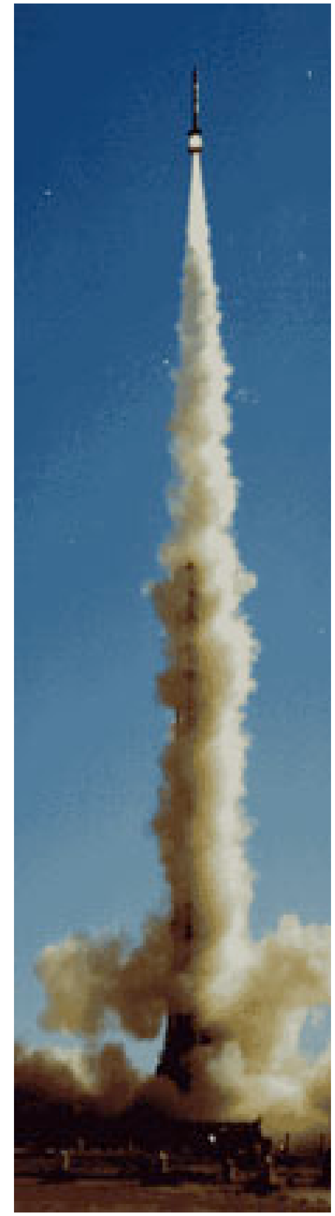
Sounding Rocket Working Group

NASA Sounding Rocket Operations Contract (NSROC)

NASA Wallops Flight Facility

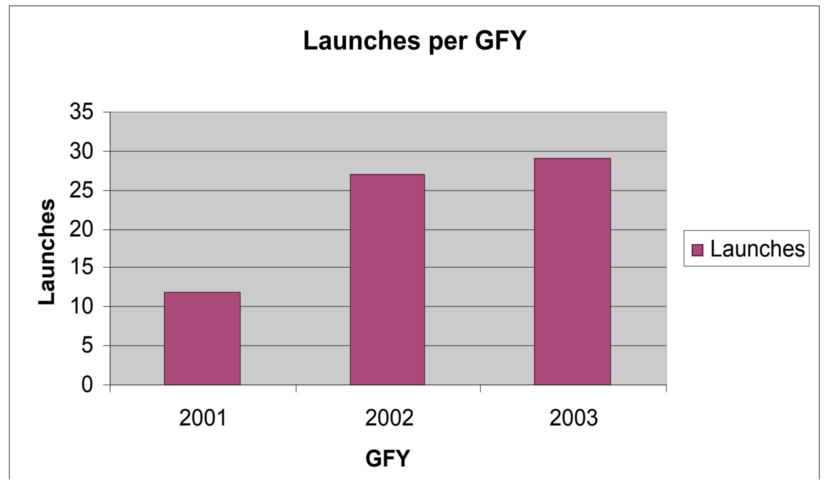
SRWG Agenda - NSROC

Introduction/NSROC State of Affairs	R. Cutler
Mission Summary & Planning	J. Scott
2002 Events of Note	D. Krause
S19D Mission Summary - Judge/36.202	
Wilkinson/36.197 AIB Summary	
JPL Mission Overview	
Talos/Oriole Vehicle Capabilities	
Terrier/Oriole Vehicle Capabilities	
Technology Thrusts	NSROC Team
GEM Overview/Status	
S-Band Tracker for Preflight Checkout	
Video Decompression Flight Results	
GLNMAC Overview/Status	J. Ozanne
NMACS Overview/Status	C. Martinez
NIACS Overview/Status	
ST-5000 Overview/Status	R. Kiefer
Data Reduction Capabilities	D. Melvin

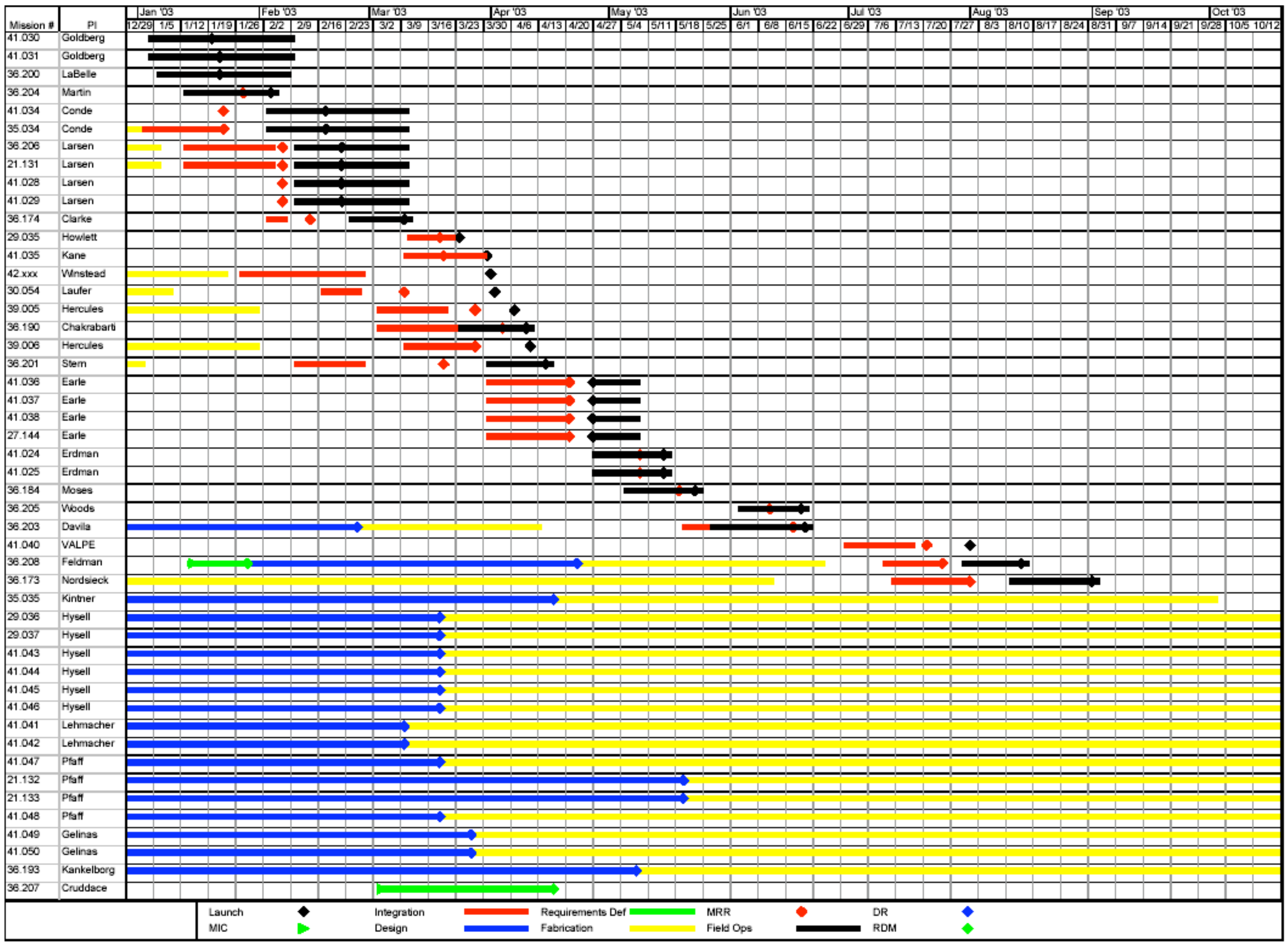


Programmatic

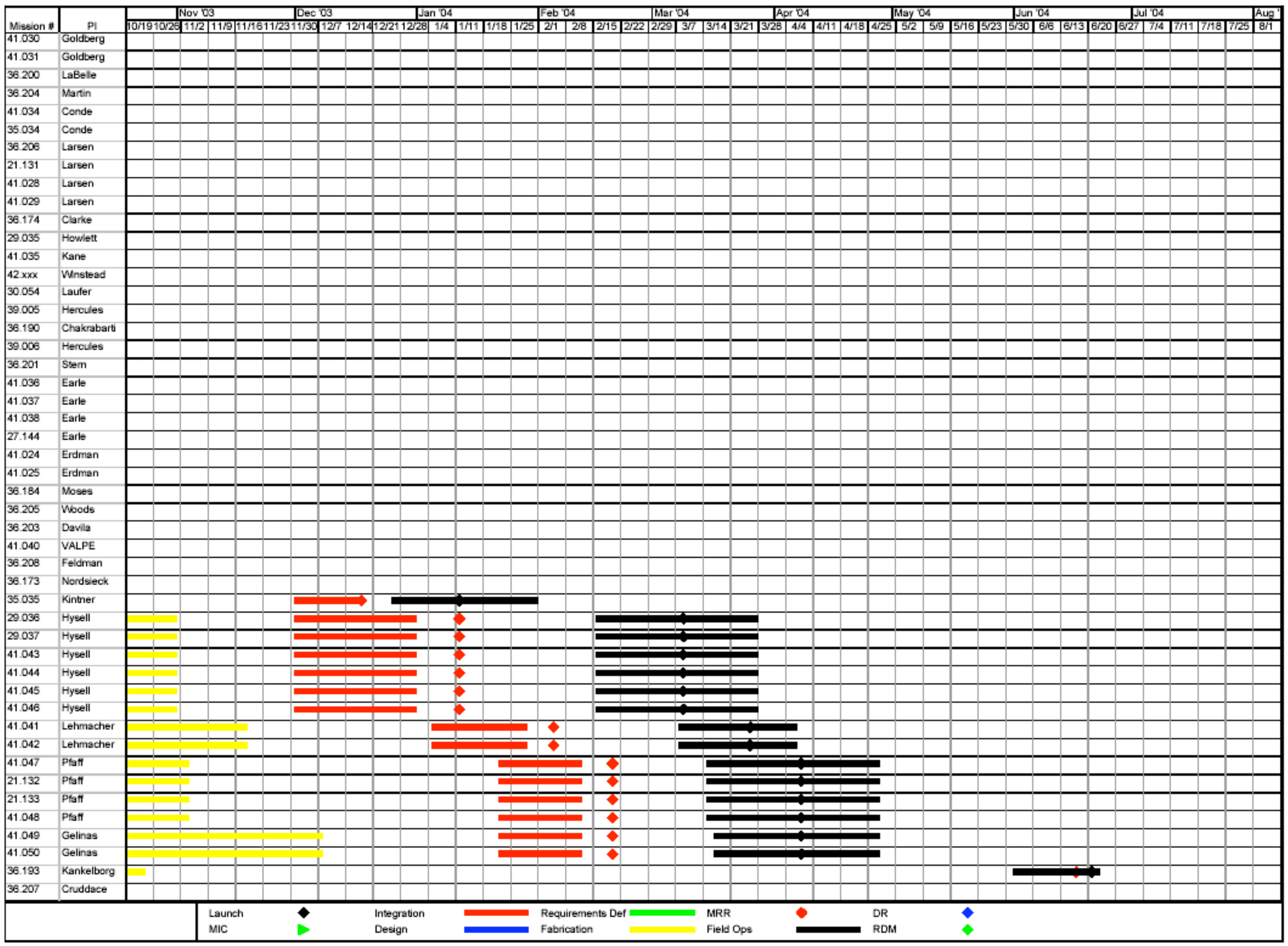
- The Past Year
  - 27 Successful Missions
  - Streamlined Processes
  - Implemented a Configuration Management System
  - New Business to WFF
  - Met the Financial Goals
- The Coming Year
  - New/Improved Technical Capability
  - Strained Resources



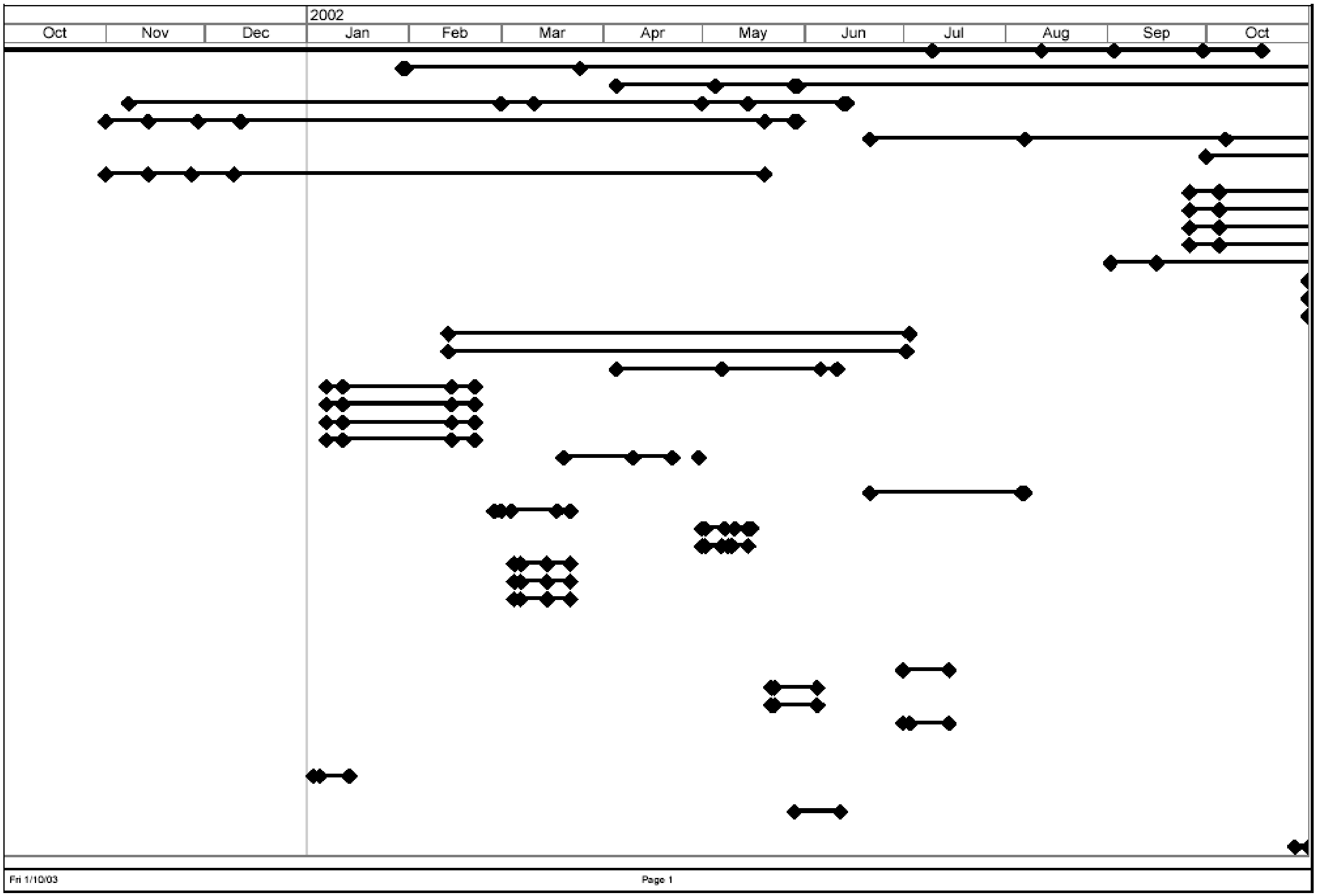
Master Mission Schedule



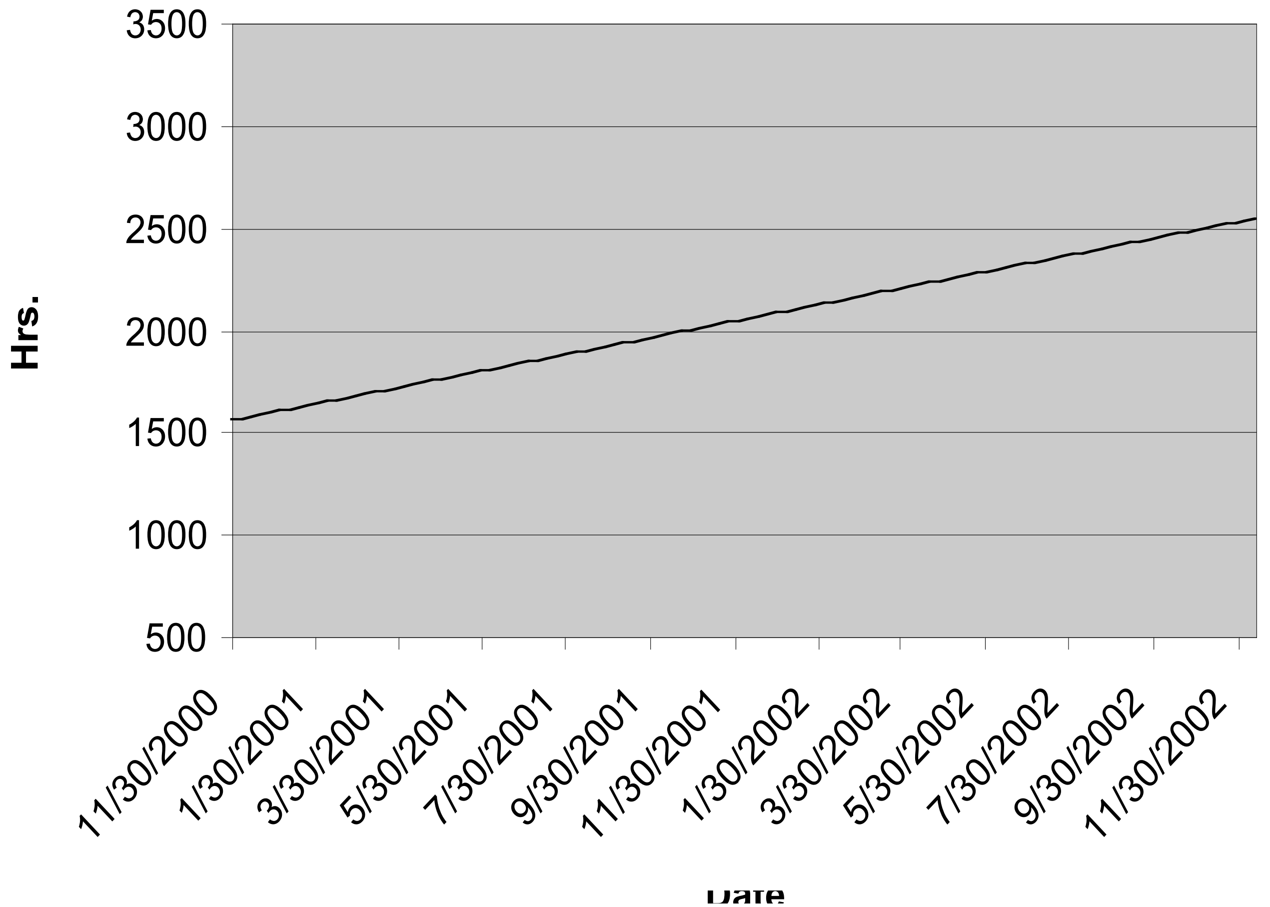
Master Mission Schedule (2)



Scheduled Launch Dates per Mission



Average Hours/Week on SR Missions



2002 Events of Note

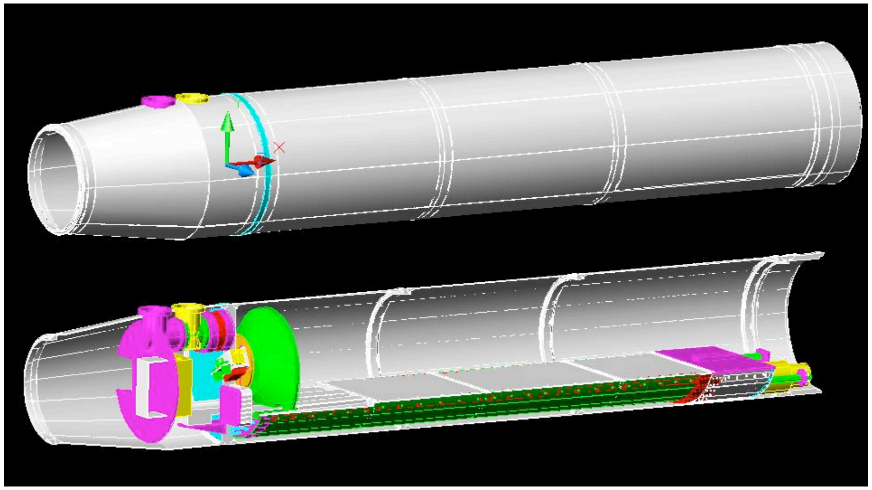
- Judge/36.202 Mission Summary
  - S19-D Boost Guidance System Return-to-Flight
- Wilkinson/36.197 Mission Failure
- JPL New Millennium Program – ST-9

Judge/36.202 S19-D RTF Mission

- Dr. Judge’s mission was the Return-to-Flight of the digital Boost Guidance System, S19-D.
- Flight Vehicle flew flawlessly.
- Cross/Down Range Dispersion was 0.19_
- Single Anomaly was a loss of DMARS TM data at 77.9 sec. Problem resolved to a pin/wire disconnect on an internal connector. Note that the DMARS TM data is an asynchronous signal (through a single wire.)

