12.5^{o} Ku link half angle.

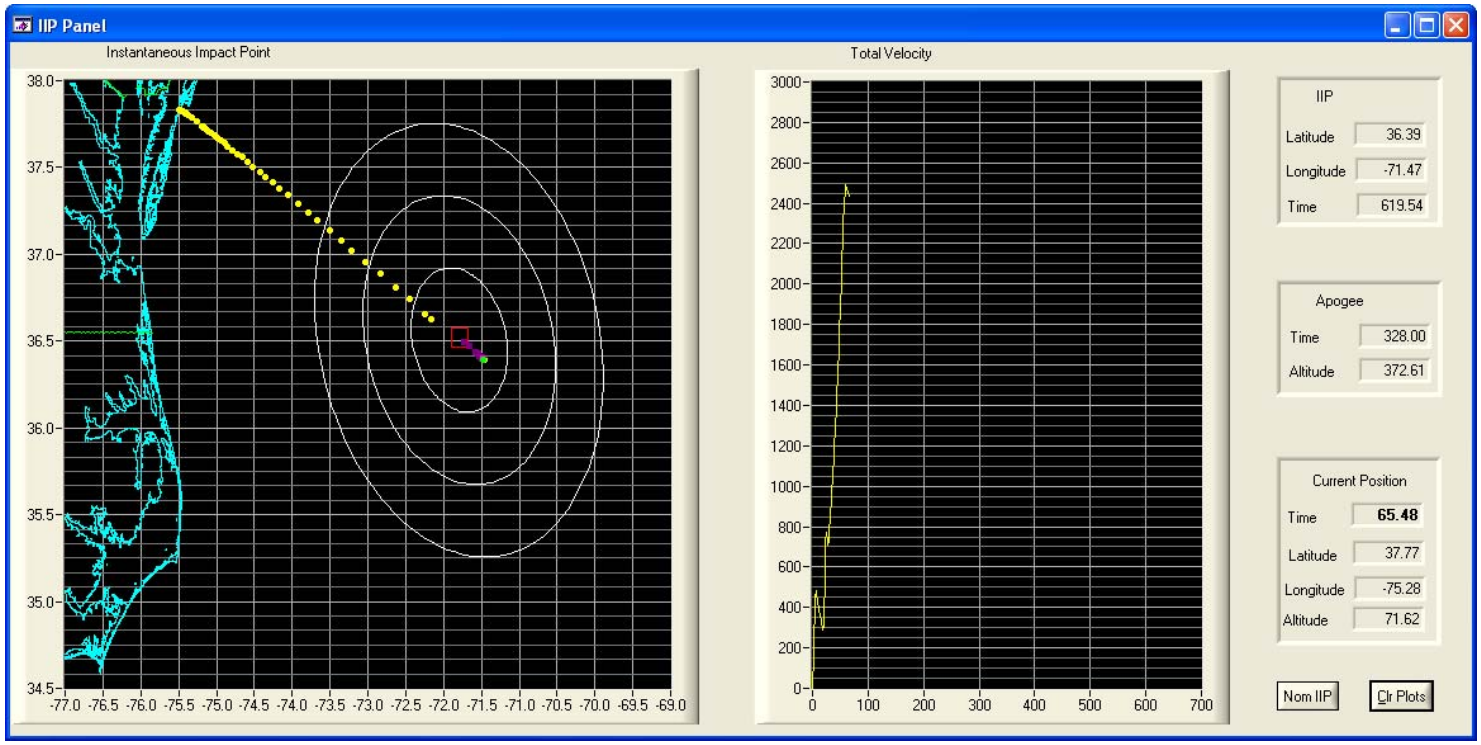


ACS Hardware - LeClair

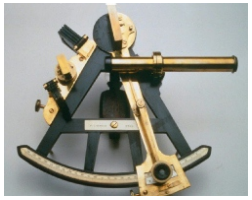


Filtered Trajectory Solution

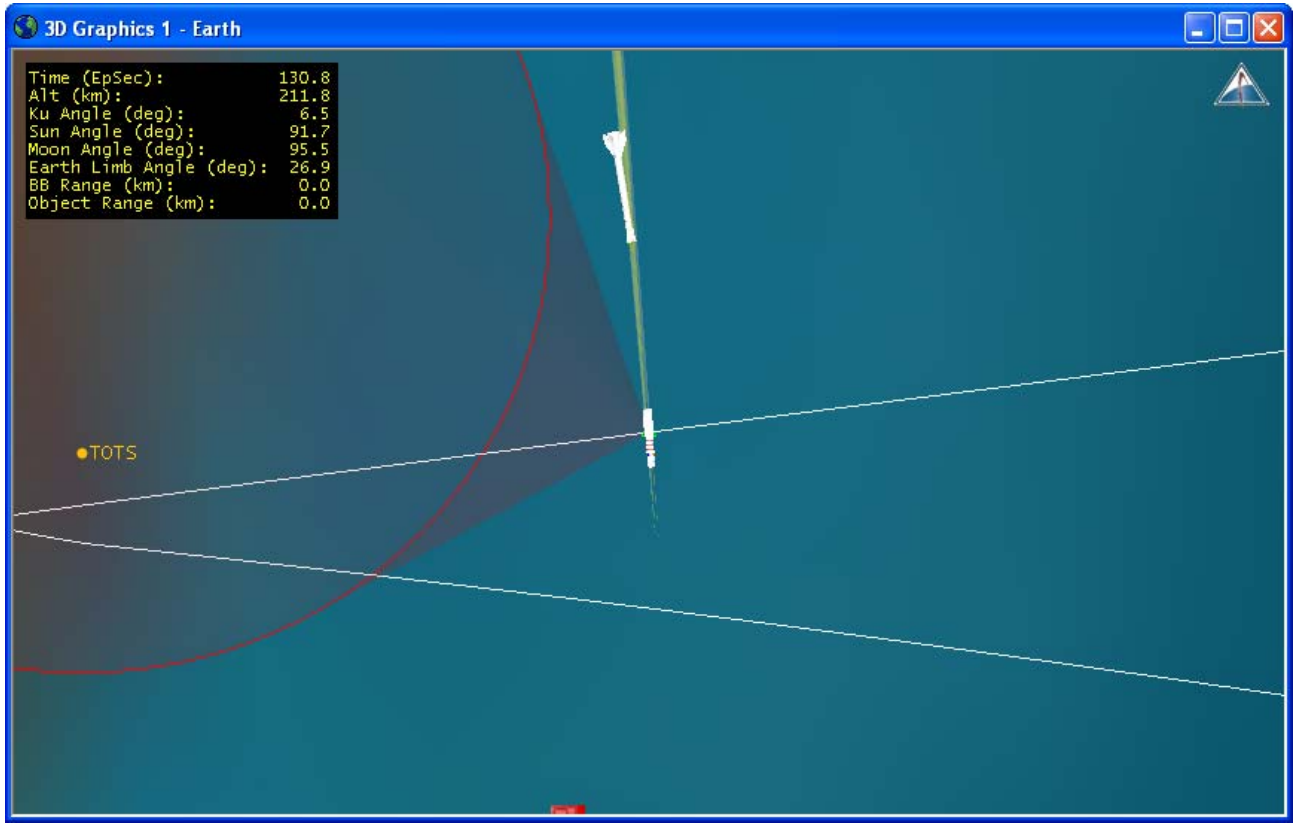
- Filtered trajectory starts with nominal and uses GPS to improve.



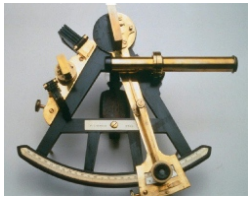
ACS Hardware - LeClair



ACS Data / Mission Planning Lab

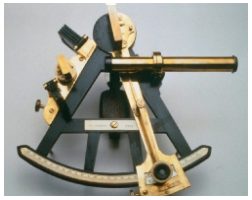


Post-flight Data Reduction



- Kintner 40.021 flight data was a challenge
  - Large coning angle varied spin rate so solar data contained many inconsistencies
  - One data reduction script contained an unknown error
  - Full flight attitude solution was recently determined
- Additional personnel
  - New employee started in February
- Post-flight Data Reduction
  - The Sounding Rocket Attitude Data Reduction Manual is being revised. Revision to be released in coming year.
  - Standard scripts and procedures exist to translate data. However, mission specific processing is often required.

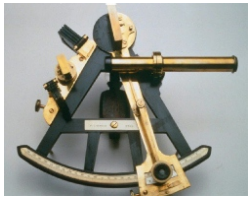
ACS Missions – Recent Past



- Woods 36.240
  - SPARCS
  - S19L
  - CUS

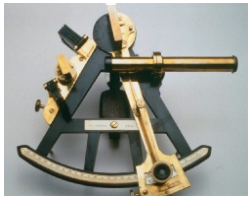
- McCammon 36.223
  - NIACS
  - S19L

ACS Missions - Present



- LeClair 39.008
  - NIACS
  - CUS
- Smith 41.075
  - RTAS
  - GLNMAC (Beamformer)
- Bock 36.226
  - CACS (w/CUS)
  - S19D
- Moses 36.221
  - SPARCS
  - S19L
- Davis 36.213
  - CACS (w/CUS)
