SRWG NSROC Agenda

NSROC Engineering

• Introduction	Krause
• NSROC Report Card (Self-Assessment)	Scott
• Discussion of recent anomalies	Krause
• Viper Dart Mission – 12.049	
• DS19 RTF Efforts	
• ACS Transition Overview	
• NIACS Demo Mission	
• NSROC GNC Activities	Costello
• GLNMAC-200	
• Inertial & Magnetic ACS Development	
• ST-5000	Percival
• NSROC EE Activities	Lankford
• Mag Cal Facility Upgrade	
• Sequence Timer Upgrade	
• Video Compression Technique	
• Remote Control Power Suitcase	

Discussion of Recent Anomalies

NSROC Engineering

- Recovery System Failure on Golub/36.199
- Shutter Door Anomaly on Cruddace/36.195

Golub/36.199 Recovery System Failure

NSROC
Engineering

Mission was launched on 6/21/01 at WSMR, NM.

- Anomaly:

Recovery System failure causing a complete loss of the payload. The main parachute was released from the parabay with the reefing line cut. The payload velocity was too great causing structural failure of the chutes' suspension lines.

- Cause:

The AIB discovered that the reefing cutters were prematurely fired, prior to launch. Most likely occurred during the repacking process.

- Corrective Actions:

Multiple steps were implemented to minimize the chance for reoccurrence.

1. All parachutes in stock were x-rayed to verify good cutters.
2. Repack procedures were modified to improve consistency in repacking methods and hardware/document traceability.
3. Established a 1000 lbm limit for the 1000 lbm Recovery Systems.
4. NSROC will perform a post flight inspection of all recovered components.
5. NSROC will no longer vibrate the flight chutes during system I&T.

Shutter Door Anomaly
Cruddace/36.195

Mission was launched on 2/22/01 from WSMR, NM.

- Anomaly:

The payload's shutter door did not close prior to atmospheric reentry.

- Cause:

The AIB determined that the microswitch failed causing the motor to draw excessive current. The redesign team also noted that the relay contact appeared to not complete the circuit when actuated.

- Corrective Actions:

1. Shorten the current dwell to 6 seconds during the open and close events.
2. Institute a change from a 2-pole to a 4-pole relay addition in the circuit for redundancy and also splitting the motor current.
3. Addition of redundant ground connections to the motor
4. Standardize the microswitch mounting scheme for all shutter doors.
5. All shutter door will complete a refurbishment following a mission.

Viper Dart
Ulwick/12.049

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Engineering

Test Mission launched on 5/16/01 at Wallops Flight Facility.

- Range assets, radar and TM, failed to track throughout trajectory.
  - Radar lost lock in 1st few seconds.
  - TM also lost lock very early during flight
  - Back up Met Ops antenna tracked and received TM signal through 51 seconds (Ground station received usable TM data through ~38 seconds)
- Airborne TM issues:
  - 30 db drop in TM signal at motor/dart separation (~3 seconds)
  - Steadily decreasing TM signal to LOS at ~51 seconds
  - GPS non-functional throughout flight (1 pulse rec'd during flight)
  - Data shifts between 6 – 8 seconds are inconclusive (accel & mag data)
- Some data suggests that the vehicle achieved a nominal flight profile.

- 2 Viper Darts preparing for launch in the near future.

DS19 Return To Flight Efforts

NSROC Engineering

DS19 Boost Guidance System failed during the 2nd mission . Problem isolated to the DMARS roll stabilized gyro platform. A workmanship issue (during a rework) was identified as an errant solder splash. The yaw cal input shorted under aerodynamic loading and the calculated yaw IIP output shifted by 15 degrees. This caused a bias in the vehicle's yaw rate and a ramp in body attitude.

Corrective Actions:

1. Perform 100% Quality Inspection of the remaining DMARS platforms.
2. Identified deficiencies; Reworked and Reinspected
3. Reevaluated all processing documentation used during:
   - DMARS manufacture
   - DS19 acceptance testing
   - Flight preparation
4. DS19 acceptance tested at WFF by SAAB (August 2001)
5. In total, 19 Action Items developed with 3 remaining OPEN

DS19 Return to Flight

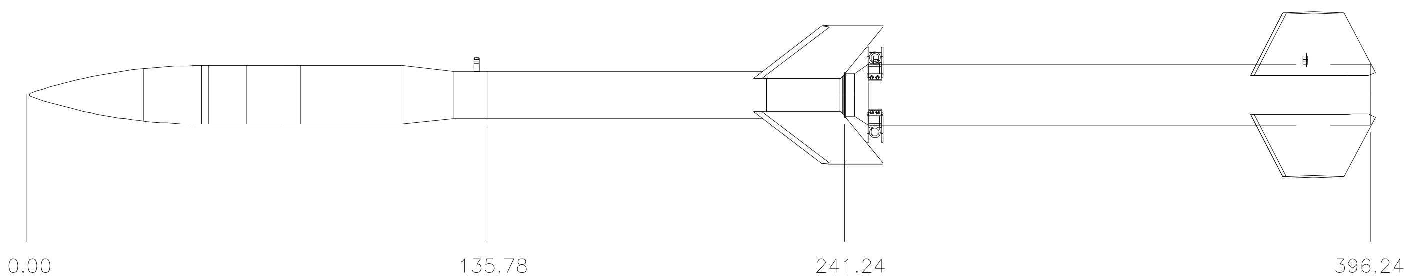
NSROC
Engineering

Current Status:

- DS19 Efforts leading towards the Return-to-Flight mission on Woods/36.192 at WSMR on 2/4/02.
- 3 DS19 RTF Action Items remaining
  - #6: WSMR detailed understanding of the DS19 vehicle capabilities
  - #9: Teleconference between WSMR Flight Safety, NSROC and SRPO scheduled for Thursday
  - #19: Brief with SRPO, NSROC and WSMR Flight Safety and Goddard Code 300 being scheduled in January

NIACS Demo Mission

NSROC
Engineering



Payload
Igniter Housing (WSM)
CDI Deck
Separation
NSROC Mag ACS
SPARCS Controller
Pneumatics
Pointing Algorithms
Mag ACS can
NSROC Inertial ACS
GLNMAC-200 Gyro #2
Pneumatics
SPARCS Controller
Pointing Algorithms
Inertial ACS can
Avionics/TM Section
HFTimer
ORSA (750 lbm)
Camera
Flight Modem (?)

Imp. Orion Motor
Rocket Motor
T-IO Tail Can
Fins - Orion

Terrier Motor
Terrier Mk 70 Motor
Taurus Fins
Drag Brakes

Notes:
Black = Existing Design
Red = New Design
Blue = NSROC Developmental Subsystem
Green = NASA Developmental Subsystem

NSROC GNC Activities

NSROC Engineering

- NSROC provided NASA with a ACS Transition Brief regarding ACS & Sensor developmental activities on 5 December 2001
- NSROC received formal Action Items prior to SRPO tasking
- Proposed tasks include:
  - GLNMAC Roll Stabilized platform
  - NSROC Inertial ACS (Coarse) System development
  - NSROC Magnetic ACS System development
  - ST-5000 Star Tracker
  - Demonstration Mission
    - To flight quality the NSROC Inertial and Magnetic ACS packages
- Current Status
  - NSROC formally answering Action Items
  - SRPO issued a Stop-Work Order to NSROC on all ACS Transition activities on 13 December 2001

NSROC Guidance & Control

- GLNMAC-200 Attitude Sensor
- ST-5000 Star tracker
- NSROC Inertial ACS (NIACS)
- NSROC Magnetic ACS
- NSROC Rate Control System
- NSROC(a) Miniaturized Attitude Determination