Wilkinson/36.197 Mission Failure

- AIB Investigation Underway
  - Investigating a thermally induced misalignment of the 2 separate optical planes following the propulsive stages
- Investigation Process includes:
  - Measure thermal growth on flight hardware
  - Verify with
    - Thermal Analysis Model
    - Determine angular misalignment estimate of Star Tracker and optical camera flight data
- Separate Optical Planes?



JPL New Millennium Program – ST-9

- Program is JPL's proposed entry for the New Millennium ST-9 mission.
- Ultimate program goal is the vehicle delivery into Elysium Planitia, a crater on the Mars surface
- This JPL/NASA/NSROC Program will provide the validation for the SMART EDL system architecture via the earth-based suborbital mission. the reentry sequence for the Mars mission and include
  - Dynamic Scaling Approach
  - Key SMART EDL technology Elements
    - Guided Entry
    - Thermal Protection
    - Parachute Decerelator
    - Terrain-Sensing
    - Terrain Relative navigation
    - Targeted Powered descent
    - Descent Propulsion
    - Landing/Arrest

NMP ST-9 Suborbital Plan

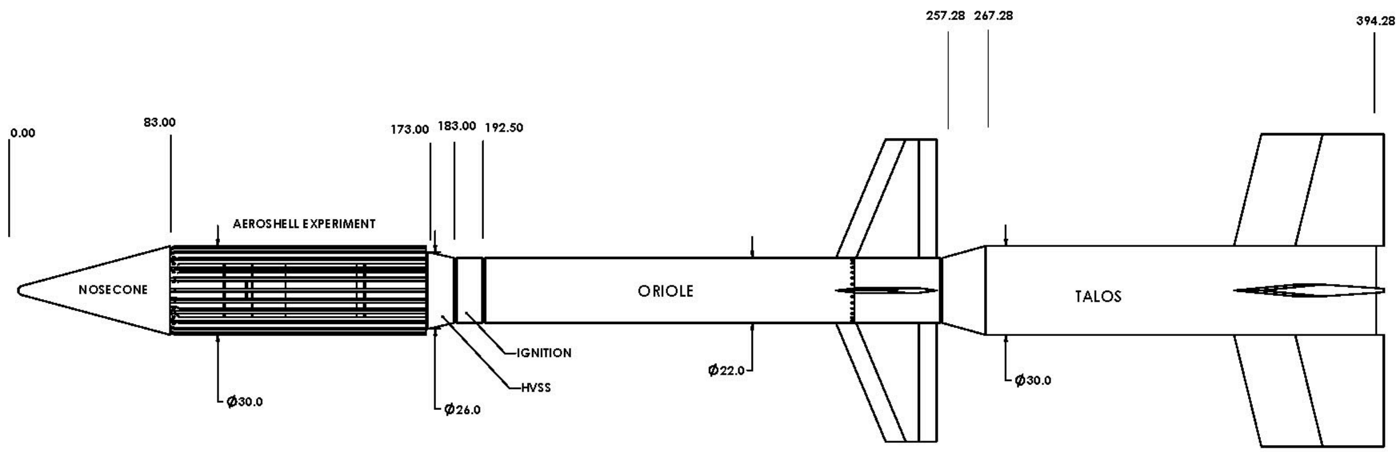
- Plan is for a series of suborbital tests for a step-wise system validation
  - Phase A

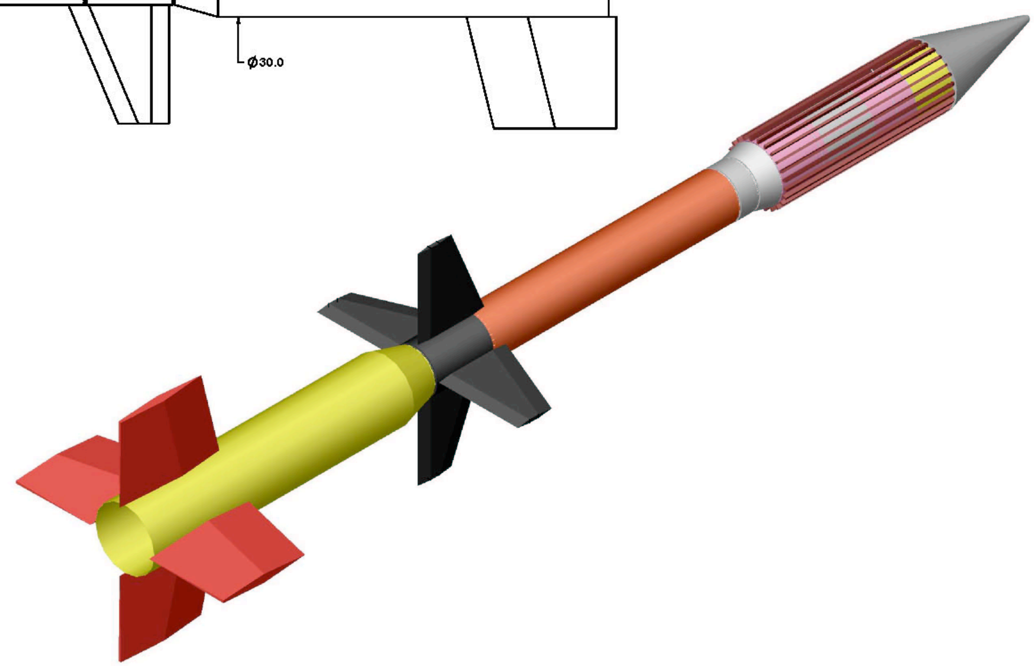
    Proof of Concept Vehicle Demonstration- Jan. '04 – WFF

  - Phase B

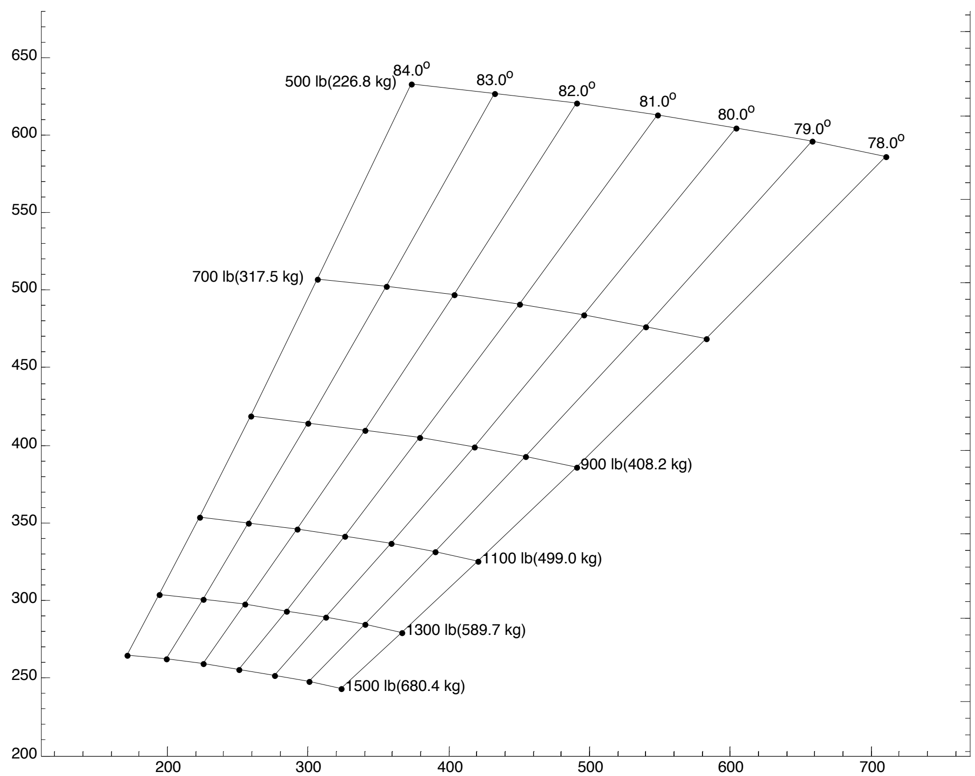
Launch #	Flight Type	When	From
1.	Prototype Aeroshield	4th Q - '04	WFF
2.	Development Flight	2nd Q - '06	WFF
3.	Development Flight	2nd Q - '06	WFF
4.	Full-up Demonstration	1st Q - '07	PFRR or Australia
5.	Full-up Demonstration	1st Q - '07	PFRR or Australia

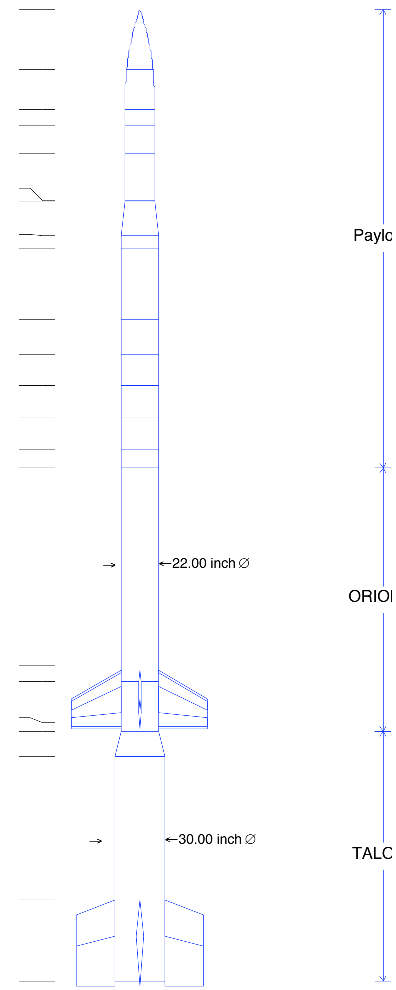
NMP Risk-Reduction Vehicle Configuration



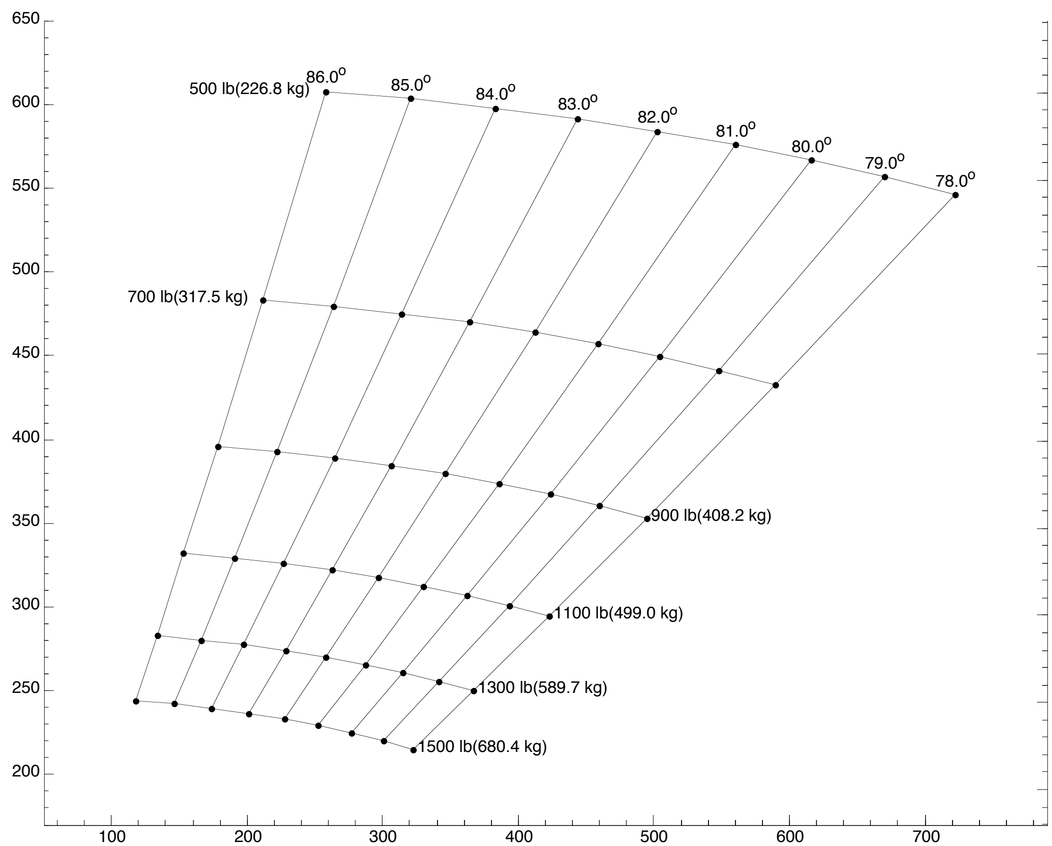


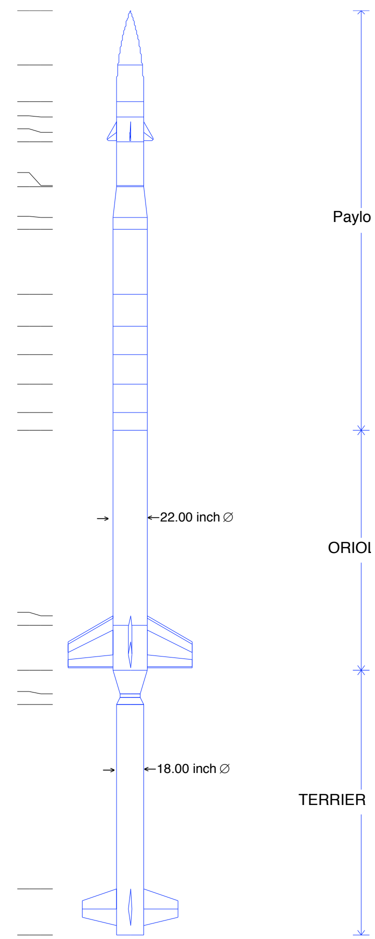
Talos/Oriole Vehicle



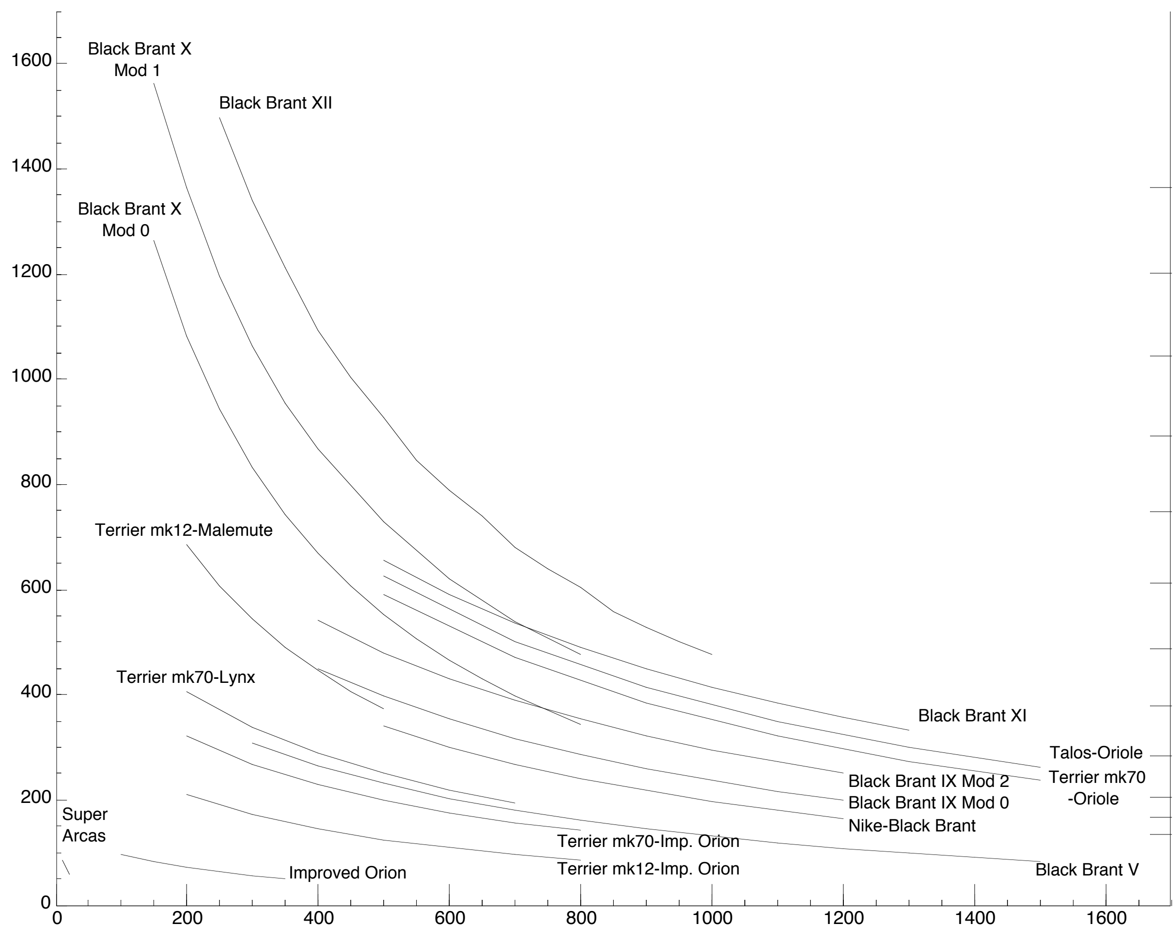


Terrier/Oriole Vehicle Capabilities





Performance Capabilities of our Stable of Sounding Rocket Vehicles



Video Compression Trade-offs

- Advantage: Allows video capability without additional weight and payload complexity for transmitters, battery, and antenna
- Disadvantage: Requires additional Ground Support Equipment, higher PCM link rates, and tradeoff between frame rate and video quality at lower bit rates
- Additional PCM Bit rate required for video: 100 kbps – 6 Mbps
- Video Frame Rates available: 2 fps – 30 fps
- 6 Mbps, 30 fps Broadcast Quality Video
- 4 Mbps, 30 fps VHS Quality Video
- 2 Mbps, 15 fps VHS Quality Video
- Latency dependent on bit rate and video frame rate
  - 6 Mbps, 30 fps: <100 ms (Complex/Solar Images)
  - 2 Mbps, 30 fps: 300 ms (Simple Stellar Images)
  - 100 kbps, 2 fps: 2-4 s (UAV, Balloon application)

Technology Enhancement Progress

- GPS Altitude Event Triggering Module (GEM)
- S-band Beacon on Test Rocket
- Remote Control Power Suitcase
- TM Data Rate Increases
- Enhanced Data Transmission
- GLNMAC
- NSROC Magnetic ACS
- NSROC Inertial ACS
- ST-5000
- Data Reduction

GPS Event Module (GEM)

System Capabilities

- 15 Programmable Events
- Upleg, Apogee and Downleg Control
- 1 KM Altitude Accuracy
- Flight proven micro-controller and driver electronics will be used

System Status

- NASA Initiated PTO to NSROC in October, 2002.
- Prototype hardware bread boarded
- Software developed
- Prototype hardware successfully tested with software using flight data from 41.032/33 Goldberg
- System ready for testing with flight GPS unit on simulator

Test Rocket S-Band Beacon

Problem

- Poor TM antenna tracking performance at Poker Flat, Alaska last Winter 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 "ø) currently used by Radars to verify they are flight ready.