  - S19D
- Kowalski 36.207
  - CACS (w/CUS)
  - S19L

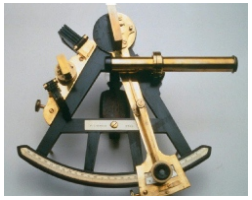
ACS Missions – Near Future



<u>Poker Campaign</u>

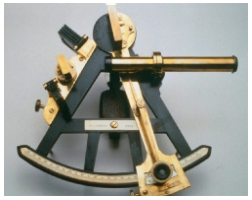
- Bounds 36.242 and 21.139
  - NMACS
  - TM GLNMAC
- Lehmacher 41.078/41.079
  - MicroIMU.
  - TM Magnetometer
  - Horizon Crossing Indicator (HCI)
- Lynch 40.023
  - NIACS
  - Solar Sensors (3 sets)
  - HCI (3)

ACS Missions – Near Future



- Green 36.244
  - CACS
  - S19D
- Korendyke 36.239
  - SPARCS - RLG
  - S19D
- Hassler 36.219
  - SPARCS - RLG
  - S19L
- Bernhardt 39.009
  - NMACS – Rate control
  - Solar Sensors (2 sets)
- Cash 36.252
  - CACS
  - S19D
- Harris 36.235
  - CACS
  - S19L

Thank you for Your Support



- NSROC GNC stands ready to support the science community.
- Questions or Comments?

Program Manager

Rob Maddox

Conclusions

- NSROC is committed to continuing the SRPO mission and program successes. 2008 has been a good year for Sounding Rockets.

- NSROC's Primary Goal is unchanged:
  - to satisfy the NASA PI mission requirements.

- NSROC is committed in expanding the technical innovations while
  - Meeting the requirements of the PIs
  - Maintaining a cost effective environment
  - Making effective use of the in-house talent, experience and hardware.

- NSROC's early receipt of the SRWG findings is important for future growth planning.
  - Thank you to the SRWG for providing these important findings