SRWG Recommendations

- WSMR Develop New Products – Jun, 2001
- Maximize Observation Time – Jun, 2000
- New ACS Systems & ST5000 – Jun, 2000
- GPS For Trajectory Data – Nov, 1999
- Solar Jitter ≤ 0.1 ArcSec – Nov, 1999
- Dedicated Development Flights 1/YR – Nov 1999
- Miniaturization (ARL) – Nov 1999
- Fine Pointing ≤1 ArcSec & ST5000 – Jun 1999
- Coarse Pointing: Timeline Errors – Jun 1999
- Midas Performance & Data reduction – Jun 1999
- Data Reduction Simplifications – Jun 1999
- Coarse Attitude – Jun 1998
- ‘ Fine Attitude – Jun 1998

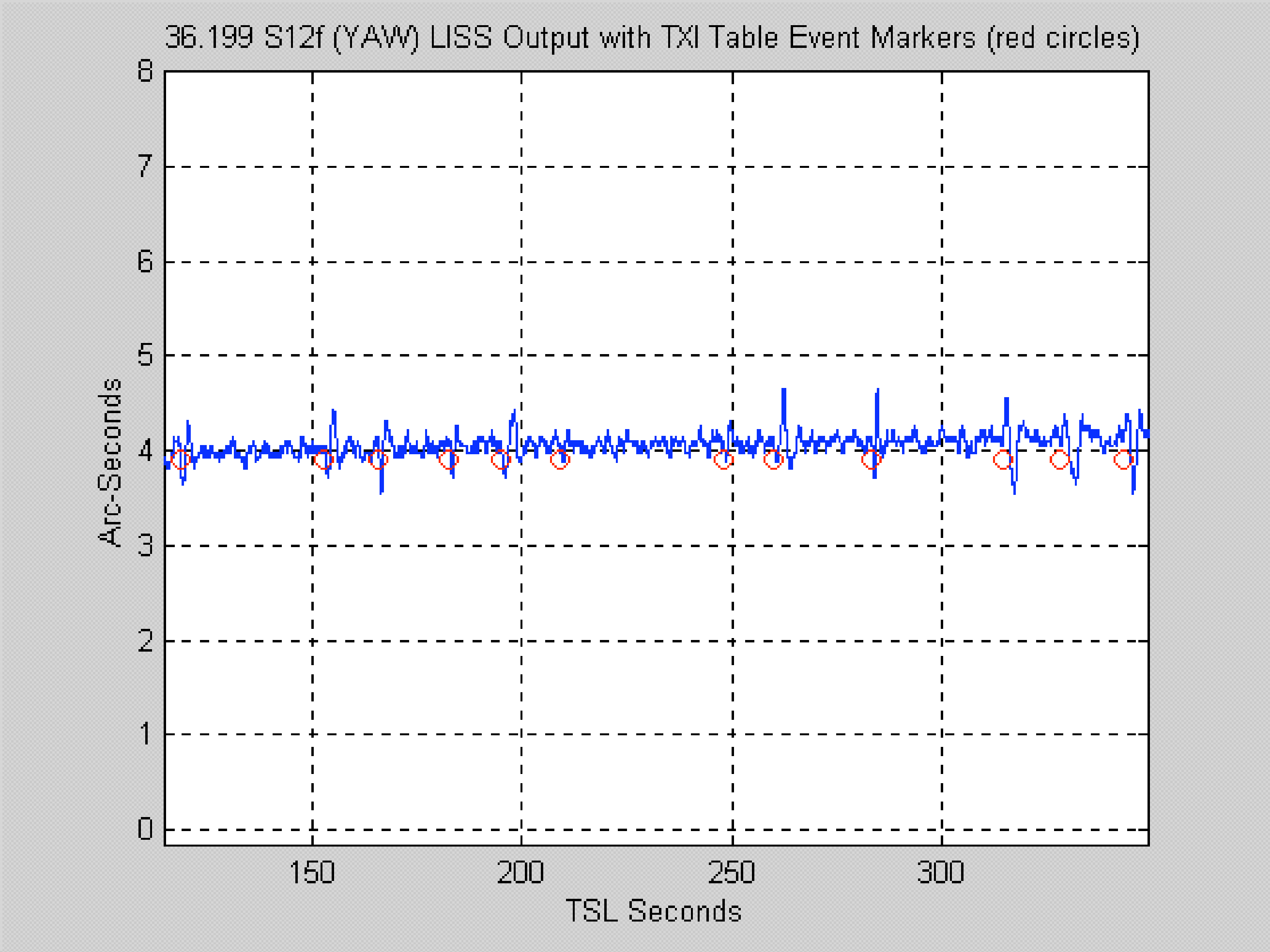
GNC PROGRESS Jun-Dec 01

NSROC Engineering

- Golub 36.199 < 0.5 ArcSec Jitter
- GLN-200 Upgraded To GLN-MAC-200
- NIACS Controller Operating In GLN-MAC
- GNC Data Reduction Capability Being Regained
- Surface-Mount Capability Achieved
- Cruddace 36.195 Flight Report Completed, < 0.5 ArcSec Jitter
- ST-5000 Mk II Flight On Harris
- NSROC(a) Orders From PSL and ARL
- NSROC(a) Data Reduction Requirement
  - For Winstead 42.002/3
- Harris 36.188 Apparently Fully Successful

Golub 36.199 Jitter (Yaw)

NSROC
Engineering



GLNMAC-200

- GLNMAC-200 Simply Locates Sandia SMAC Computer Within Casing Rather Than Separately
- Sandia Claims Improved Performance Over LN-200
  - Precise Calibration, Temperature Compensation
  - Sandia Will Calibrate NSROC GLMAC For The Foreseeable Future
- GLN-200 Flown 9 Times
  - 7 Successes, No GLN-200 Related Failures
- GLNMAC-200 Yet To Fly
- Future Expansion: IMU, GPS

GLNMAC-200

- Basic Requirement < 1 Deg Accuracy
- MIDAS is < 3 Deg (approaching 1 deg)
  - Drift Rate is 0.5 Deg/Min = 3 Deg in 6 Min
- LN-200
  - Bias Repeatability 1 to 10 Deg/Hr, 1 sigma
  - Bias Variation 0.35 Deg/Hr, 1 sigma, 60 sec correlation time
  - Random Walk 0.05 to 0.15 Deg/SQRT(Hour)
  - Scale Factor Stability – 100 to 300 ppm
  - Non-Orthogonality – 20 ArcSec, 1 sigma
- Sandia Improves Accuracy About 50%
  - By Carefully Calibrating For TEMPERATURE

GLNMAC-200 Environmental

NSROC Engineering

- 3-axis **Random Vibration** @ 20 seconds/axis
  - 0.005 g^2/Hz, @ 20 Hz
  - 20 - 40 Hz, @ 6 dB/Oct
  - 0.02 g^2/Hz, @ 40 – 2,000 Hz
  - **6.2 g rms**

- **Temperature Cycle** (one thermal cycle)
  - Ramp to 60°C at1°C/minute & mainatain for 1 hour minimum
  - Cool to 0°C at 1°C/minute & maintain for 1 hour minimum
  - Return to room temperature at 1°C/minute
  - **Monitor GLNMAC performance throughout entire cycle**