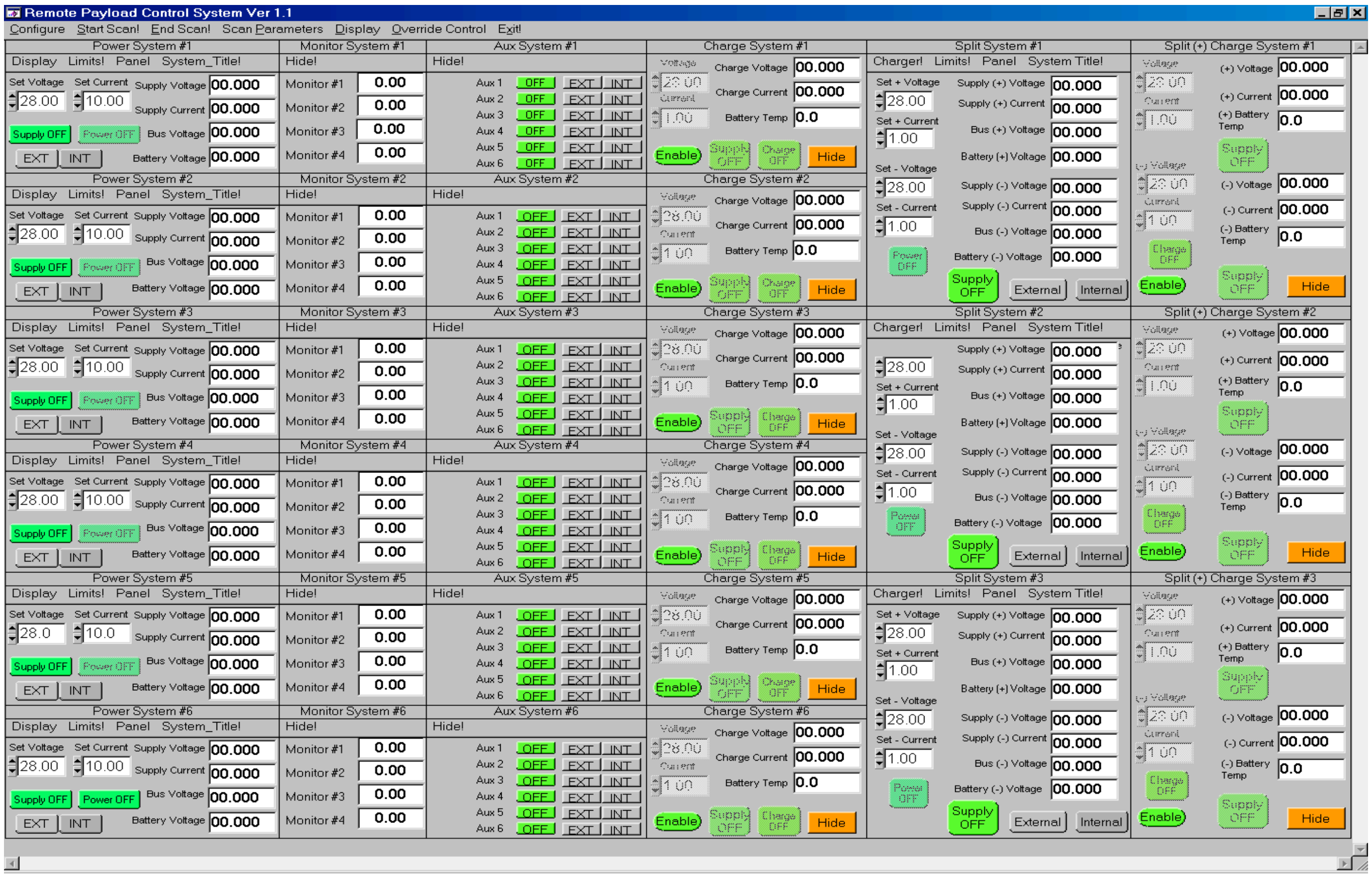
Status

- 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 has a working prototype unit and is currently working on the antenna development
- NSROC has developed the design for the power supply, control system and PCM system simulator and submitted for PC board fabrication

Remote Control Payload Control System

- System communicates with power supplies and relay controller (located in close proximity to launcher) unit via 2 fiber optic lines. Less than nine copper lines required between blockhouse and remote unit, which provides emergency shutdown/relay reset commands should any uncontrollable situation arise.
- Successfully used for testing and launch of 36.202 Judge on August 8, 2002
- System is configurable for monitoring maximum and minimum supply voltages and currents with automatic shutdown for overvoltage or overcurrent conditions.
- Capability for remote monitor display added since Judge launch. This will allow for remote display of payload control status allowing additional mission personnel to monitor payload status.
- Four RPCS's will be used to support all instrumented Peru missions, thereby minimizing copper land lines required.

Remote Control Payload Control System



Remote Control Payload Control System

Control Unit

Launch Pad Unit

TM Data Rate Increases

Increasing PCM bit rate to 16 MBPS

- PSL has a new, more compact footprint, PCM encoder system with Parallel Digital Data Inputs successfully tested at 16 MBPS composite data rate.

Enhanced Data Transmission

Upper S-Band

Problem

- Not enough RF Bandwidth for all required TM downlinks for 36.200 Labelle/Dartmouth mission

Solution

- Use frequencies in Upper S-Band (2300-2400 MHz)

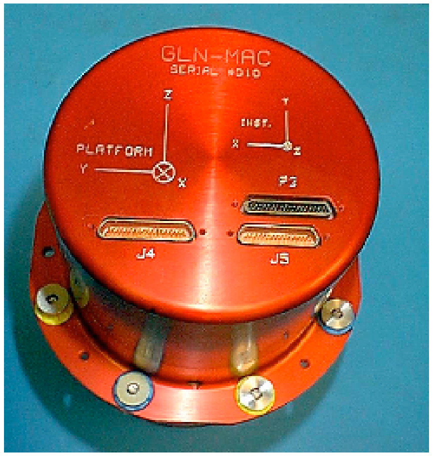
Status

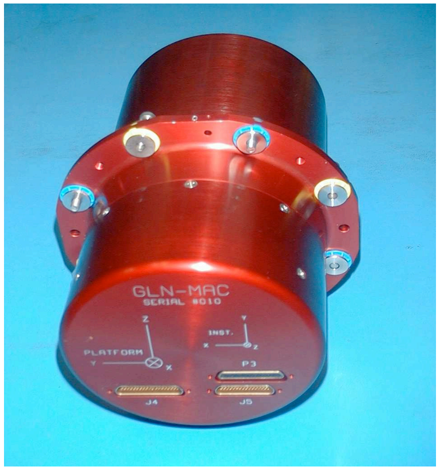
- Requested and received permission from Direct Broadcast Audio companies for use of 2332.5 MHz.
- Requested and got permission through NASA frequency scheduling for both 2332.5 and 2370.5 MHz
- NSROC tasked PSL to develop and produce Upper S-Band antenna which covers both RF frequencies.
- Purchased new frequency programming plugs for S-Band transmitters.

GNC Agenda

- GLN-MAC-200 Manufacturing - John Ozanne
- NIACS - NMACS Development - Carlos Martinez
- NIACS - NMACS Pneumatics - Jerry Doyon
- ST5000 - Star Tracker - Ron Kiefer
- ACS Data Analysis - Dennis Melvin

GLN-MAC

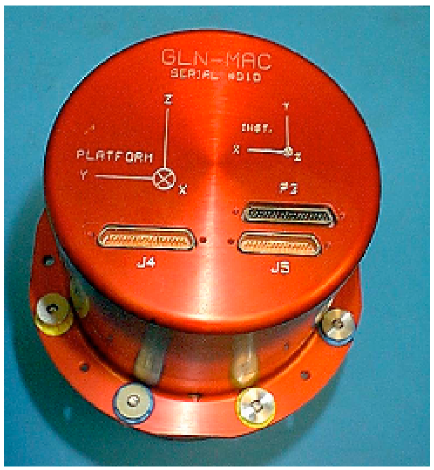




Roll Isolated IMU and Flight Computer

Presented By: John Ozanne NSROC – GNC

Performance



Weight……………………………………….. 5.7 lbs.
Size…………………………… 8.263 in X Ø 4.125 in
Performance Capabilities
Spin Isolation……………………………..15 Hz max
LN-200 Gyro Performance
Bias Repeatability…………………….1 degree/hour
Random Walk…………………..…….0.05 deg/√hour
Scale Factor Stability…………………100ppm (1_)
Bandwidth……………………………….…..>500 Hz
Operating Range……………….…..…± 1000deg/sec
Quantization…………………..………..…..1.9 _ radian
LN-200 Accelerometer Performance
Bias repeatability………………….…….200 _g (1_)
Scale Factor Stability……………….…300 ppm(1_)
Noise…………………………………….500 _g/√Hz
Bandwidth……………………………………...100 Hz
Operating Range……………………………....± 40 g
Data Output Rate
Typical……………………………………….400 Hz
Activation Time……………………….…0.8 seconds
Full Accuracy ……………………………..5 seconds

GLN-MAC – MIDAS – DMARS Comparison

Parameter	GLN-MAC	MIDAS	DMARS
Weight	5.7 lbs	8.3 lbs	7.2 lbs
Size	8.26 X 4.125D	7.5 X 5.25D	6.5 X 4.3D
Gyro	IFOG	Displacement	DTG
Data			
Rate	400 Hz	N/A	90 Hz
Type	Digital	Analog	Digital
Pitch, Yaw, Roll	Delta Angle	Gimbal Angle	Delta Angle
X,Y,Z	Delta Velocity	N/A	Delta Velocity
Bias Drift	1 deg/hr	30 deg/hr	20 deg/hr

Advantages of the GLN-MAC

- Gyros are solid state
  - More rugged and reliable than their mechanical counterparts
  - Wider bandwidth – take rate data at 400 Hz
- No Gimbal Lock
  - Unlimited range of motion in all axes
- More Accurate
  - Drift Rates
    - 30X better than MIDAS
    - 20X better than DMARS
  - G-Sensitivity
    - 20X better than DMARS
- Assembled by NSROC
  - We can control the assembly processes and techniques

Applications to the Sounding Rocket Program

- TM Attitude Sensor
  - Attitude information to < 1º in all three axes
- NIACS - NSROC Inertial Attitude Control System
  - Better than 1º attitude control in all three axes
- Boost Guidance
  - Reduce dispersion

NSROC believes that eventually a single GLN-MAC will perform all three functions on a single mission.

GLN-MAC Program Status

Milestone	Schedule	Status
Government Use Notice	---------	Signed on 14 May 2002
2.1 NSROC Review of Documentation	25 Nov 2002	Complete
2.2 GLN-MAC Unit #3 Build at SNL	9-13 Dec 2002	Complete
2.3 NSROC Document Preparation	31 Dec 2002	Complete
2.4 GSE	24 Feb 2003	In Process
2.5 Hardware Procurement (Rec'd)	21 Apr 2003	In Process
2.6 NSROC GLN-MAC	23 Jun 2003	Scheduled Start for April '03
2.7 Acceptance Testing at SNL	27 Jul 2003	Immediately after 2.6

NSROC GLN-MAC will be available for sounding rocket applications by the end of 2003

NSROC Magnetic Attitude Control System (NMACS)

Presented By:
Carlos Martinez

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Introduction

- In June of 2002 a PTO task plan to develop a Magnetic ACS was presented to NASA.
- The goal:
  - To expand our in house capabilities and reduce the requirements for single source vendors.
  - Utilize latest computing software tools to design, simulate and test ACS.
  - Utilize latest technology components to reduce system cost or improve performance.
  - Create Graphical User Interface (GUI) with real-time display of ACS data.

Agenda

- Overview of the magnetic ACS
- Status
- Schedule
- New computer software tools utilized to develop and test ACS
- Ground Support Equipment (GSE)
- Demos

System Overview

- The magnetic attitude control system deals with two different types of error:
  - The misalignment between the vehicle's angular momentum vector and the local geomagnetic field line (*precession angle)*.
  - The offset between the nominal spin axis and the angular momentum vector (*nutation angle)*.
- To avoid instability and/or unacceptable slow convergence, the attitude control logic combines the two error signals.
- A 3-axis magnetometer and a rate gyro provide the reference for corrective thruster firings.

System Overview

- System capability
  - Absolute pointing error < 5 degrees
  - Convergence time less than 60 seconds depending on initial error angle, spin rate, and mass properties of the payload
  - Roll control to desired radians/second
  - Easy RS232 interface to the system using a GUI
  - Instrumentation timer used to enable/disable thrusters

System Overview

- Major system components
  - Electronic stack with the controller deck, the TM deck, valve driver deck and the power deck
  - 3-axis magnetometer
  - 1-axis gyrochip
  - 28V battery pack
  - Mono-level pneumatic system with 2-valve for pitch/yaw and 2-valve for roll control
  - 17.26 in. skin

Status

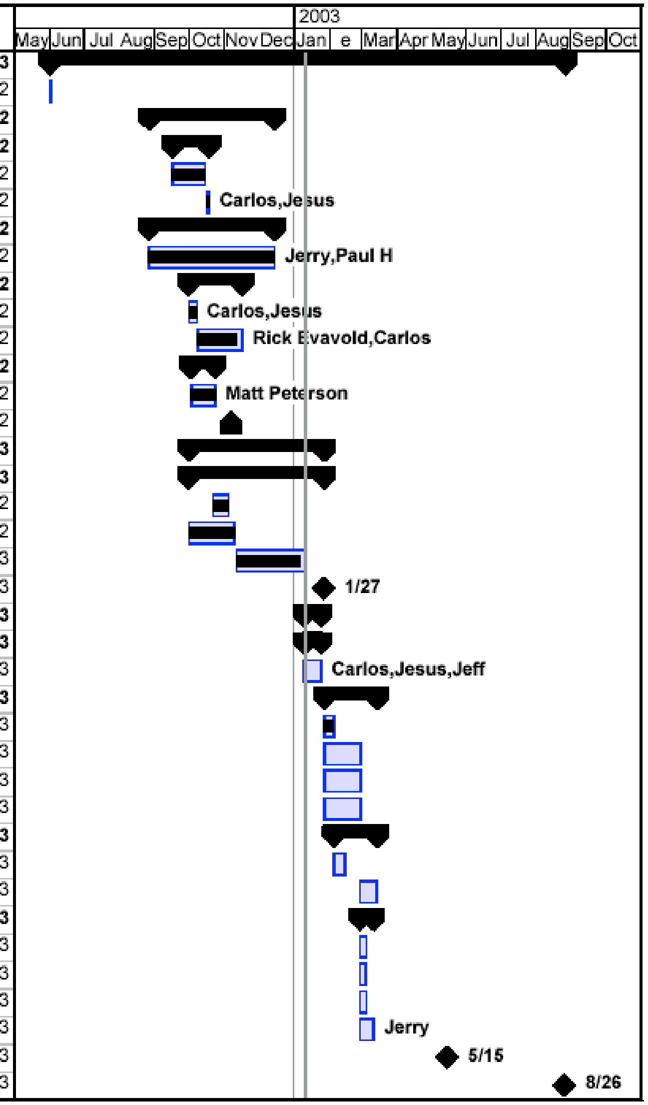
- Real-time computer simulation and testing of the system control logic has been completed.
- The firmware for the control logic has been implemented and tested.
- An engineering unit has been assembled and tested in the HILTS and in the horizontal air bearing vehicle.
- Design of the TM interface has been completed.
- Design of the GSE has been completed.

Schedule

- Design review tentatively scheduled for January 27^{th}.
- Fabrication and assembly of first flight unit starting after the DR.
- First test flight is tentatively scheduled for May 2003.
- Second test flight is tentatively scheduled for September 2003.

Schedule

ID	Task Name	Duration	Start	Finish
1	NSROC SPARCS Mag ACS	323 days	Sat 6/1/02	Tue 8/26/03
2	NASA PTO Task 144	1 day	Sat 6/1/02	Sat 6/1/02
3	System Design	79 days	Tue 8/27/02	Sat 12/14/02
4	Control System design	24 days	Tue 9/17/02	Fri 10/18/02
5	Control Law Formulation	20 days	Tue 9/17/02	Mon 10/14/02
6	Control Law Review	2 days	Thu 10/17/02	Fri 10/18/02
7	Pneumatics	79 days	Tue 8/27/02	Sat 12/14/02
8	Pneumatics Trade Study	79 days	Tue 8/27/02	Sat 12/14/02
9	Adapt Electrical System	34 days	Tue 10/1/02	Sat 11/16/02
10	Adapt ACS TM Interface	5 days	Tue 10/1/02	Mon 10/7/02
11	Electrical Schematics/Wiring List	28 days	Wed 10/9/02	Sat 11/16/02
12	Mechanical Design	15 days	Thu 10/3/02	Wed 10/23/02
13	Configuration and drawings	15 days	Thu 10/3/02	Wed 10/23/02
14	Design Review	1 day	Thu 11/7/02	Thu 11/7/02
15	System Development	85 days	Tue 10/1/02	Mon 1/27/03
16	Control System Development	85 days	Tue 10/1/02	Mon 1/27/03
17	Firmware	10 days	Tue 10/22/02	Mon 11/4/02
18	HILTS tests	29 days	Tue 10/1/02	Sat 11/9/02
19	Horizontal Air Bearing Testing	44 days	Tue 11/12/02	Fri 1/10/03
20	Design Review	1 day	Mon 1/27/03	Mon 1/27/03
21	Documentation	11 days	Fri 1/10/03	Fri 1/24/03
22	Procedures	11 days	Fri 1/10/03	Fri 1/24/03
23	ATP	11 days	Fri 1/10/03	Fri 1/24/03
24	Flight Unit Fab and Testing	34 days	Tue 1/28/03	Fri 3/14/03
25	Electronics	6 days	Tue 1/28/03	Tue 2/4/03
26	Mechanical Fab	24 days	Tue 1/28/03	Fri 2/28/03
27	Electrical Wiring	24 days	Tue 1/28/03	Fri 2/28/03
28	Pneumatics	24 days	Tue 1/28/03	Fri 2/28/03
29	Component Level testing	28 days	Wed 2/5/03	Fri 3/14/03
30	Flight Electronics	8 days	Wed 2/5/03	Fri 2/14/03
31	Pneumatics	11 days	Fri 2/28/03	Fri 3/14/03
32	ATP	8 days	Fri 2/28/03	Tue 3/11/03
33	Bench Test	4 days	Fri 2/28/03	Wed 3/5/03
34	HILTS	3 days	Fri 2/28/03	Tue 3/4/03
35	Air Bearing	4 days	Fri 2/28/03	Wed 3/5/03
36	Pneumatics	8 days	Fri 2/28/03	Tue 3/11/03
37	Demonstration Flight #1	1 day	Thu 5/15/03	Thu 5/15/03
38	Demonstration Flight #2	1 day	Tue 8/26/03	Tue 8/26/03



New Computer Software Tools Utilized to Develop and Test ACS

- MATLAB, Simulink and the Real-Time Workshop computing software tools from The MathWorks Inc. are being utilized for vehicle and system modeling, real-time simulation, and hardware in the loop testing of the control system.
- The investment in these software tools has been a major contribution to this project; as demonstrated in the quick development of the Magnetic ACS, as a visualization and a training tool.

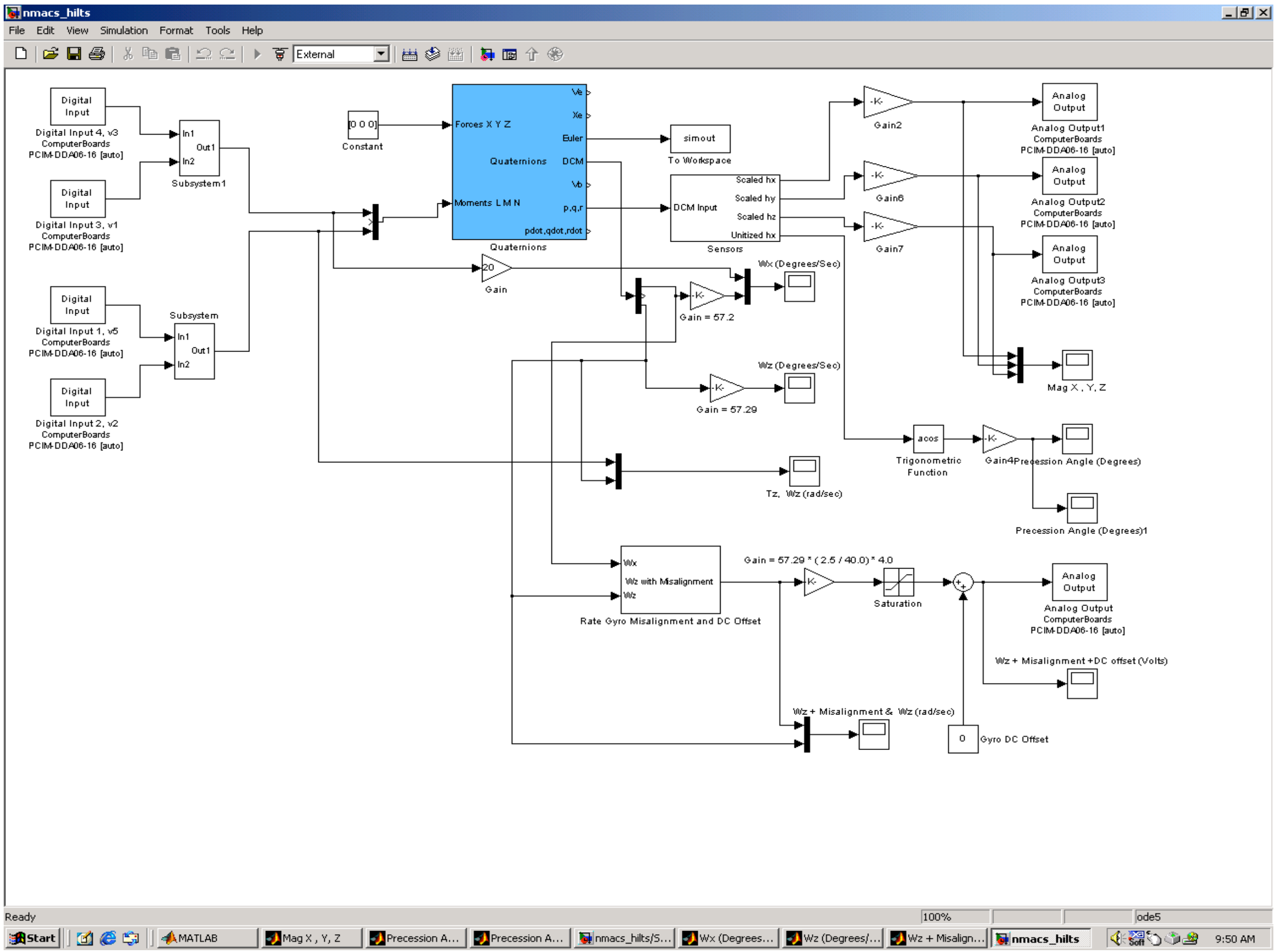
Ground Support Equipment (GSE)

- Power console.
  - External Power.
  - Monitors for battery, tank transducer, current.
  - External/Internal Power switching.
- Graphical user interface (GUI).
  - Load parameters.
  - Data displayed with numeric displays or strip charts.
  - Runs on MS Windows.

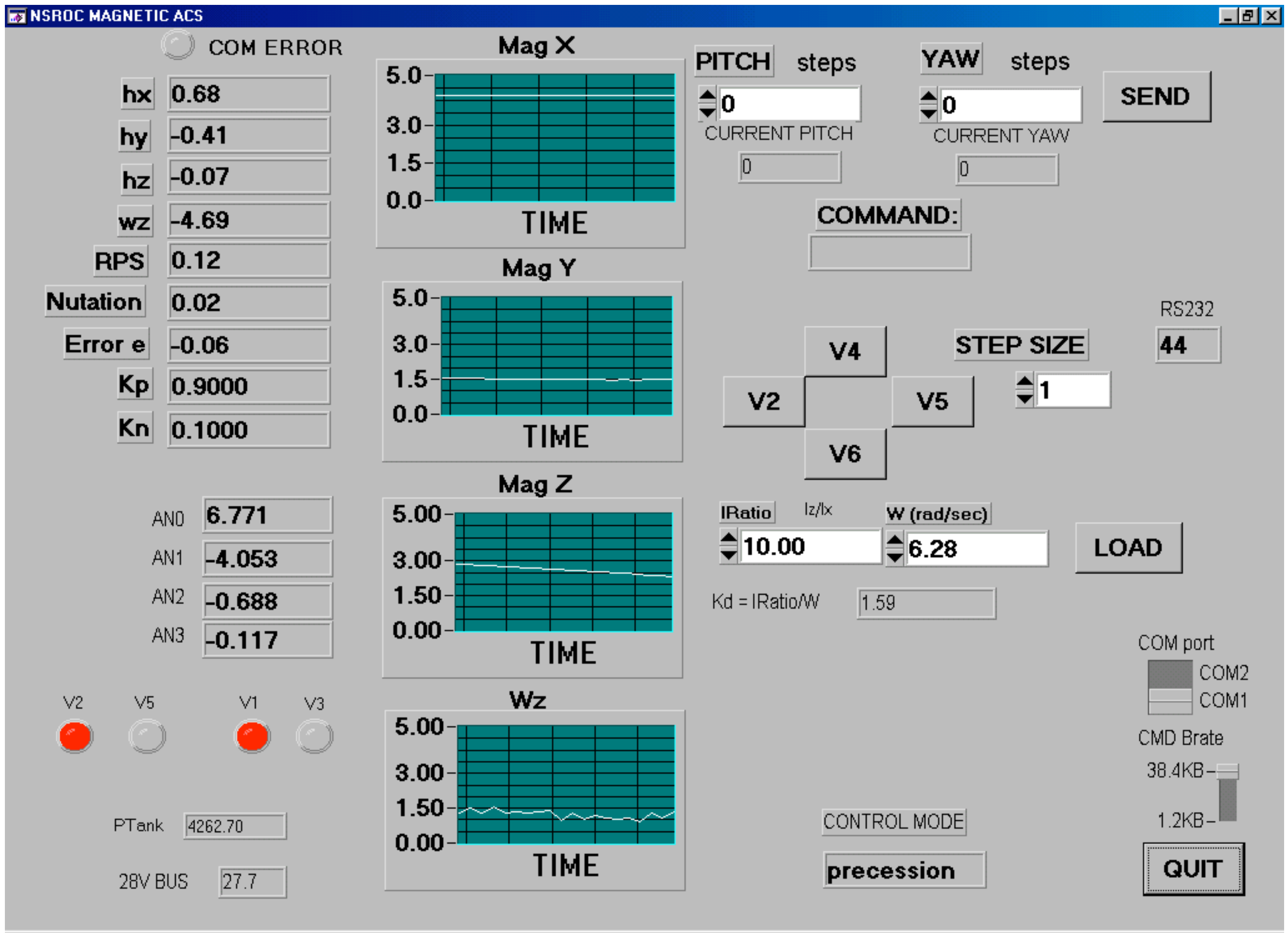
GSE

- Hardware in the loop test system (HILTS).
  - The HILTS provides an automated and complete test of the system firmware, hardware, wiring and control logic.
  - In addition to the testing capabilities the HILTS provides, it is a valuable tool during the development process.
- Horizontal air bearing test vehicle.
  - The HAB completes the system testing by including the pneumatics system.

HILTS Simulink Model



NMACS GUI


NSROC MAGNETIC ACS
COM ERROR
hx 0.68
hy -0.41
hz -0.07
wz -4.69
RPS 0.12
Nutation 0.02
Error e -0.06
Kp 0.9000
Kn 0.1000
AN0 6.771
AN1 -4.053
AN2 -0.688
AN3 -0.117
V2
V5
V1
V3
PTank 4262.70
28V BUS 27.7
Mag X
5.0
3.0
1.5
0.0
TIME
Mag Y
5.0
3.0
1.5
0.0
TIME
Mag Z
5.00
3.00
1.50
0.00
TIME
Wz
5.00
3.00
1.50
0.00
TIME
PITCH steps
0
CURRENT PITCH
0
YAW steps
0
CURRENT YAW
0
SEND
COMMAND:
RS232
44
V4
V2
V5
V6
STEP SIZE
1
IRatio Iz/Ix
10.00
W (rad/sec)
6.28
LOAD
Kd = IRatio/W 1.59
COM port
COM2
COM1
CMD Brate
38.4KB
1.2KB
CONTROL MODE
precession
QUIT

Demos

- Simulink demo
- HAB video clips

NSROC Inertial Attitude Control System (NIACS)

Presented By:
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Introduction

- In June of 2002 a PTO task plan to develop an Inertial ACS was presented to NASA.
- The goal:
  - To expand our in house capabilities and reduce the requirements for single source vendors.
  - Utilize latest technology components such as the GLNMAC to improve performance, reduce system cost and to replace aging components.
  - Utilize latest computing software tools to design, simulate and test ACS.
  - Create Graphical User Interface (GUI) for the ACS with real-time display of data.

Agenda

- Overview of the inertial ACS
- Status
- Schedule
- Ground Support Equipment (GSE)
- Demos

System Overview

- The inertial attitude control system determines the vehicle attitude and computes the error signals from the present vehicle attitude to the target attitude.
- The heart of the inertial ACS is the GLNMAC-200.
- The embedded computer in the GLNMAC-200 executes the attitude determination algorithm and the attitude control laws.

System Overview

- System capability
  - Absolute pointing error < 1 degrees.
  - Acquisition time less than 50 seconds.
  - RS422/RS232 interface to the system using a GUI and the Sandia Labs S5 software.
  - Real time vehicle attitude display (animation).
  - Vehicle attitude data downlinked in quaternions and/or direction cosines.
  - TM interface is implemented using standard asynchronous serial data and analog channels.

System Overview

- Major components
  - GLNMAC-200.
  - Electronic stack with TM deck, valve driver deck and power deck.
  - 28V battery pack.
  - Bi-level pneumatic system with 4-valve for pitch/yaw and 2-valve for roll control.
  - 17.26 in. skin.

Status

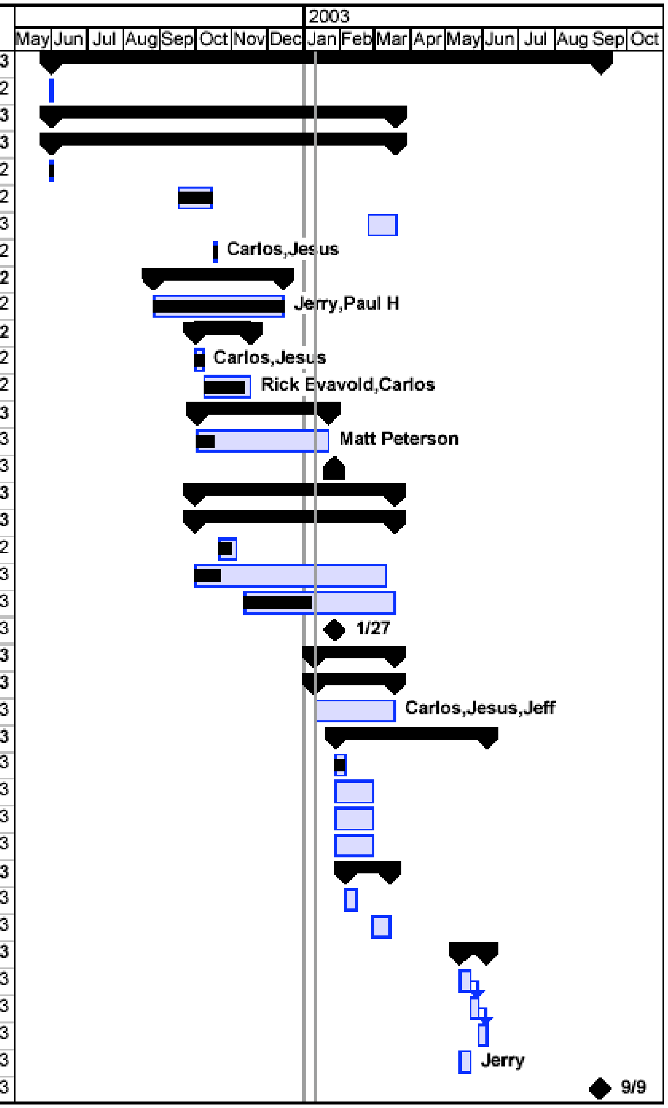
- Real-time computer simulation and testing of the inertial control logic has been completed.
- The firmware for the control logic has been implemented and tested.
- An engineering unit has been assembled and tested in the horizontal air bearing vehicle.
- Design of the TM interface has been completed.
- Design of the GSE has been completed.
- Implementation of the control logic for spinning payload is in progress.

Schedule

- Design review tentatively scheduled for January 27th.
- Fabrication and assembly of first flight unit starting after the DR.
- First test flight is tentatively scheduled for September 2003.

Schedule

ID	Task Name	Duration	Start	Finish
1	**NSROC Inertial ACS**	**333 days**	**Sat 6/1/02**	**Tue 9/9/03**
2	NASA PTO Task 143	1 day	Sat 6/1/02	Sat 6/1/02
3	**System Design**	**209 days**	**Sat 6/1/02**	**Wed 3/19/03**
4	**Control System design**	**209 days**	**Sat 6/1/02**	**Wed 3/19/03**
5	Attitude Determination algorithm	1 day	Sat 6/1/02	Sat 6/1/02
6	Control Law Formulation	20 days	Tue 9/17/02	Mon 10/14/02
7	Spinning Mode	17 days	Tue 2/25/03	Wed 3/19/03
8	Control Law Review	2 days	Thu 10/17/02	Fri 10/18/02
9	**Pneumatics**	**79 days**	**Tue 8/27/02**	**Sat 12/14/02**
10	Pneumatics Trade Study	79 days	Tue 8/27/02	Sat 12/14/02
11	**Adapt Electrical System**	**34 days**	**Tue 10/1/02**	**Sat 11/16/02**
12	Adapt ACS TM Interface	5 days	Tue 10/1/02	Mon 10/7/02
13	Electrical Schematics/Wiring List	28 days	Wed 10/9/02	Sat 11/16/02
14	**Mechanical Design**	**79 days**	**Thu 10/3/02**	**Tue 1/21/03**
15	Configuration and drawings	79 days	Thu 10/3/02	Tue 1/21/03
16	**Design Review**	**1 day**	**Mon 1/27/03**	**Mon 1/27/03**
17	**System Development**	**121 days**	**Tue 10/1/02**	**Tue 3/18/03**
18	**Control System Development**	**121 days**	**Tue 10/1/02**	**Tue 3/18/03**
19	Firmware	10 days	Tue 10/22/02	Mon 11/4/02
20	HILTS tests	116 days	Tue 10/1/02	Tue 3/11/03
21	Horizontal Air Bearing Testing	91 days	Tue 11/12/02	Tue 3/18/03
22	Design Review	1 day	Mon 1/27/03	Mon 1/27/03
23	**Documentation**	**48 days**	**Fri 1/10/03**	**Tue 3/18/03**
24	**Procedures**	**48 days**	**Fri 1/10/03**	**Tue 3/18/03**
25	ATP	48 days	Fri 1/10/03	Tue 3/18/03
26	**Flight Unit Fab and Testing**	**92 days**	**Tue 1/28/03**	**Wed 6/4/03**
27	Electronics	6 days	Tue 1/28/03	Tue 2/4/03
28	Mechanical Fab	24 days	Tue 1/28/03	Fri 2/28/03
29	Electrical Wiring	24 days	Tue 1/28/03	Fri 2/28/03
30	Pneumatics	24 days	Tue 1/28/03	Fri 2/28/03
31	**Component Level testing**	**28 days**	**Wed 2/5/03**	**Fri 3/14/03**
32	Flight Electronics	8 days	Wed 2/5/03	Fri 2/14/03
33	Pneumatics	11 days	Fri 2/28/03	Fri 3/14/03
34	**ATP**	**17 days**	**Tue 5/13/03**	**Wed 6/4/03**
35	Bench Test	7 days	Tue 5/13/03	Wed 5/21/03
36	HILTS	5 days	Thu 5/22/03	Wed 5/28/03
37	Air Bearing	5 days	Thu 5/29/03	Wed 6/4/03
38	Pneumatics	7 days	Tue 5/13/03	Wed 5/21/03
39	Demonstration Flight #1	1 day	Tue 9/9/03	Tue 9/9/03



New Computer Software Tools Utilized to Develop and Test ACS

- MATLAB, and Simulink software tools from The MathWorks Inc. are being utilized for vehicle and system modeling, and real-time simulation.
- The investment in these software tools has been a major contribution to this project; as demonstrated in the quick development of the inertial ACS, as a visualization and a training tool.

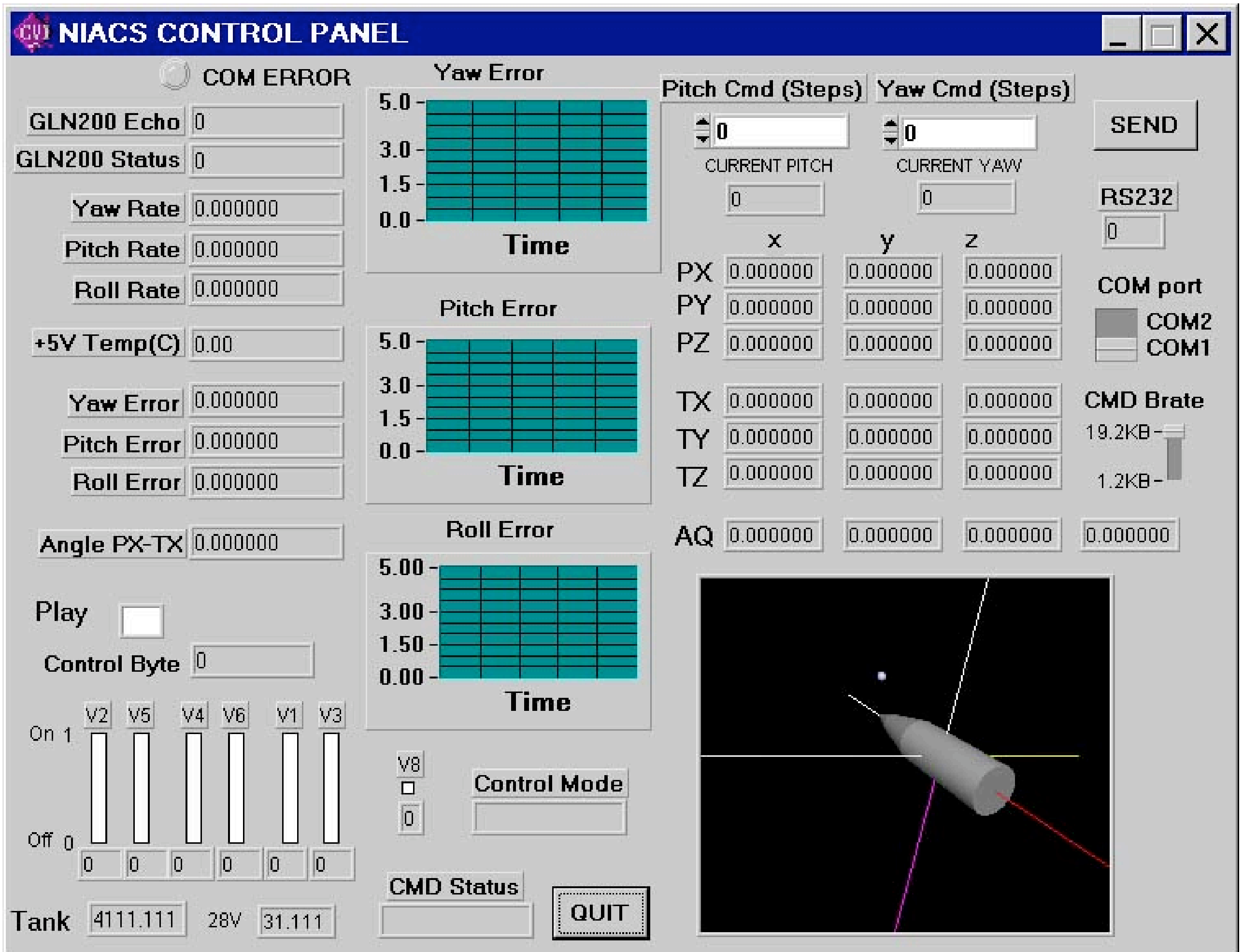
Ground Support Equipment (GSE)

- Power console.
  - External Power.
  - Monitors for battery, tank transducer, system current.
  - External/Internal Power switching.
- Graphical user interface (GUI).
  - Data displayed with numeric displays or strip charts.
  - Runs on MS Windows.
  - Celest program to Convert Launcher settings to Celestial coordinate system.
- The Sandia Labs S5 software.
  - Starts ACS program, loads initial attitude and targets.
  - Monitor GLNMAC-200 status.