GLNMAC-200 Manufacturing

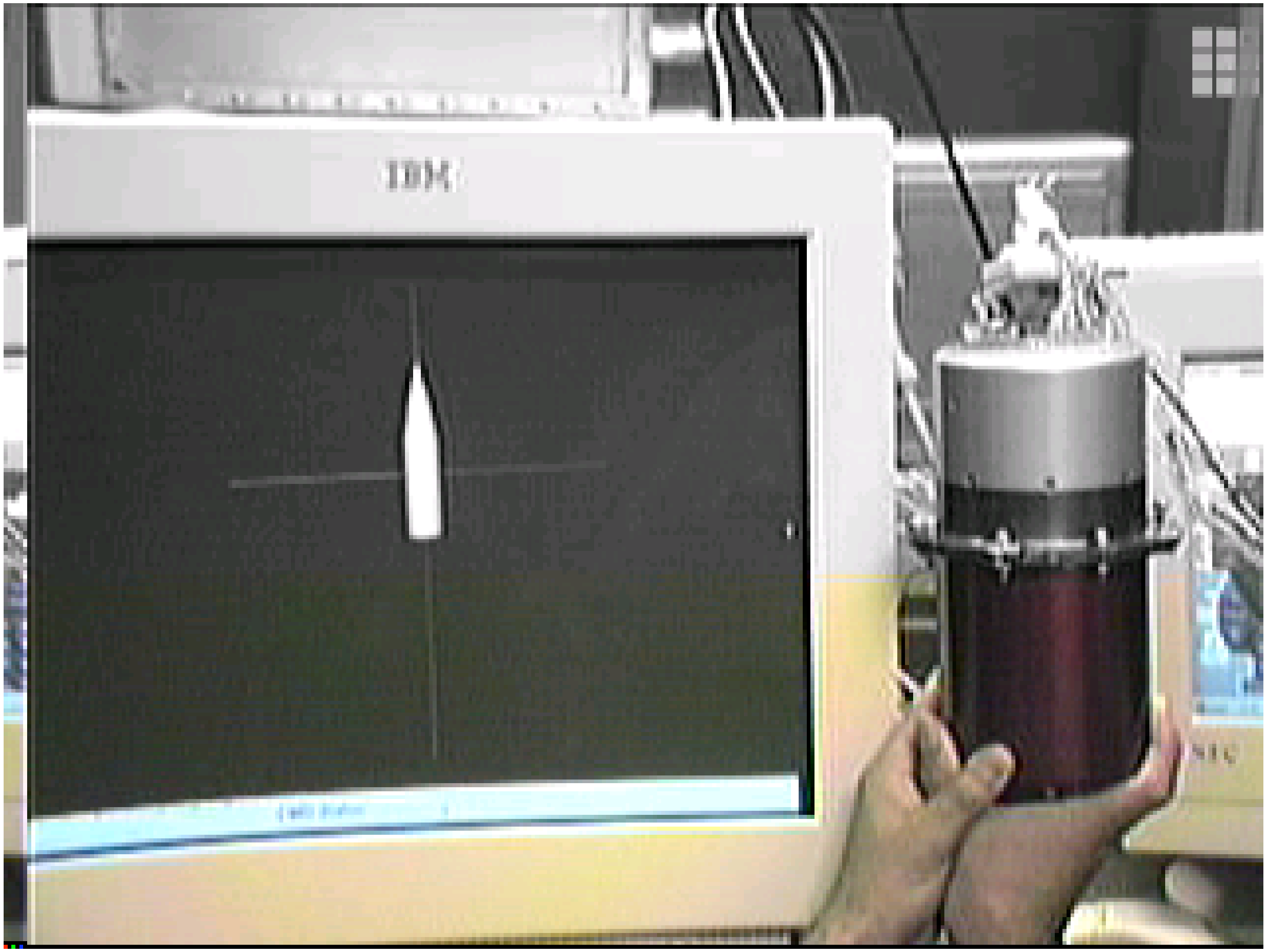
- Licensing Agreement / Government User Notice
  - Being Negotiated By NASA / DOE
  - Required To Obtain Sandia Documentation
- NSROC Assembly of GLN-200
  - LN-200 Procured From Litton
  - Machined Parts Procured From Sandia Supplier
  - Multi-layer Printed Circuit Boards Procured From Sandia Supplier
  - Boards Populated At WFF Using Surface-Mount Technology
  - Calibration Performed At Sandia For Foreseeable Future
- NSROC Observes Assembly Process At Sandia
- Sandia Observes NSROC Assembly at WFF

GLNMAC-200 FUTURE USES

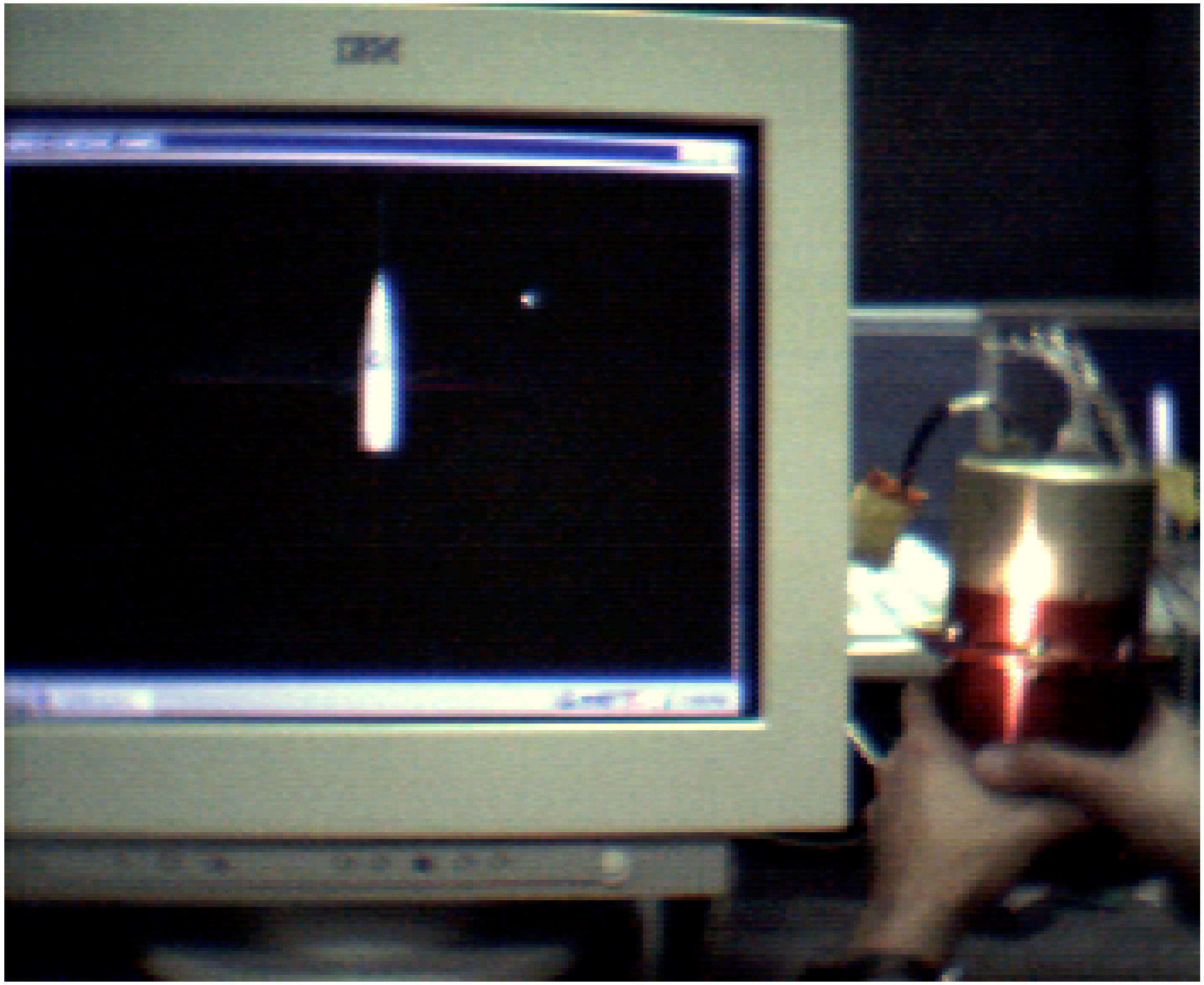
- The GLNMAC-200 Will Be The Sensor For The NSROC Inertial ACS
- The Following Future Possibilities May Be Considered
  – TM GYRO – Replace MIDAS
  – Incorporate Inertial Navigation
  – DS-19 Boost Guidance System – Replace DMARS
  – AeroJet System – Replace MARI
  – Self-Contained ACS And BGS
  – GPS Input To Supplement Or Replace Inertial Position
- Based On Accuracy, Reliability, And Cost, The GLNMAC-200 Is The Inertial Sensor Of Choice For The Foreseeable Future