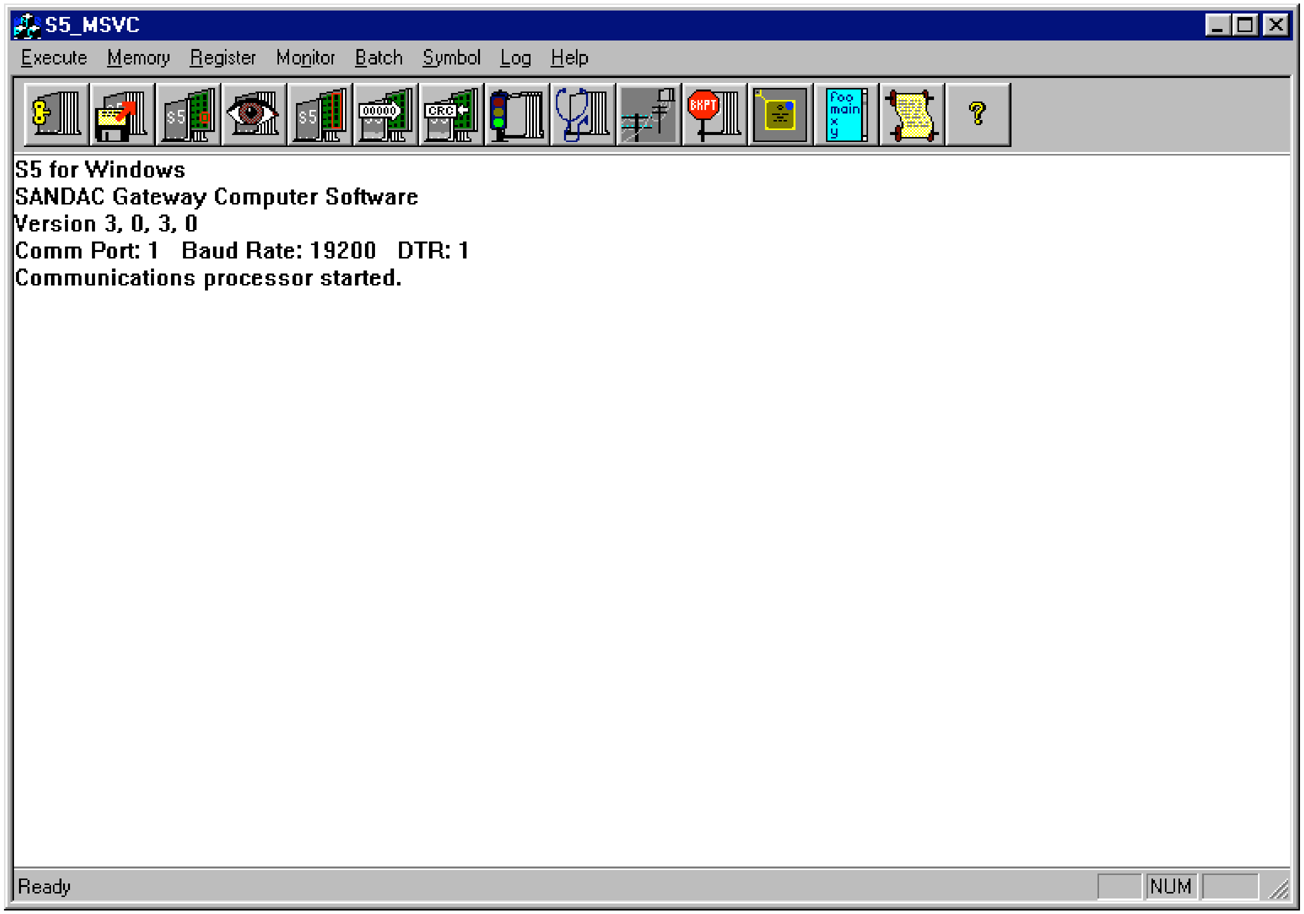
GSE

- Hardware in the loop test system (HILTS).
  - Implementation of the HILTS is in progress.
- Horizontal air bearing test vehicle.
  - The HAB completes the system testing by including the pneumatics system.

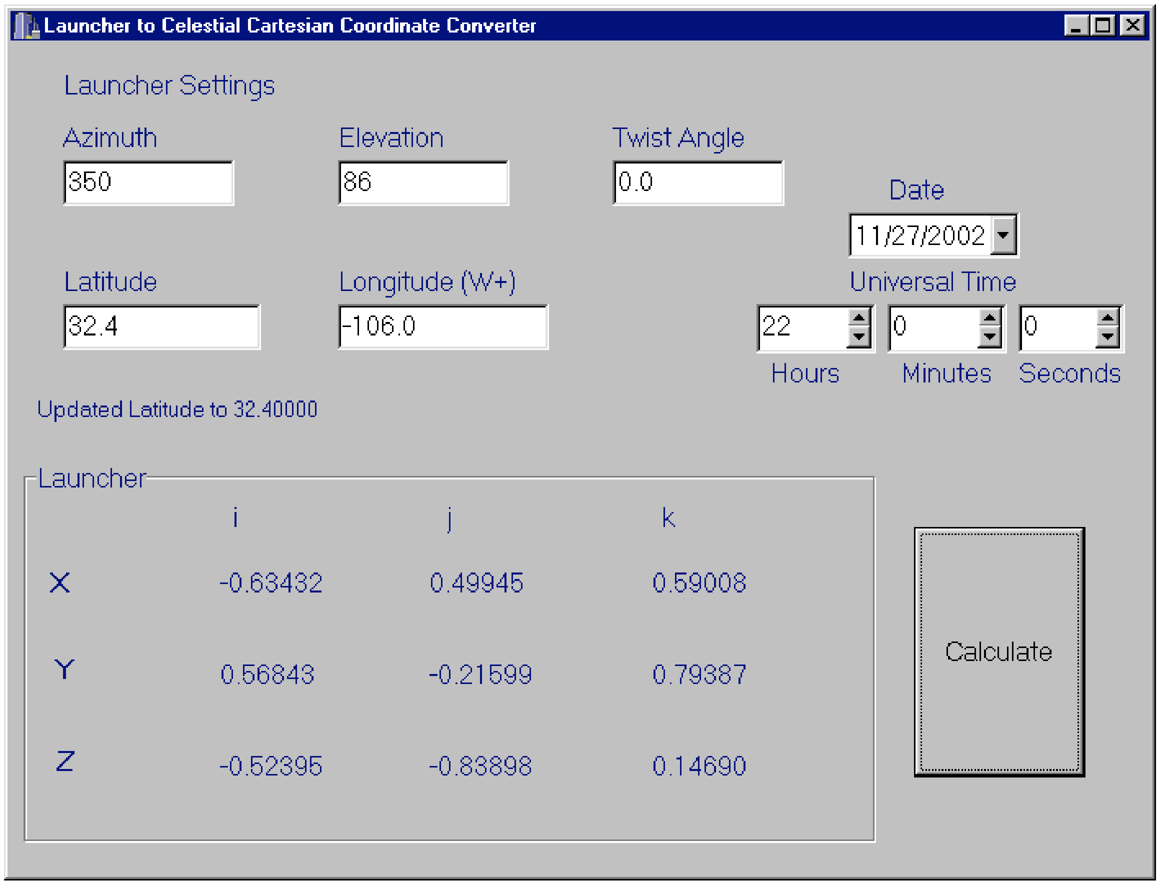
NIACS GUI


NIACS CONTROL PANEL
COM ERROR
GLN200 Echo 0
GLN200 Status 0
Yaw Rate 0.000000
Pitch Rate 0.000000
Roll Rate 0.000000
+5V Temp(C) 0.00
Yaw Error 0.000000
Pitch Error 0.000000
Roll Error 0.000000
Angle PX-TX 0.000000
Play
Control Byte 0
V2 V5 V4 V6 V1 V3
On 1
Off 0
0 0 0 0 0 0
Tank 4111.111
28V 31.111
Yaw Error
5.0 3.0 1.5 0.0
Time
Pitch Error
5.0 3.0 1.5 0.0
Time
Roll Error
5.00 3.00 1.50 0.00
Time
V8
0
Control Mode
CMD Status
QUIT
Pitch Cmd (Steps)
Yaw Cmd (Steps)
0
0
CURRENT PITCH
CURRENT YAW
0
0
x y z
PX 0.000000 0.000000 0.000000
PY 0.000000 0.000000 0.000000
PZ 0.000000 0.000000 0.000000
TX 0.000000 0.000000 0.000000
TY 0.000000 0.000000 0.000000
TZ 0.000000 0.000000 0.000000
AQ 0.000000 0.000000 0.000000 0.000000
SEND
RS232
0
COM port
COM2
COM1
CMD Brate
19.2KB
1.2KB

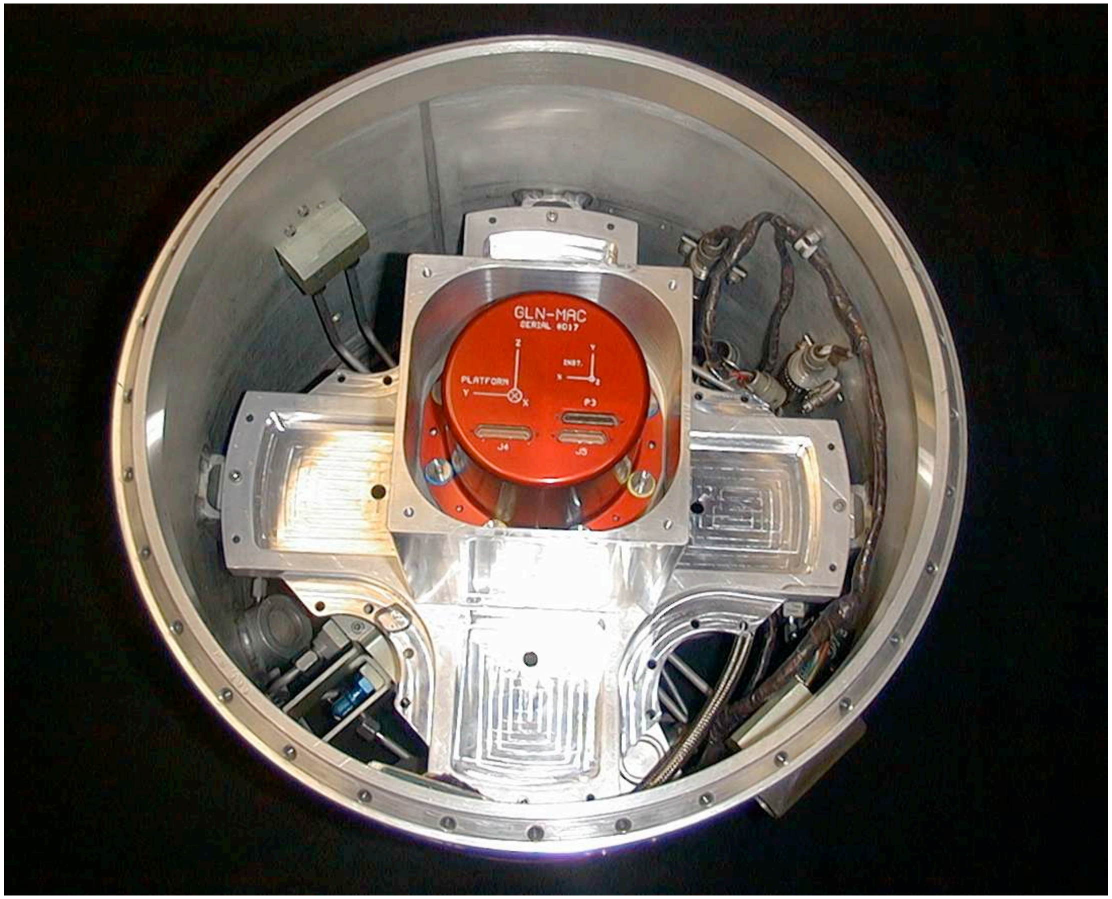
SNL S5 software



Celest program GUI



ACS module



Demos

- Simulink demo
- HAB video clips

NMACS Mechanical/Pneumatic Design

Jerry Doyon/ Matt Peterson

INTRODUCTION

- In this presentation we will show the NMACS Mechanical/Pneumatic layout and design.
- We arrived at this design considering the following factors:
  - Weight
  - Component Reliability
  - Cost
  - Design flexibility

NMACS Mechanical/Pneumatic Design

<u>WEIGHT</u>

- Vendor Components are compact units. Some minor specifications were changed to reduce weight and cost. (These are transparent to system operation)
- Each Mechanical component design has been trimmed of excess material to minimize weight without compromising strength through extensive use of Solidworks software and experience.
- The overall weight of the NMACS will be approximately the same as existing and past Magnetic system packages.

NMACS Mechanical/Pneumatic Design

COMPONENT RELIABILITY

- We only considered reliable vendors who had experience in the Aerospace industry.
- We are relying on years of experience to make good component choices.
- These choices have Space Flight Heritage.

COST

- In house fabrication designs were evaluated in detail to simplify manufacturing methods, thereby reducing cost.
- Each vendor component was selected for simplicity of design, without compromise of quality.
- Our design flexibility also reduces cost by allowing component sharing in this and other flight pneumatic system applications. (NIACS)
- Common design allows larger quantity purchases and fabrications, also reducing per unit cost.
- The Mechanical layout was designed for ease of assembly to save fabrication time, which also reduces cost.

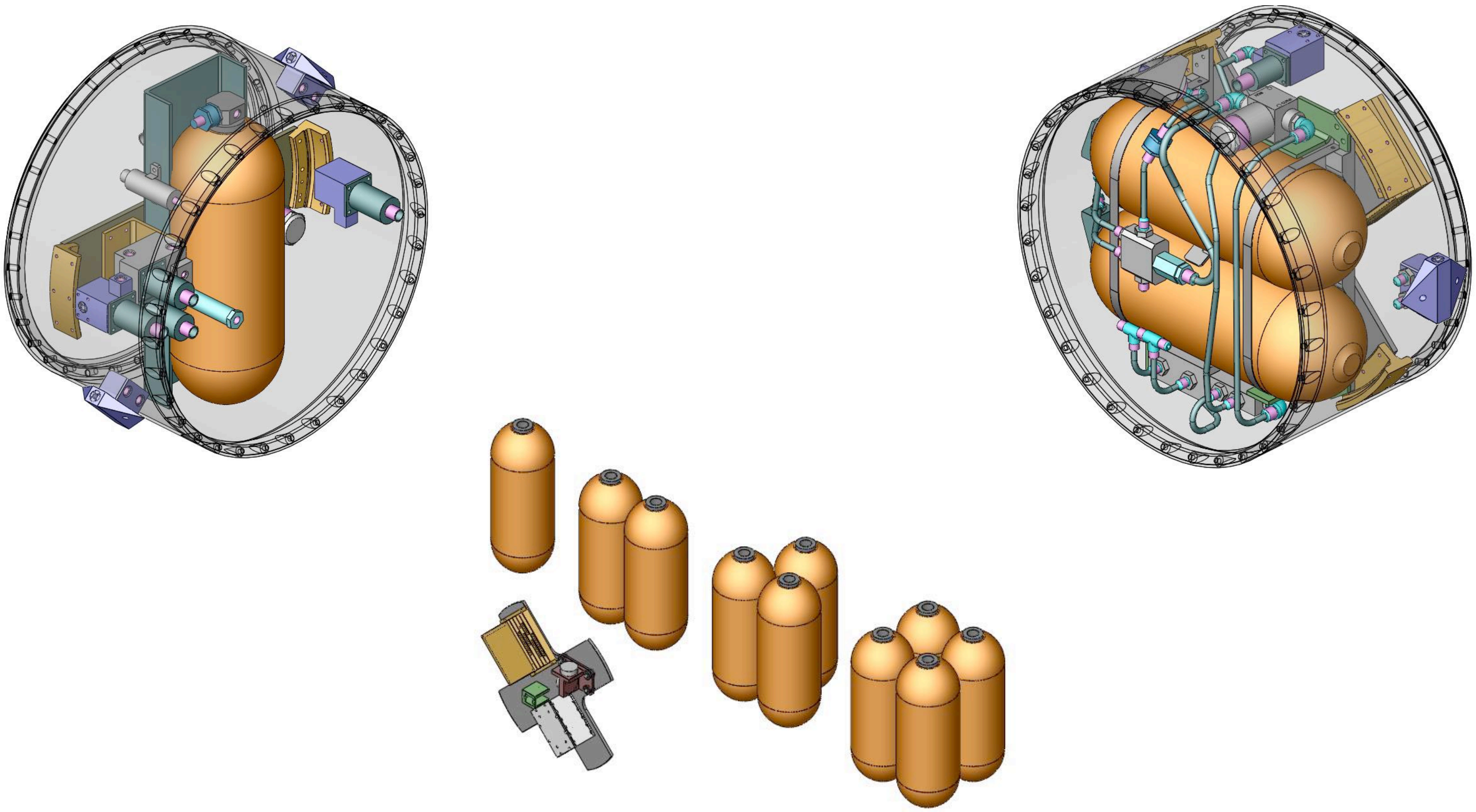
NMACS Mechanical/Pneumatic Design

DESIGN FLEXIBILITY

- We incorporated a feature in this design that allows ganging of pressure tanks, in order to meet a variety of Gas Budget needs.
- Most of the remaining components are standardized, pre-engineered to adapt, while maintaining the most compact package possible.
- Vendor components are shared in all designs.
- Nozzle design lends to ease of change-out as requirements change.(mass props.)
- Independent electronics X-deck, lends to ease of testing and change-ability.