GLNMAC-200 HITL

NSROC Engineering



GLNMAC-200 HITL



NSROC ACS Systems Development

- Inertial ACS Overview
- Inertial ACS Design Goals
- Magnetic ACS System
- RCS System Status
- Above Systems Based On SPARCS VII
- NSROC(a) ARL Miniaturized Components
- WSMR Development – all except NSROC(a)
- Flexible, Tailorable Pneumatic Systems

Inertial ACS System Overview

NSROC
Engineering

- NSROC Inertial ACS (NIACS)
  - Core System For Missions Requiring Inertial Control
  - Based On SPARCS-VII Architecture
  - SPARCS Controller Activates Nozzles
  - GLNMAC-200 Inertial Sensor w/Flight Computer
  - Initial Capability – Coarse Inertial System
  - Follow-On Capability – Celestial Missions w/ST-5000
  - Capable Of Interface With Advanced Sensors
    SPARCS "SuperController" May Be Developed

Inertial ACS Design Goals

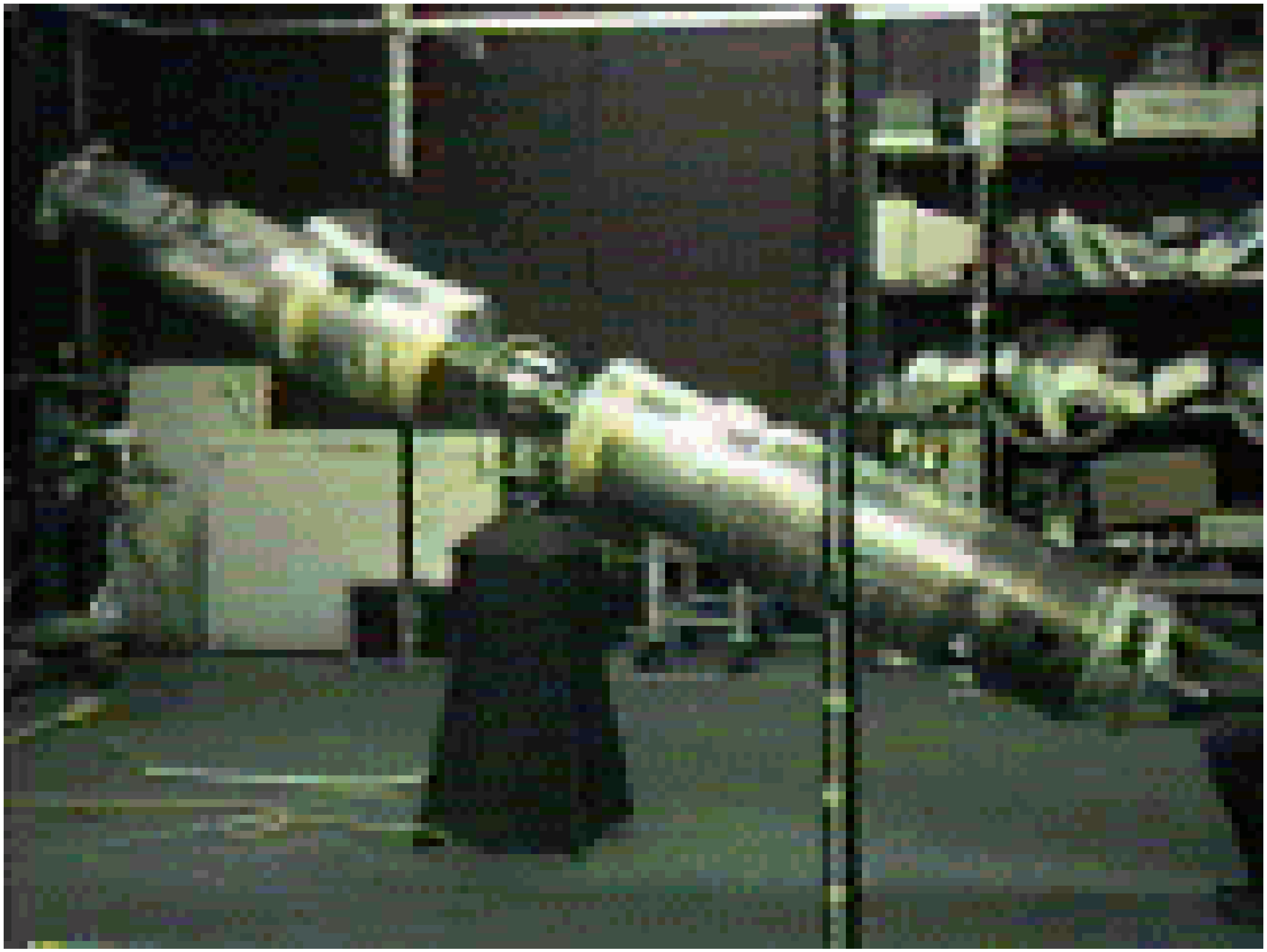
- Gain margin > 6 dB, Phase Margin > 40 Deg
- Attitude Determination Within 1 Deg Or Better
- Attitude Control Within 2 Deg Or Better
- Rapid Acquisition (Will Depend On Mission).
- Improved Reliability
- Minimal Refurbishment Will Be Required
  - GLNMAC-200 Re-Calibration
- Early Replacement For Space Vector Inertial System

Magnetic ACS System

NSROC Engineering

- Based On SPARCS-VII Architecture (Remove LISS, Sun Sensors)
- Align Payload To Magnetic Field Vector
  - Control Within 5 Deg Of B-Field Or Better
  - Deadbands Tailored By Principle Investigator
  - Essentially Same Capability As Space Vector System
- Capable of Rolling Or Non-Rolling Payloads
  - 4 Pitch/Yaw Nozzles On Non-Rolling Payload
  - 2 Pitch Nozzles On Rolling Payload
  - 4 Roll Nozzles If Mission Requires
- Pneumatics Tailored To Mission Requirements
- SPARCS-VII Magnetic System Air Bearing Test - 1997

Magnetic ACS
Air Bearing Test



RCS System Status

NSROC
Engineering

- RCS Test Flight On Winstead 12.050 Dec 19, 2000
  - Based On SPARCS-VII
  - Rates < 0.5 Dec/Sec In < 10 Sec (spec 30 sec)
  - Jitter < 0.1Deg/Sec
  - Drift < 0.05 Deg/Sec (Control Valves Off)
  - Re-Entry Spin-Up to 1 Hz OK
  - 3-Axis 40 Deg/Sec Timex Rate Gyro Model CD-040

Pneumatics System

NSROC Engineering

- 100% Flight Proven Hardware
- Flexible Design Tailored To Mission & ACS System
  - Can Handle Payloads Of Increasing Weight & Time
  - Without Adding Weight To Small Payloads
- Up To Three Levels Of Control
- Fine Control May Use SPARCS-VII Differential Nozzles
- Separate Section Or Incorporated In ACS Section
- May Have Remote Nozzles (Usually In ORSA)
- May Have Independent Circuits For Roll & Pitch/Yaw
- Many Tank Sizes Available

Pneumatics Systems For Test/Demo Mission

NSROC Engineering

- Inertial System ACS In Two Sections
  - Two levels Of Control
  - Eight Nozzles; Four Roll, Four Pitch/Yaw
  - Two Independent Circuits – Roll And Pitch/Yaw
  - Two 370 Cu In Pneumatic Tanks
- Magnetic System ACS In One Section
  - One Level Of Control
  - Six Nozzles: Four Roll, Two Pitch/Yaw
  - One Circuit
  - One 370 Cu In Pneumatic Tank

ACS Systems Verification/Validation

NSROC Engineering

- System Stability Reports
  - Gain And Phase Margins For All Modes
- Hardware in The Loop (HILTS)
  - NSROC Real-Time Display System (NRADS)
- Horizontal Air Bearing Tests
  - Validates Ground Station/TM As Well As System
- Engineering Test/Demo Mission
  - Camera To Validate Inertial System
  - Inertial System To Validate Magnetic System
  - Post Flight Analysis/Data Reduction

NSROC(a)

NSROC Engineering

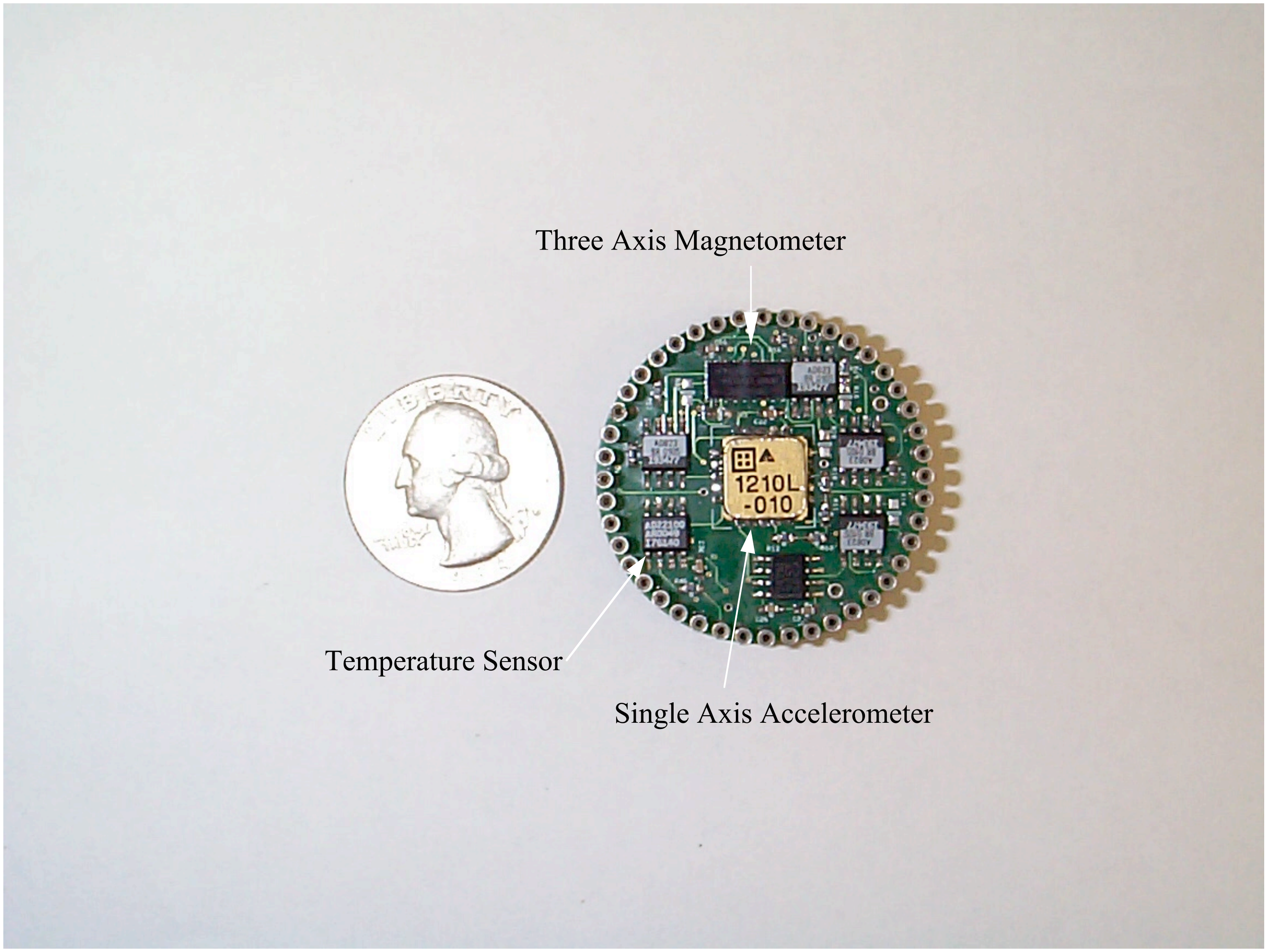
- Missions Flown

– Winstead 12.050	Dec 2000	WFF
– Laufer 30.046	Apr 2001	WFF

- Missions Scheduled

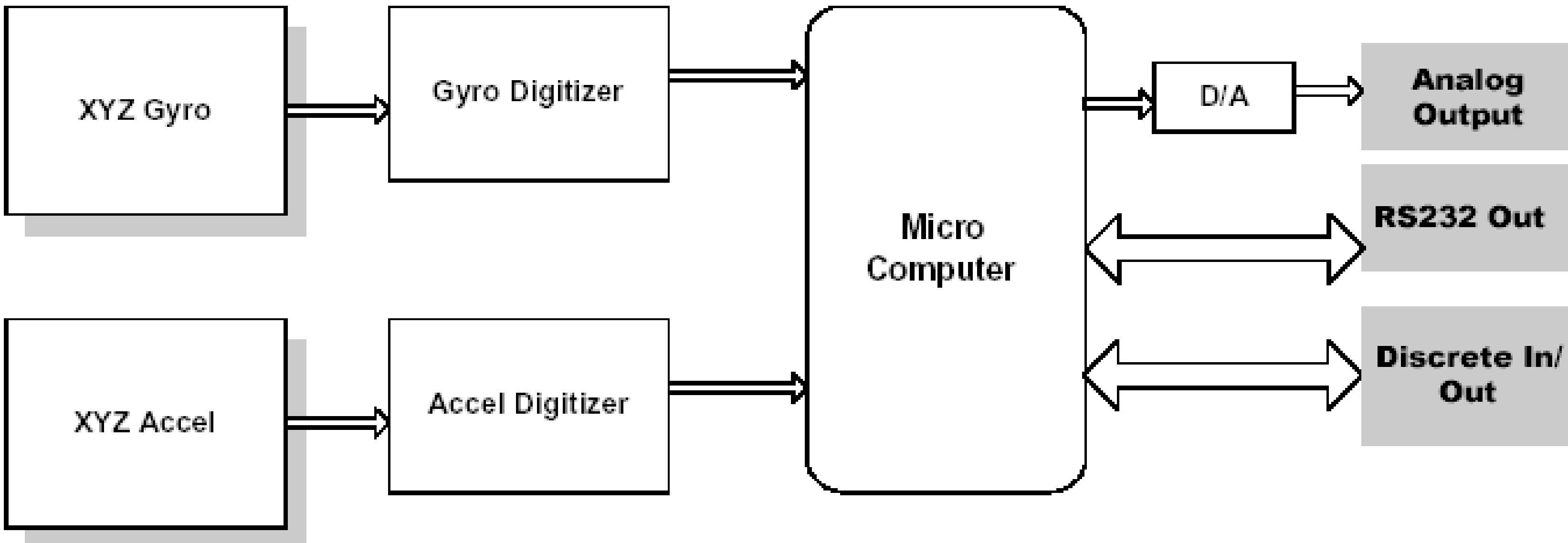
– Winstead 42.002, 003	Feb, 2002	WFF
– Lynch 30.049, 050, 051, 052	Mar, 2002	PFRR
– Erdman 41.022, 023	May, 2002	WSMR
– Croskey 31.124, 125	May, 2002	WSMR
– Goldberg 41.032, 033	Jul, 2002	Norway
– Erdman 41.024, 025	Nov, 2002	WSMR
– Goldberg 41.030, 031	Feb, 2003	Sweden