NMACS Mechanical/Pneumatic Design

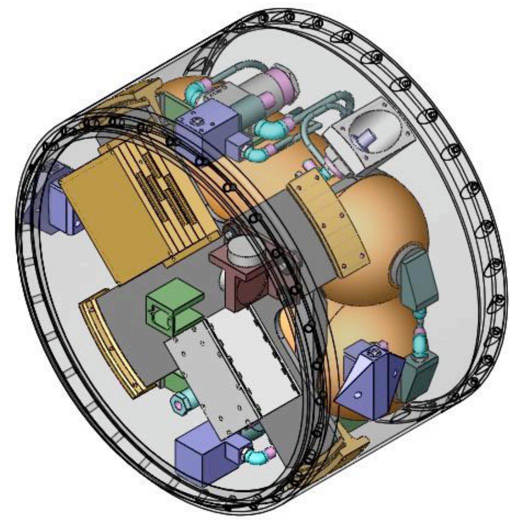
GAS BUDGET FLEXIBILITY



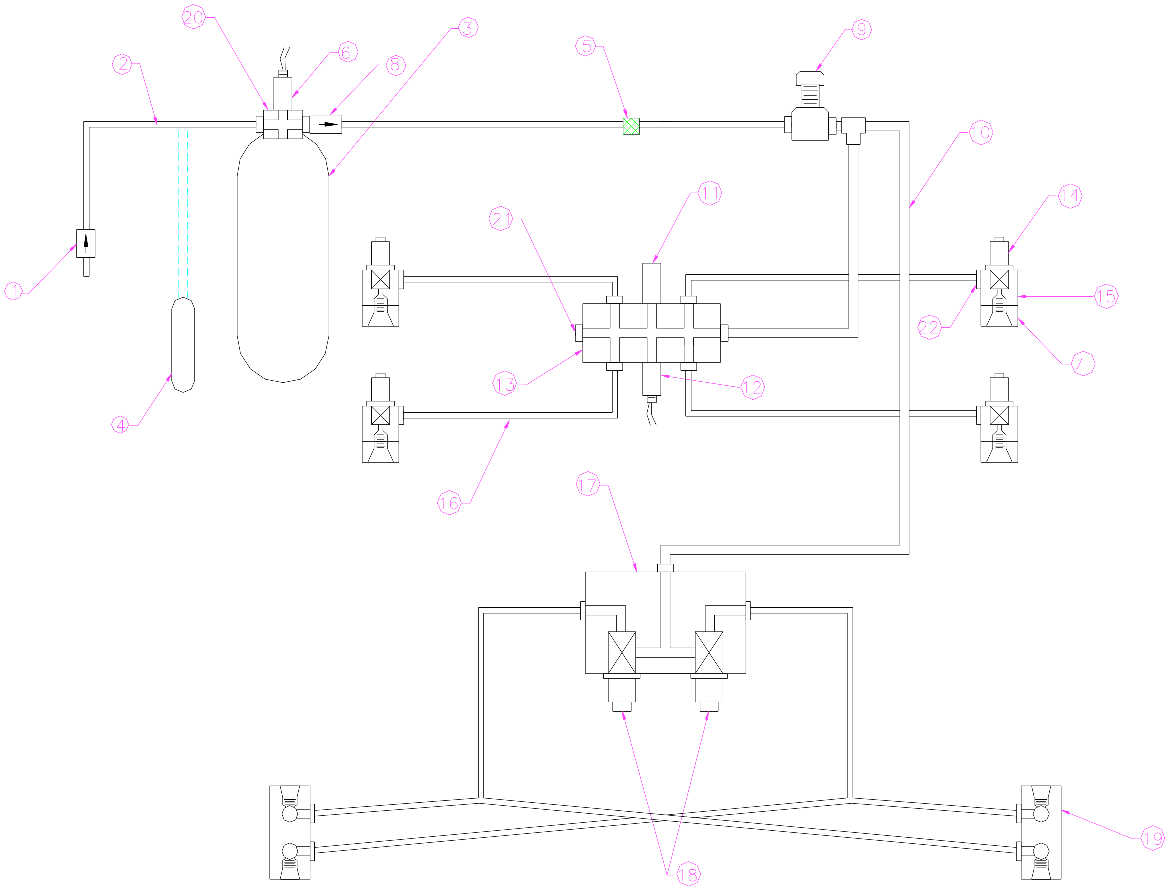
NMACS Mechanical/Pneumatic Design

ELECTRONICS X-DECK

- Simple to manufacture
- Lightweight
- Ease of feed thru
- Removable as a package



Pneumatic Schematic



NMACS Mechanical/Pneumatic Design

Summary

- To you the customer, this means reliability and cost savings with little risk or compromise of quality.
- In the real world we know that we must be Weight conscious, Flexible, Reliable and Cost effective to meet our customers unique needs. We designed this function of the NMACS with this view in mind.

Current Status

- Parts on order.
- Existing inventory suitable for use on the test round and several future missions. (Avoiding waste as well)
- We will be conducting Nozzle thrust test in a Vacuum within the next few weeks.
- Solid works models are done, providing accurate fit checks and assembly directions.

Space Astronomy Laboratory
AD ASTRA
SAL
PRO ASTRIS
University of Wisconsin

ST5000

The Next Generation Star Tracker

ST5000 Star Tracker

- Flew on Harris 36.188 payload Dec. 6, 2001.
- Camera lens movement problem was corrected and other enhancements were implemented. Remaining qualification testing will be completed this month.
- More robust operating system implemented.
- Roof top testing still ongoing.
- Preparing for Nordsieck 36.173 flight this Fall.

ST5000 Star Tracker

- Second tracker to be received by WFF.
- University of Wisconsin will finish qualification testing of this unit later this month.
- Air bearing tests at WFF will confirm that ACS control is equivalent or better than present control using a Ball tracker.
- This tracker will fly on the In-Focus balloon mission this summer.

ST5000 Star Tracker

- The ST5000 will be flown on the NSROC test flight at WSMR in August 2003.
- Preparations have begun to obtain a 3rd ST5000 tracker to support this flight.
- NSROC has an approved license agreement with SAL/UW to fabricate future ST-5000 star trackers at WFF.

ST5000 Star Tracker

QUALIFICATION SCHEDULE - 2003

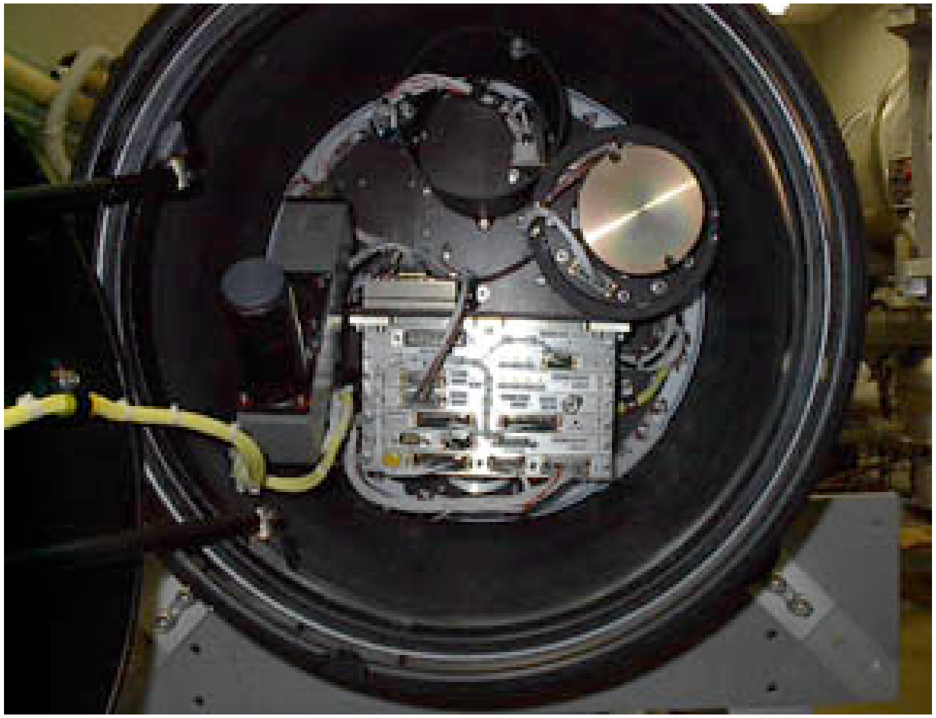
- WFF air bearing testing – February/March
- In-Focus Balloon Flight in July
- NSROC Test Flight this August
- Nordsieck 36.173 Flight in September

ST5000 Star Tracker

Camera Sensor Head

Its mounting configuration is identical
to the footprint of the Ball tracker

ST5000 Star Tracker



Harris 36.188 Payload

Ball tracker is located at 12:00 high

ST5000 tracker shown at ~1:00 (gold color)

ST5000 Star Tracker

GENERAL CHARACTERISTICS

- FOV: 5.4 x 7.4 degrees
- Lost-In-Space Determination: 5.1 seconds
- Sensitivity Range: -1 to +8 magnitude
- Stars tracked simultaneously: 1 to 8
- Update Rate: 100ms
- MASS: Sensor - 4.4 lbs.; Electronics - 6.4 lbs.
- SIZE: Sensor 5”ø x 10” length; Electronics 6” x 9” x 5.5”, includes the mounting plates
- Real Time imagery at Ground Station: Video downlink at 19200 baud using Progressive Image Transmission technology will fully reconstruct the viewing image <20 seconds.

GNC: Attitude Data Analysis

Basic principles:

1. Measurements sufficiently mimic payload attitude dynamics.
2. Measurements contain desired signal plus error signal.
3. My task is to extract the desired signal (attitude information).

Techniques and tools:

1. Attitude is well behaved (derivatives exist).
2. Hence, the attitude signal can be accurately described using a simple model and a finite set of parameters.
3. High data sampling rate implies a “fine resolution” of the solution.

GNC: Attitude Data Analysis

Missions:

Pfaff	21.125	(gyro, magnetometer)
Christensen	21.128	(gyro, magnetometer)
Erdman	41.022, 41.023	(magnetometer, solar sensor)
Winstead	42.002, 42.003	(magnetometer, solar sensor)
Goldberg	41.032, 41.033	(magnetometer, solar sensor, gyro)

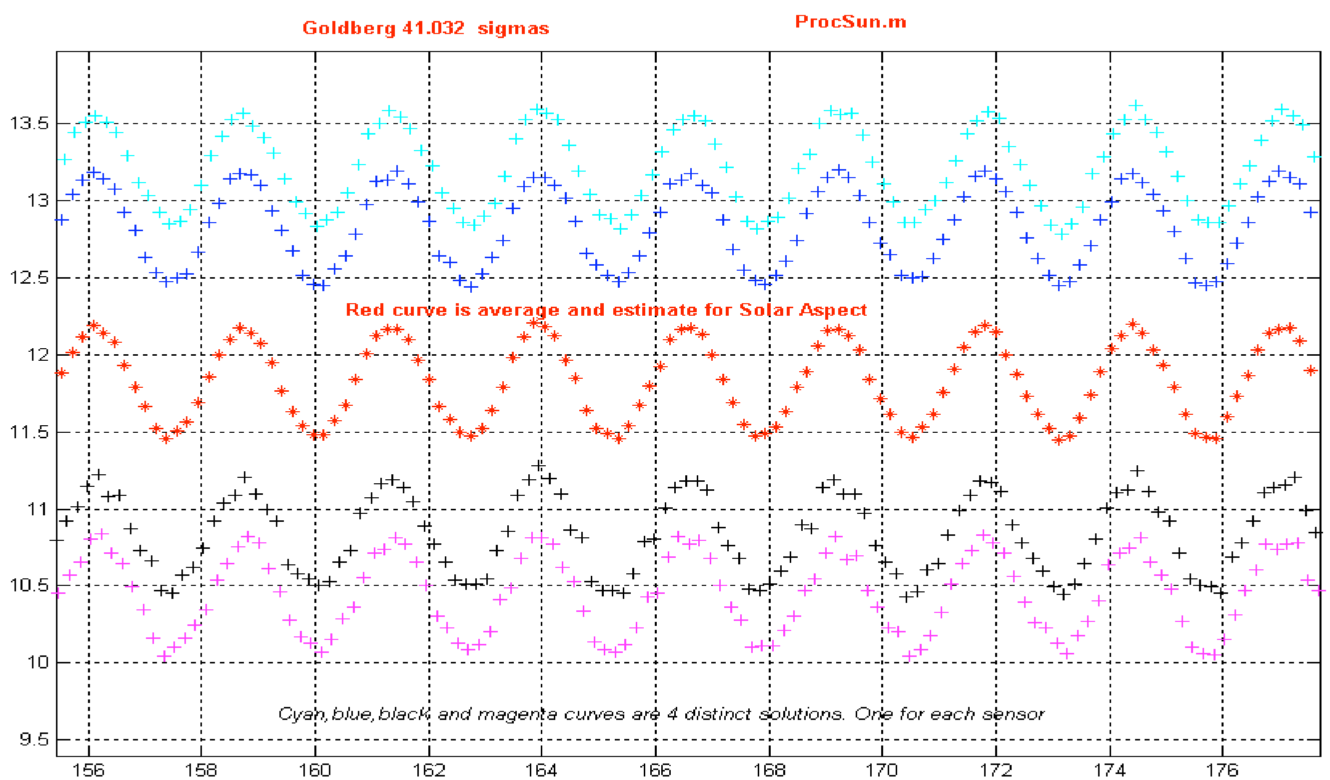
GNC: Attitude Data Analysis

- Solar Sensor Data (solar aspect angle).
- Two techniques:

1. *SunnyTM* – low resolution, standard calibration coefficients.
2. *ProcSun* – high resolution, distinct calibration coefficients for each pair of adjacent sensors. Four solution estimates, but the average of these four solutions is “excellent” best estimate.

ProcSun is an enhanced computational equivalent of a Time-Event-Module.

GNC: Attitude Data Analysis



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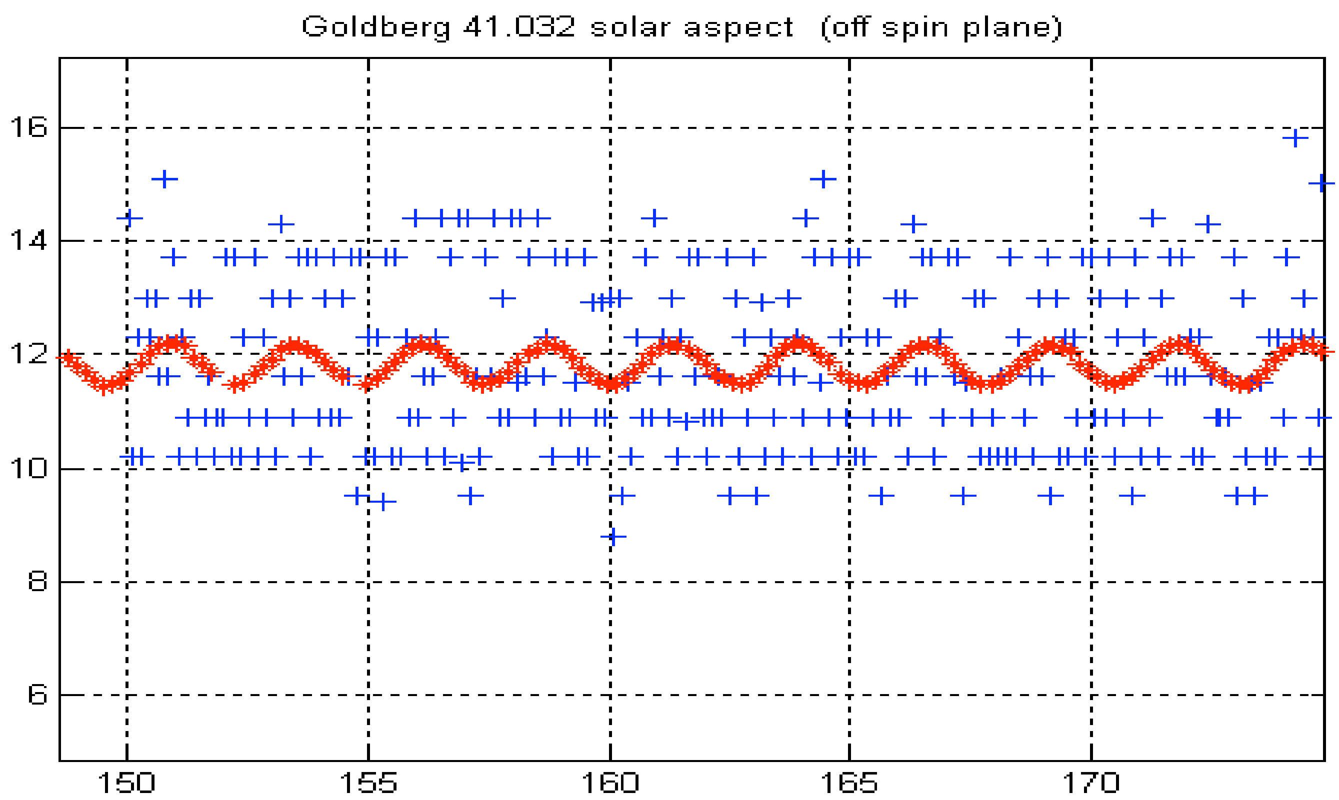

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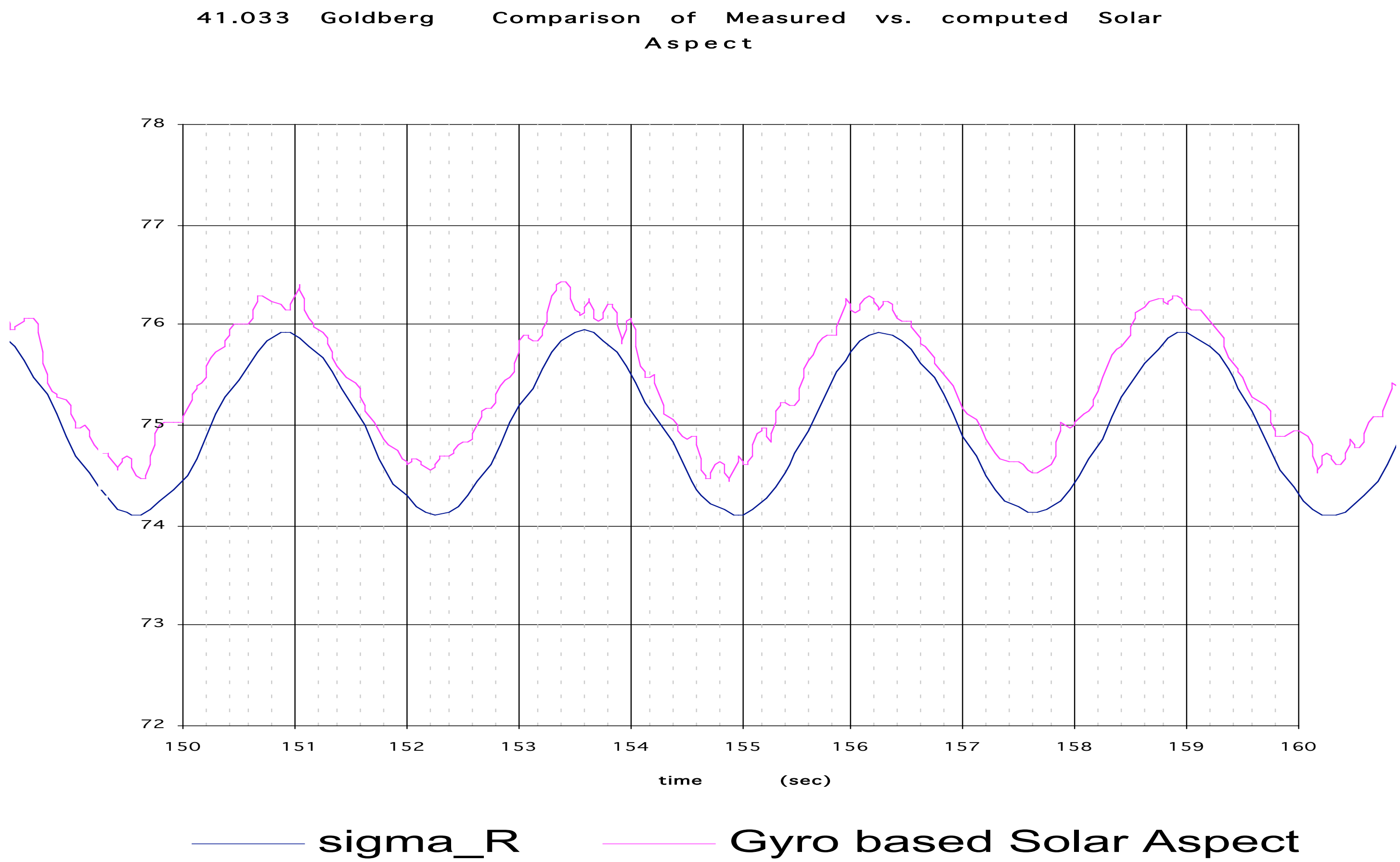