NSROC(a)


Three Axis Magnetometer
Temperature Sensor
Single Axis Accelerometer
1210L
-010

NSROC(a) Addition

NSROC Engineering



- Inertial Sciences Incorporated
  - 3 Axis Rate Gyro/IMU
  - Erdman 41.022/3 and 41.024/5

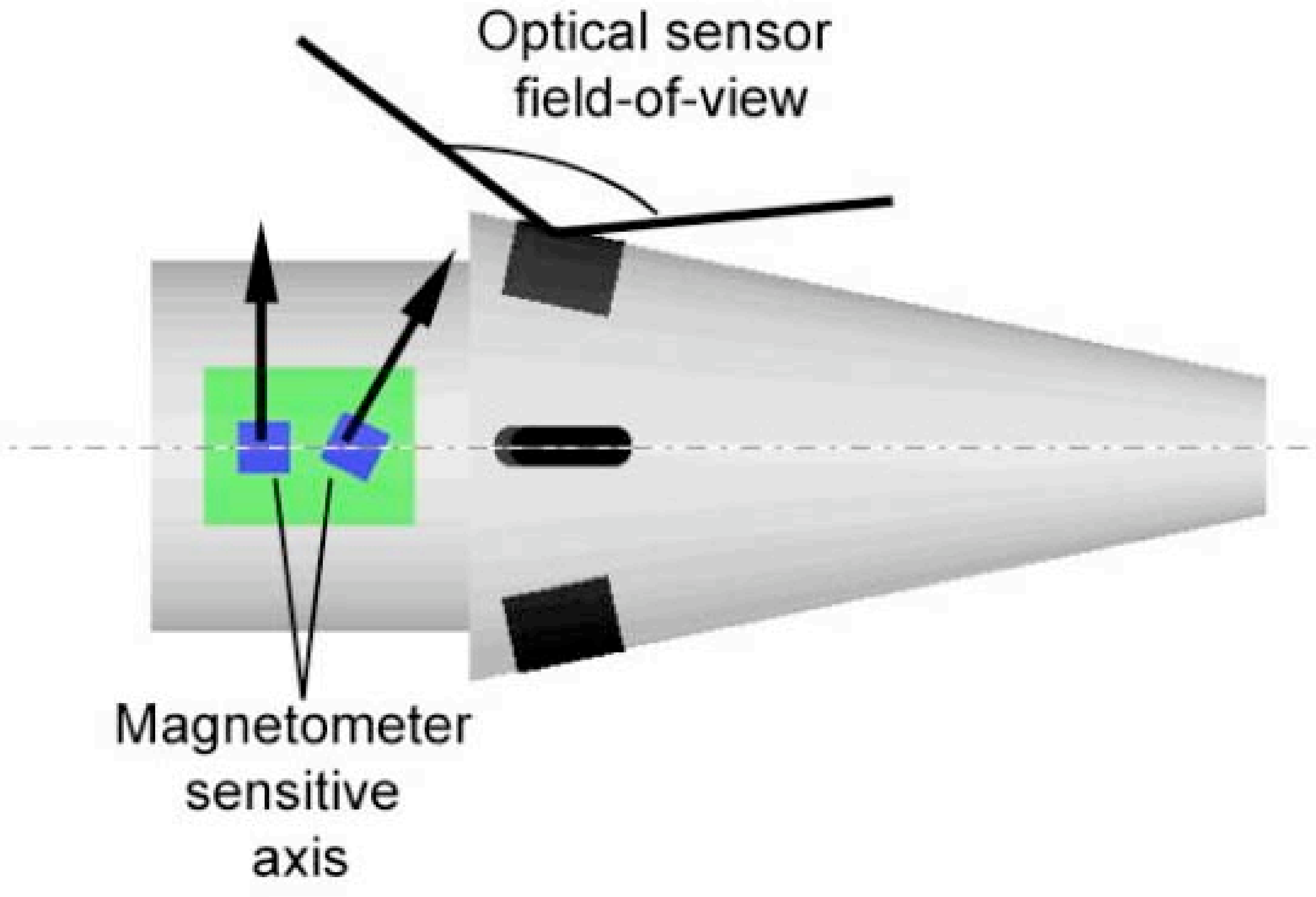
NSROC(a) Potential

- Uses
  - Attitude TM For Non-ACS Missions (Targets, ETC)
  - Attitude TM For Sub-Payloads
  - ACS Systems For Small Rockets (Viper-Dart)