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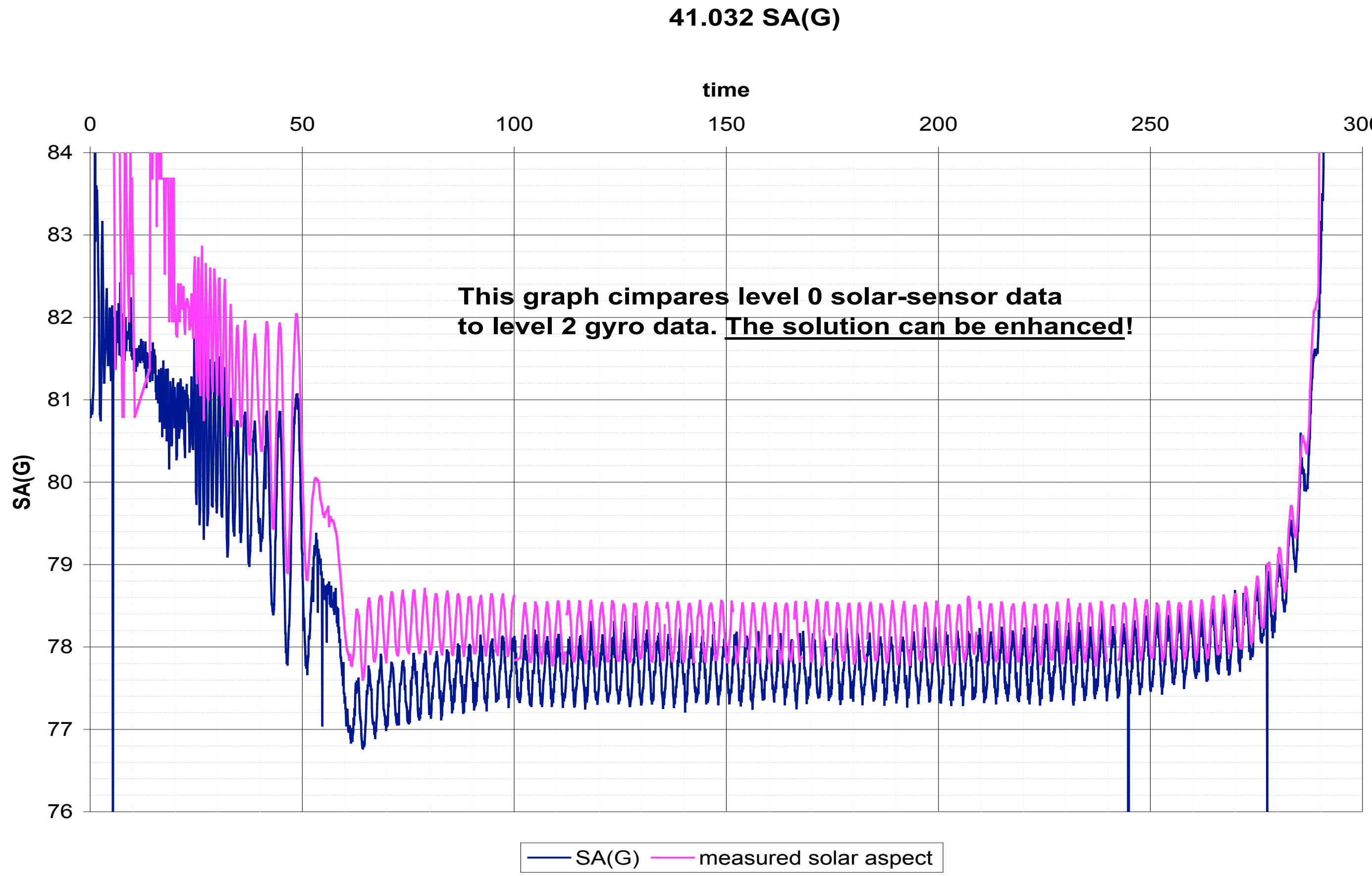
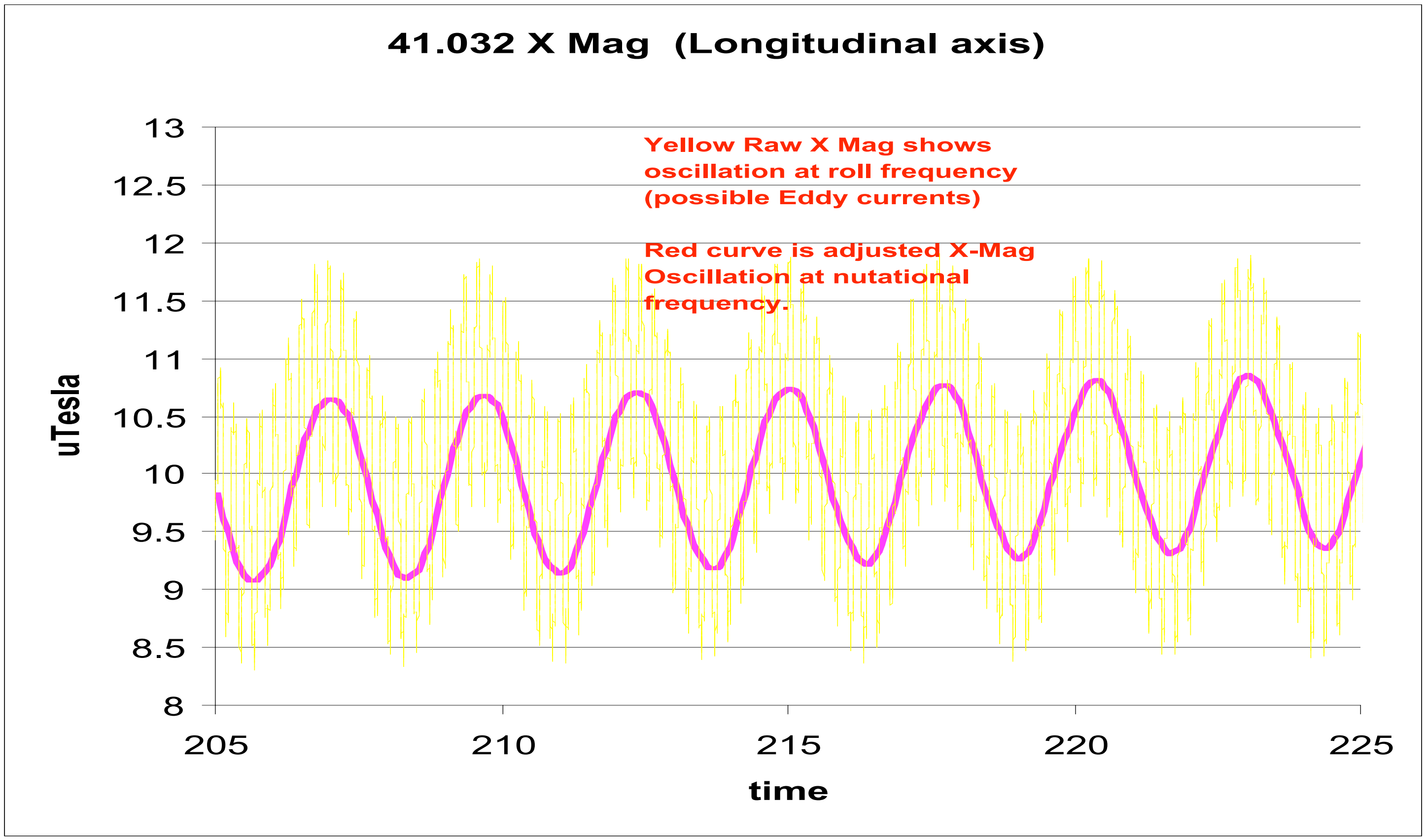


GNC: Attitude Data Analysis

- Magnetometer data analysis.
- Two step procedure:

1. Mag-Cal — Enhancement of instrument response coefficients, and correction for internal magnetic fields (present during test).
2. Flight-Cal — Correction for internal fields present in flight, but not during Mag-Cal. These procedures may rely on theoretical magnetic field model, if total measured field strength is questionable.

GNC: Attitude Data Analysis



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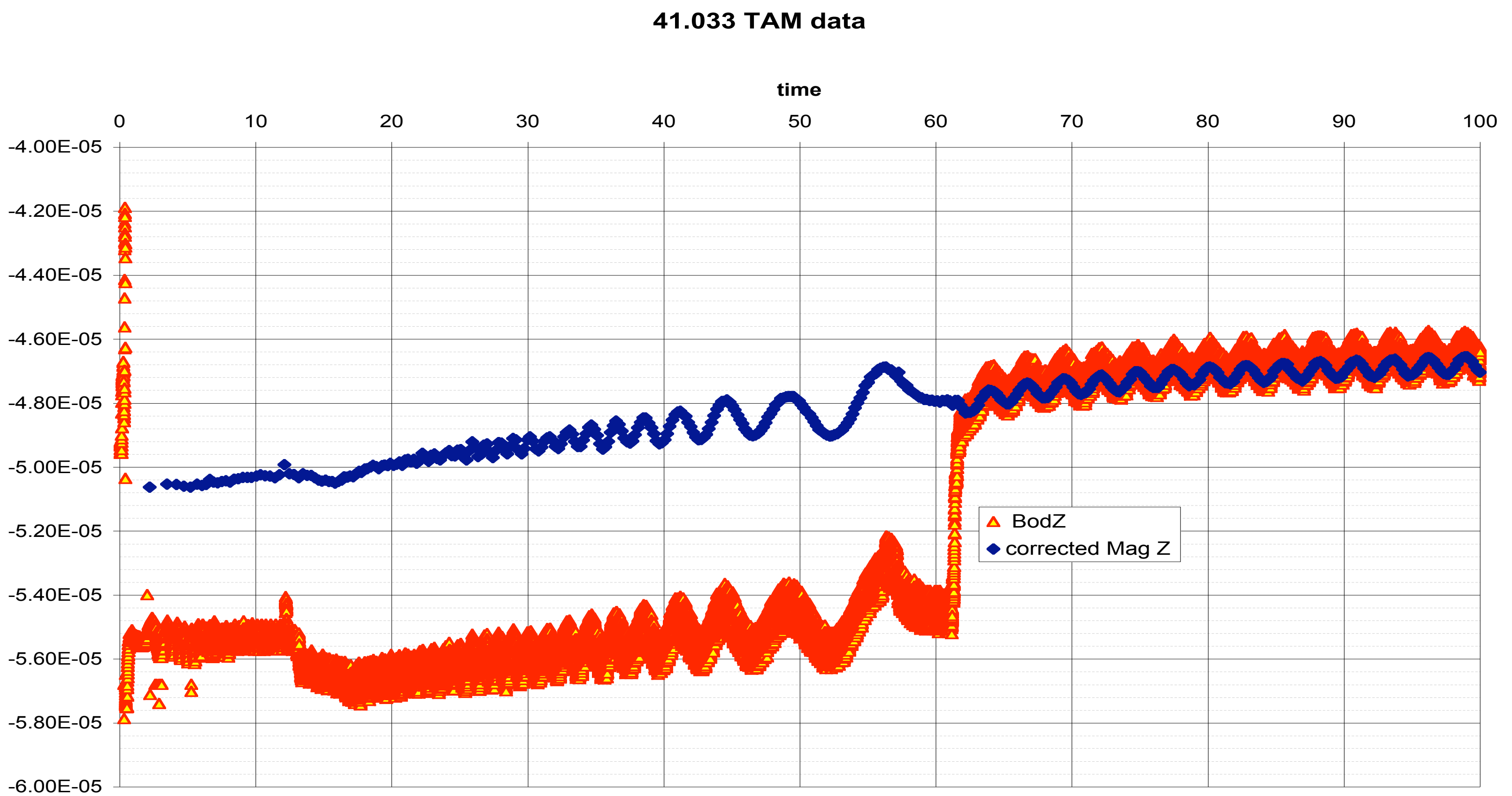

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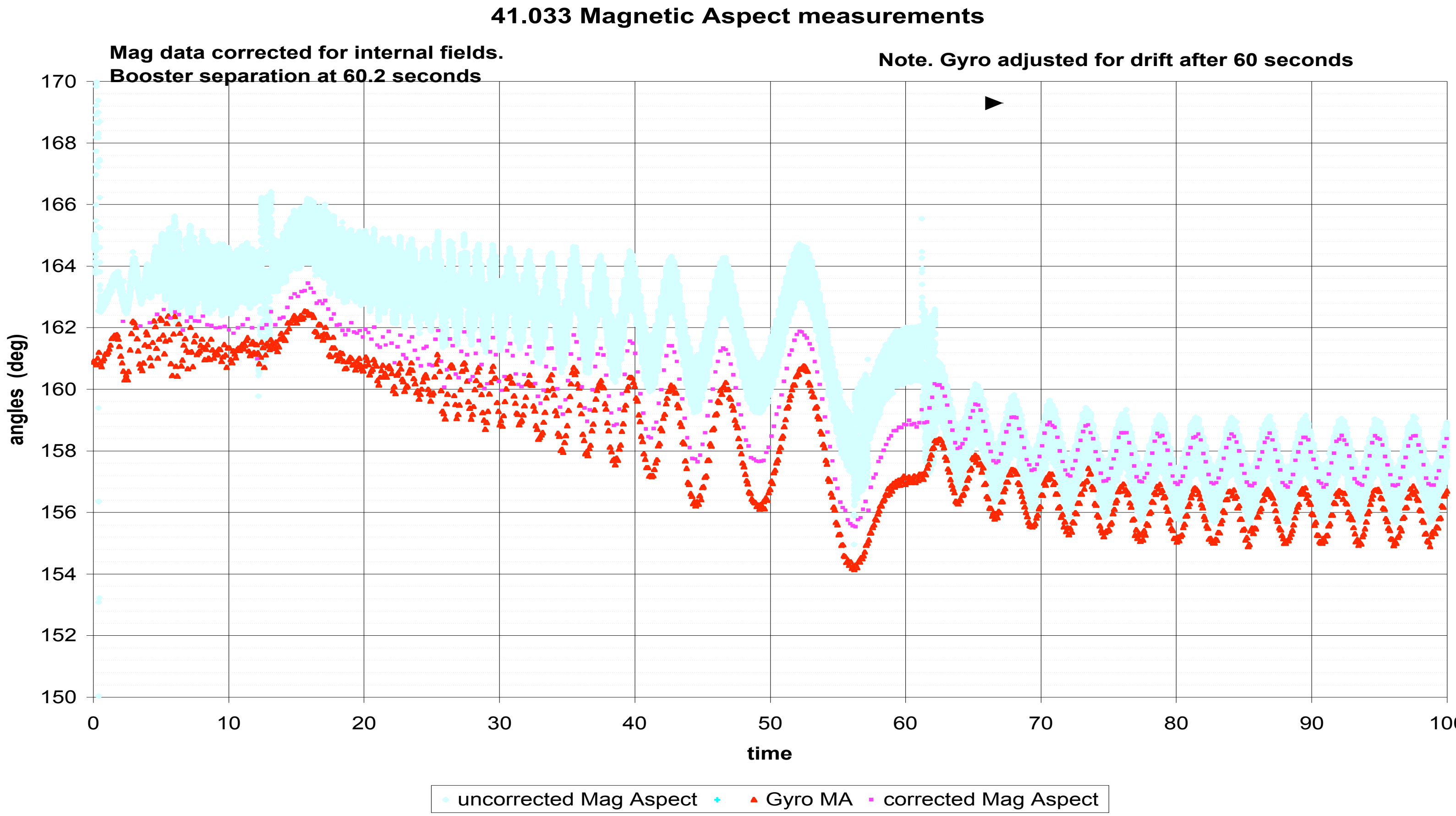