- Difficulties
  - Data Reduction Complexity
  - Sensors Are Not Roll-Stabilized

Magnetometers And Sun Sensor

NSROC Engineering



NSROC(a) Data Output

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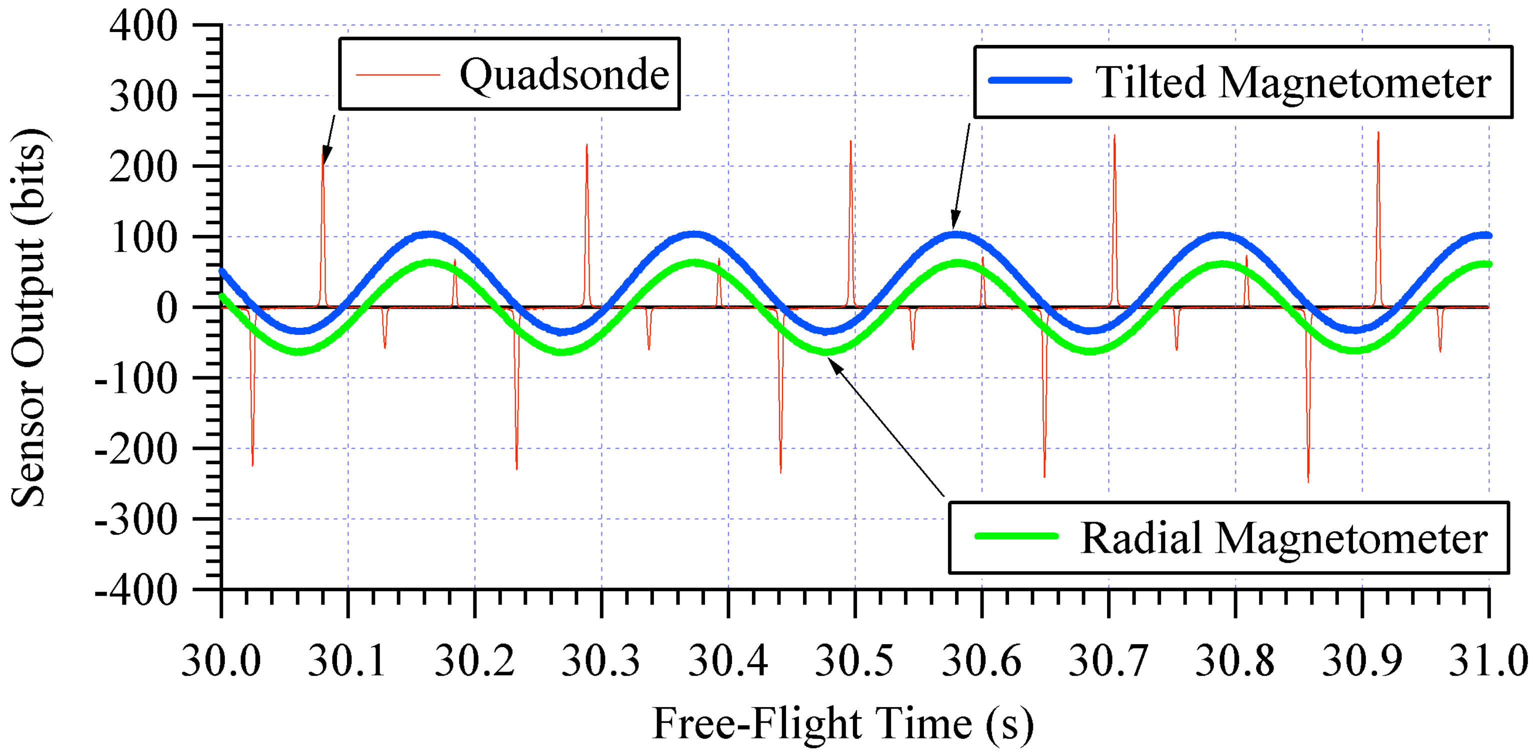
Engineering



GNC Conclusions

NSROC
Engineering

- NSROC Can Replace Space Vector Systems Soon
  - Use Up Space Vector Assets
  - Be Ready For Space Vector Failure
  - MIDAS/MARI Assets Provide Breathing Space
  - Flexibility Plan For Transition
- NSROC Can Bring All Systems In-House Eventually
  - Currently No Urgency For DS-19 w/DMARS
  - AeroJet Would Require Eventual MARI Replacement (DMARS Or GLNMAC-200)
- NSROC(a) Provides Cheap Capability Extension

NSROC Electrical Engineering Activities

- Mag Cal Facility Upgrade
- Sequence Timer Upgrade
- Video Compression Technique
- Remote Control Power Suitcase
- Low Cost Telemetry System

NSROC
Engineering

Mag Cal Facility Upgrade

- Upgraded early November, 2001 to include a remote earth field sensing magnetometer.
- The upgrade includes a PC104 system with 16 bit ADC to read the remote magnetometer and output via RS-232 the measurement. The remote magnetometer RS-232 output is converted to fiber and sent to the main control room and read by the main control computer.
- The control computer software has been modified to read and display this data.
- This upgrade required no modifications to the main control computer hardware, but did include extensive software modifications to allow for monitoring, testing, and adjusting the earth field for drift detected in the earth field.
- Other modifications included changing reports to accurately reflect the measurements and changing window sizes to accommodate the remote magnetometer displays.

Mag Cal Facility Upgrade

NSROC
Engineering

Mag Cal Facility Upgrade

NSROC
Engineering

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NSROC Engineering

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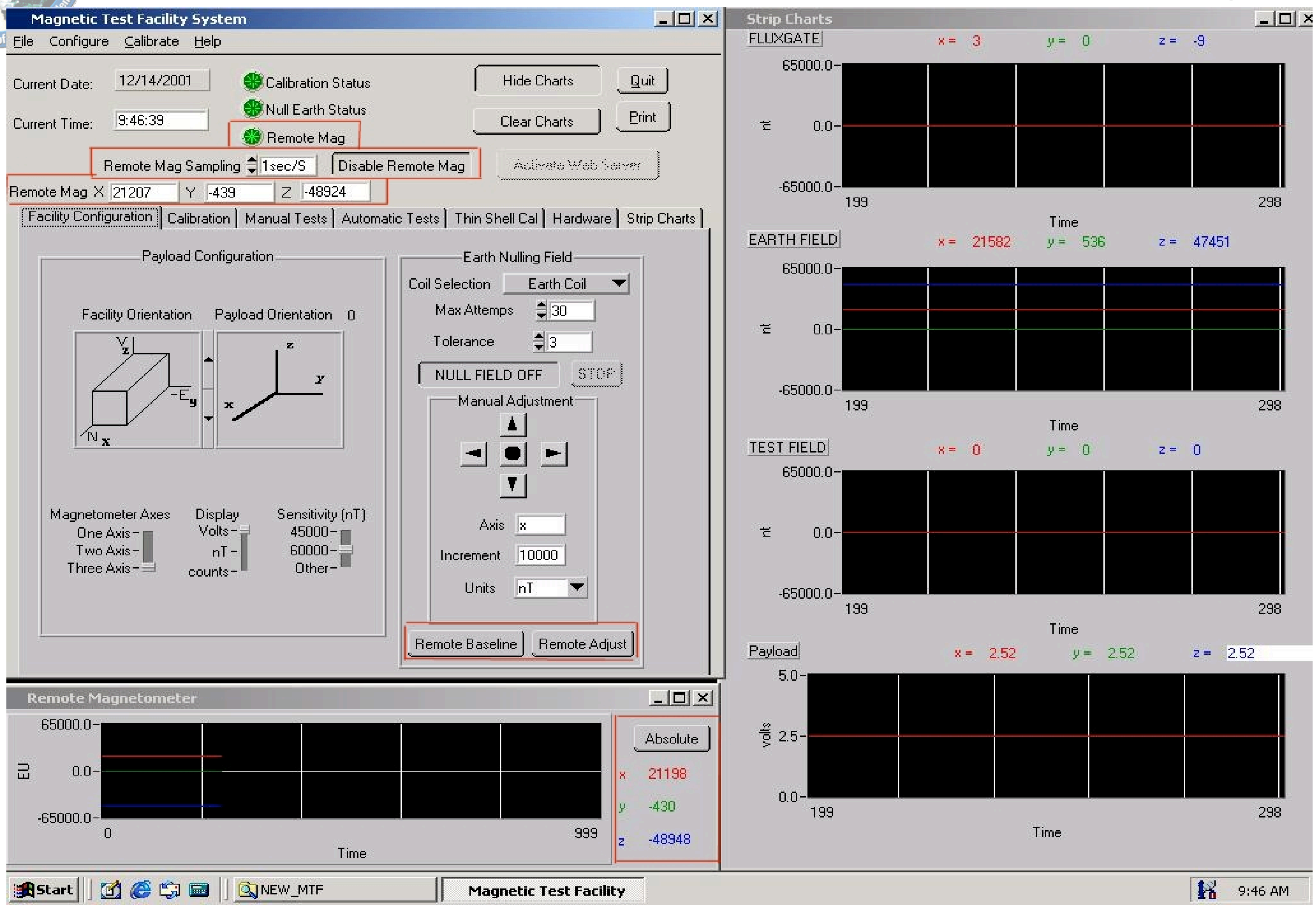
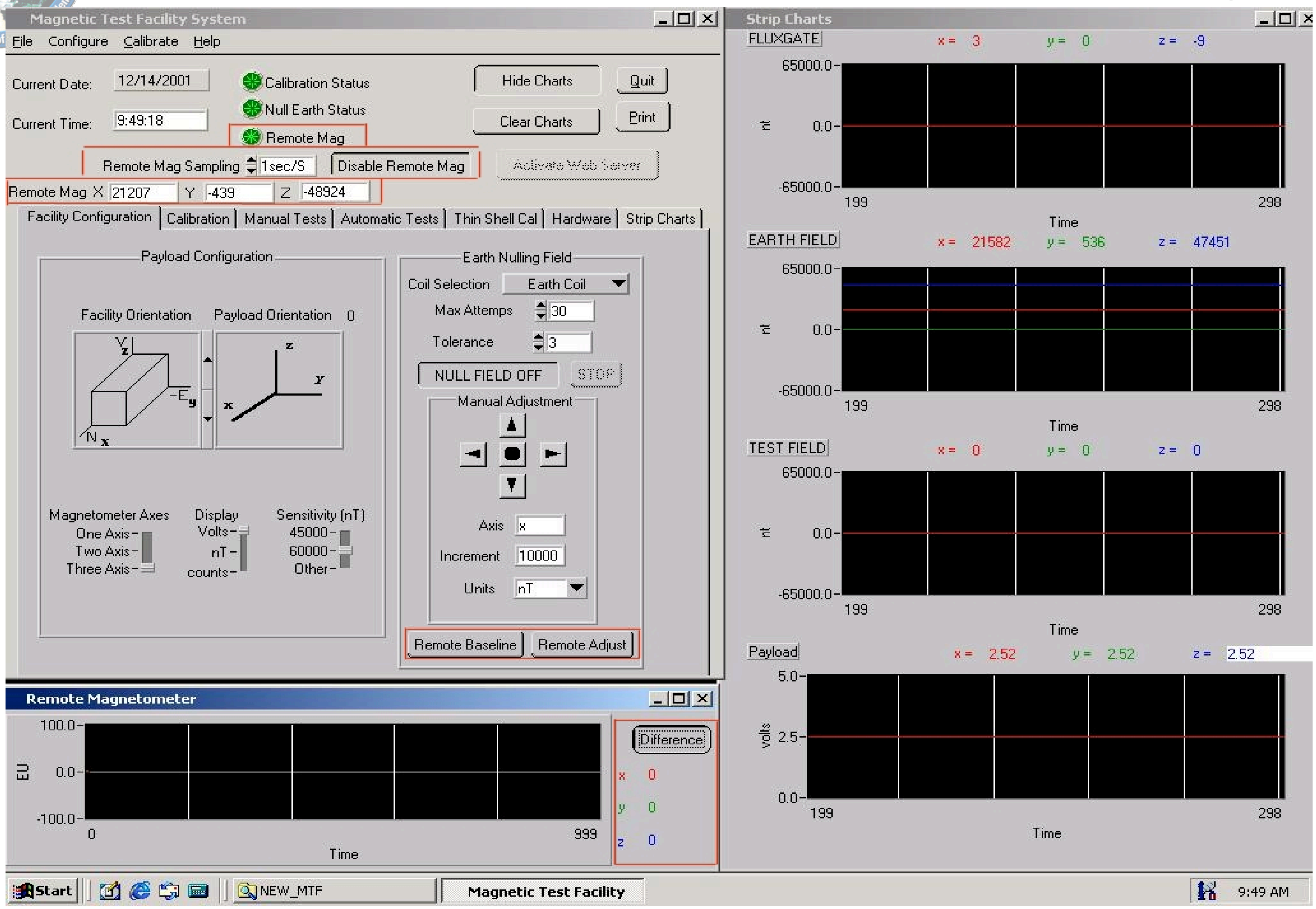


Mag Cal Facility Upgrade

NSROC
Engineering



Mag Cal Facility Upgrade

NSROC Engineering

Open Issues

- The alignment of the remote magnetometer to the coil system needs to be completed and measured

Sequence Timer Upgrade

NSROC
Engineering

Key Features

- Timer can be reprogrammed in the payload via laptop computer
- Timer & support module now combined into one box

Status

- Successfully flown on 36.183 Wilkinson and 21.126 Hecht instrumentation systems
- Successfully tested through all levels of payload testing except flight on 21.127 Hecht.
- Atmel Microcontroller revision just released solves previous low programming voltage issue.
- Plan to fly prime on 36.197 Wilkinson after NSROC management formal approval

Sequence Timer Upgrade

Implementation plan for NSROC flight approval

1. Submit a Qualification Report and include the following data:
   a. Describe the qualification process; component level, system level and flight
   b. Provide a comparison of all MFT and the RPMFT events during the 2 qualification flight test
   c. Identify any design deviations between the original component qualification, 2 flight tests and the final released design
   d. Identify any anomalies, during the component and system processing, during the preflight testing and during the mission
   e. Include the final design
2. Prepare a briefing for an independent NSROC Technical Group to concur with the design and processes for the RPMFT. The briefing shall include adequate data for a thorough peer review to adequately assess the functioning of the RPMFT in the current design.

Video Compression Technique

NSROC
Engineering

Status

- The first flight unit and support GSE was shipped to WFF in early September, 2000 and integrated into 12.050 Terrier-Lynx TM system.
- Mission 12.050 flew on December 19, 2000 and successfully flight qualified this new hardware.
- NSROC has placed an order for 5 units with delivery set for January, 2002.
- PSL has added scan rate or resolution field programmability to the 5 new units.
- PSL proposes to upgrade the digitization and compression technique to allow the circuitry to shrink from 2 modules to 1.

Schedule

- Mission 36.197 Wilkinson has a requirement to fly one of these units in Summer of 2002.
- Professor Laufer from UVA proposes to incorporate one of these units in his student mission, currently set to fly in September, 2002.
- Mission 36.201 Stern will fly one of these units in April 2003

Remote Control Power Suitcase

NSROC Engineering

Key Features & Benefits

- Remote computer control of payload power & switching
- COTS GPIB equipment
- Low IR land line loss (<100')
- Automated over-voltage/over-current system shutdown
- Display of all system voltages & currents real time
- Support up to (6) (+V) systems or (3) split (+/-V) systems standard
- No additional power supplies required for battery charging
- Interlock to prevent charging while payload system on

Status

- All commercial software & hardware received
- Display software developed and tested
- Design of interface circuitry between GPIB hardware and P/L 95% complete
- Fabrication of interface circuitry set for January, 2002
- System ready to support I & T and launch of 36.112 Martin in March/April 2002

Low Cost Telemetry System

NSROC
Engineering

- **Approach**
  - NSROC (a) package $960-$1300 (Depending upon sensors used)
  - Custom built 8/16 channel PCM system ~$500-$1000
  - Transmitters
    - 1 Watt S-Band Transmitter $1600 each (3 Units procured)
    - 1 Watt S-Band Transmitter for Viper Dart $3630 each
  - Antennas
    - New Haigh-Farr 14” S-Band Antenna $1500 each
    - New Haigh-Farr 2.125” S-Band Antenna $850 each
    - New Haigh-Farr 2.125” GPS Antenna $800 each
- **Targeted Missions**
  - Chemical Release Payloads
  - Low Budget Student Payloads
  - Terrier-Lynx Target Missions

Conclusion

- NSROC believes that the SRWG findings are valuable in supporting the needs of the PIs and the science.