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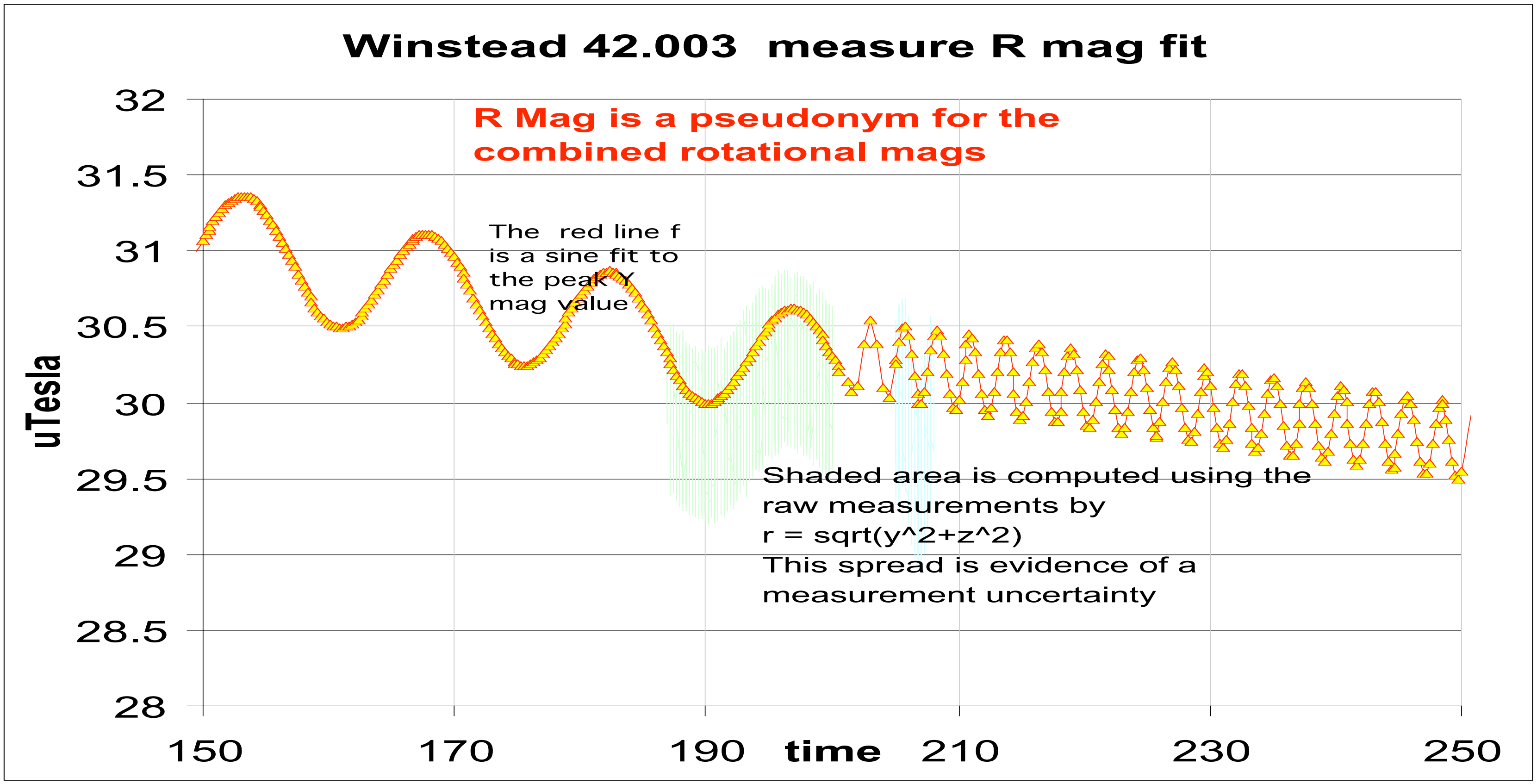
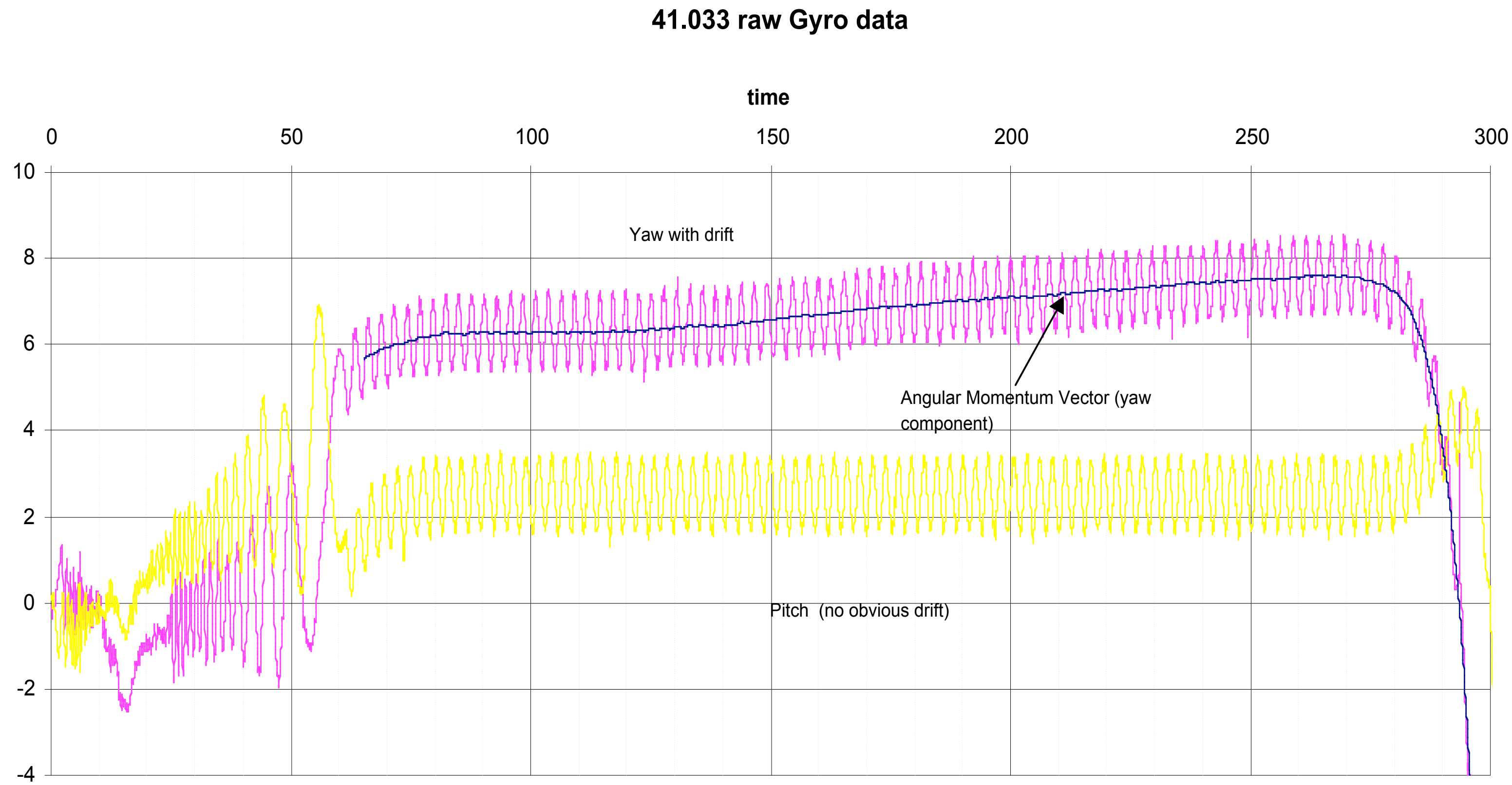


GNC: Attitude Data Analysis

- Gyro Drift Correction.
- Two step procedure:

1. Comparison of Gyro inertial solution (pitch/yaw) to Theory.
   Theoretical Assumption: *Angular Momentum Vector is fixed.* This assumption would apply during Science portion of most flights (i.e. above atmospheric drag effects). Hence, any drift of the observed Angular Momentum Vector during this phase could be assumed to be the effect of gyro drift, and can be backed out of the solution.
2. Comparison of Gyro (*drift corrected via step 1*) Earth relative solution to Magnetometer and/or Solar data.
   Compute expected Mag (Solar) aspect angles using Gyro solution and Mag-Field model (solar look angles), and compare to measured aspect angles. Time dependent drifts between the computed and measured aspects would be consistent with uncorrected drift.

GNC: Attitude Data Analysis



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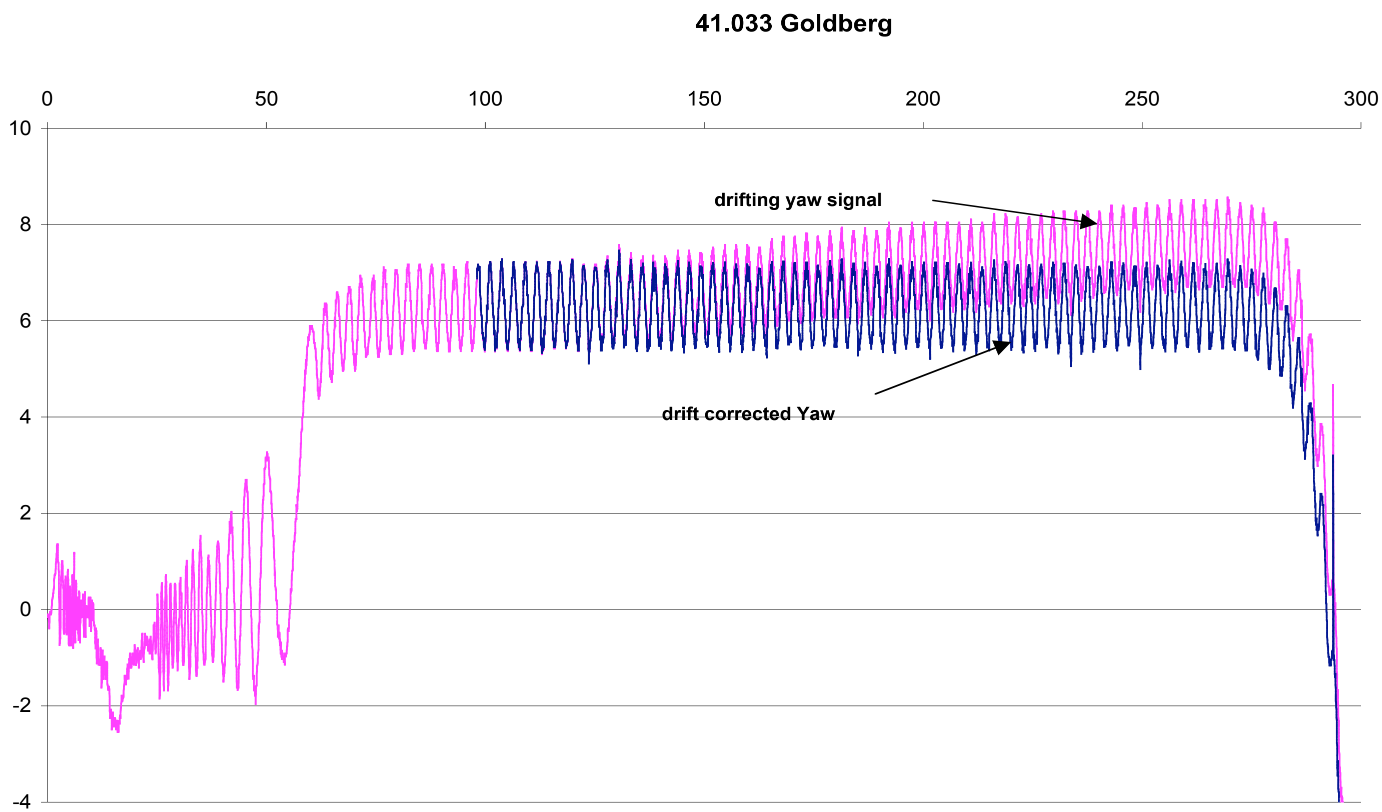

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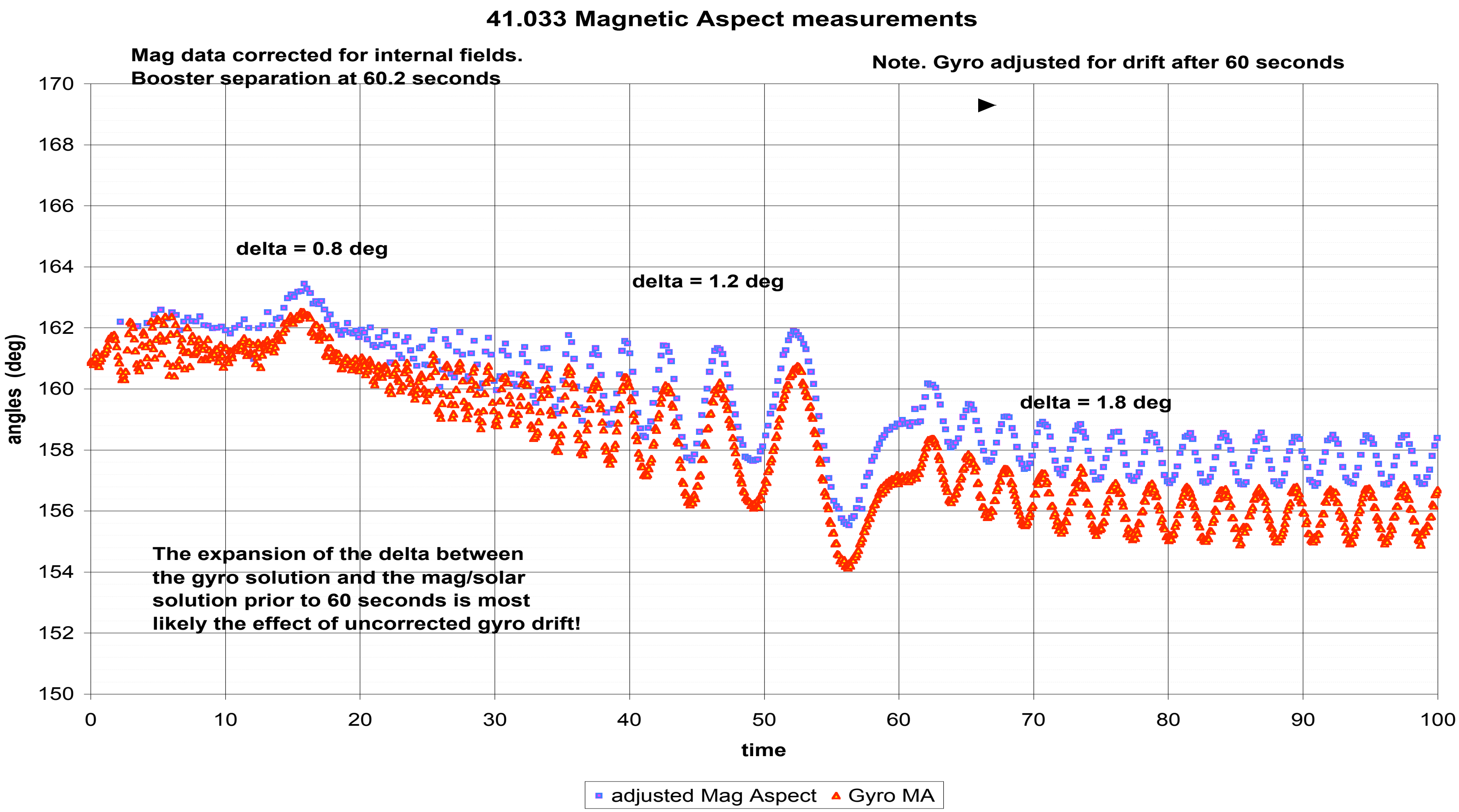

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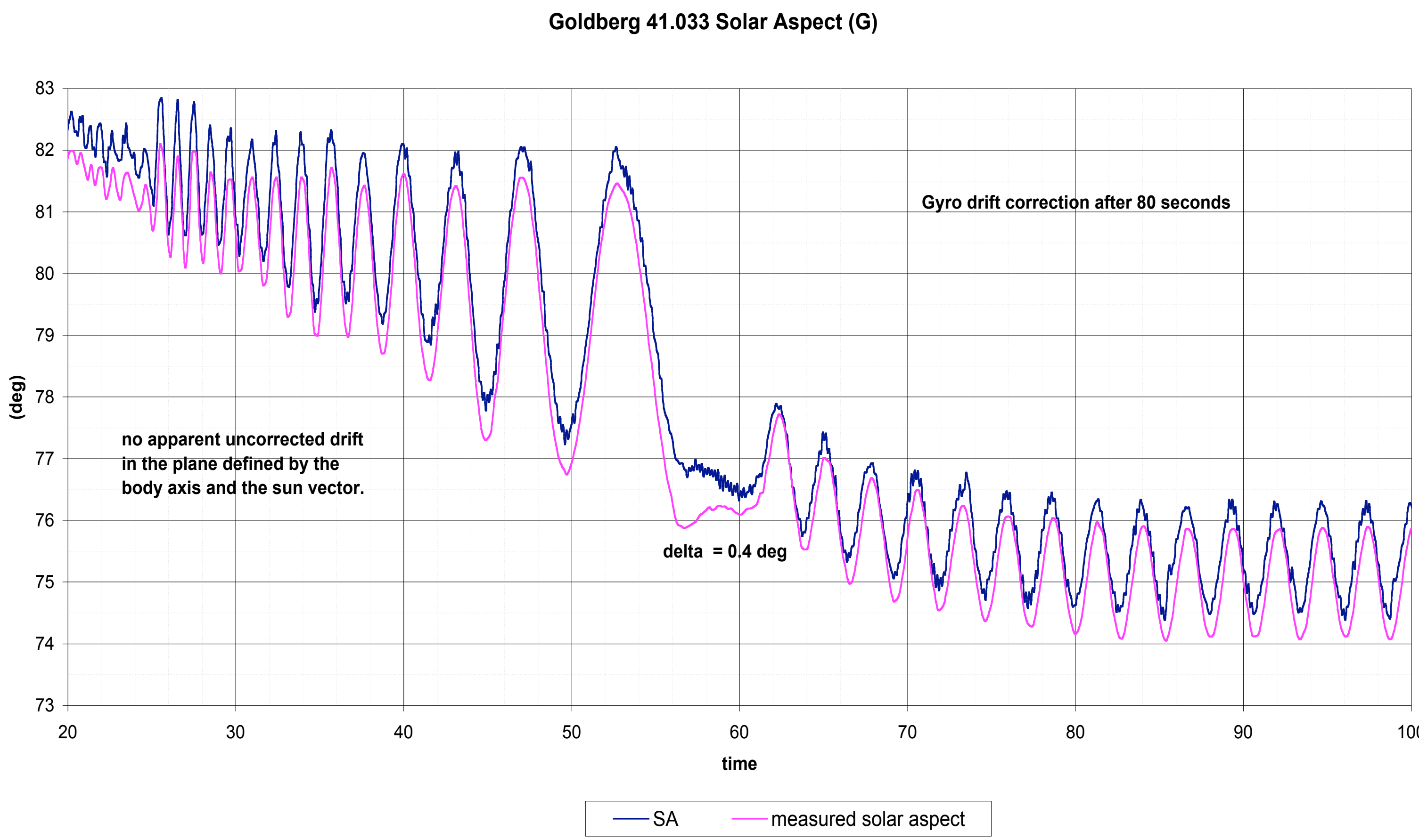

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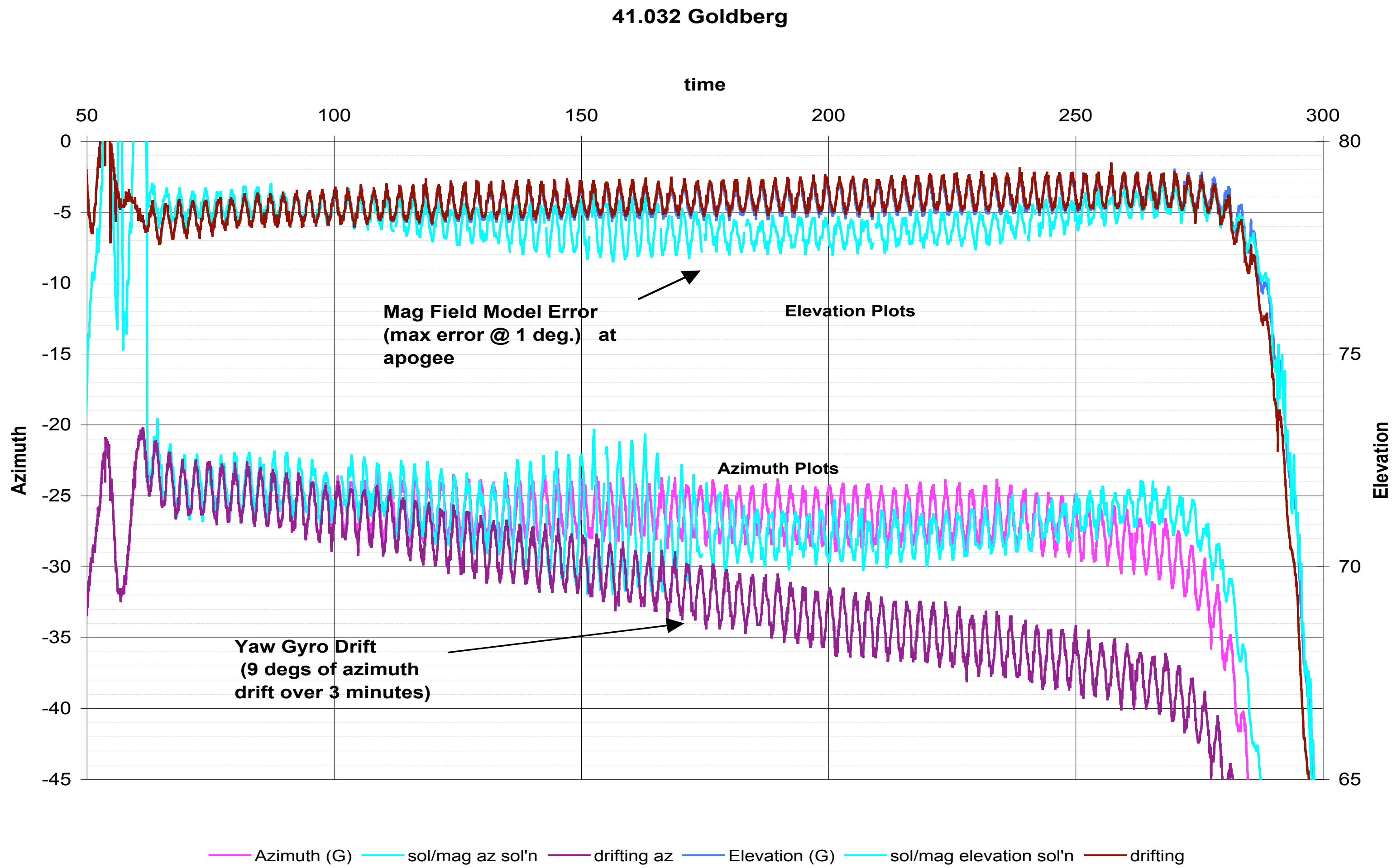

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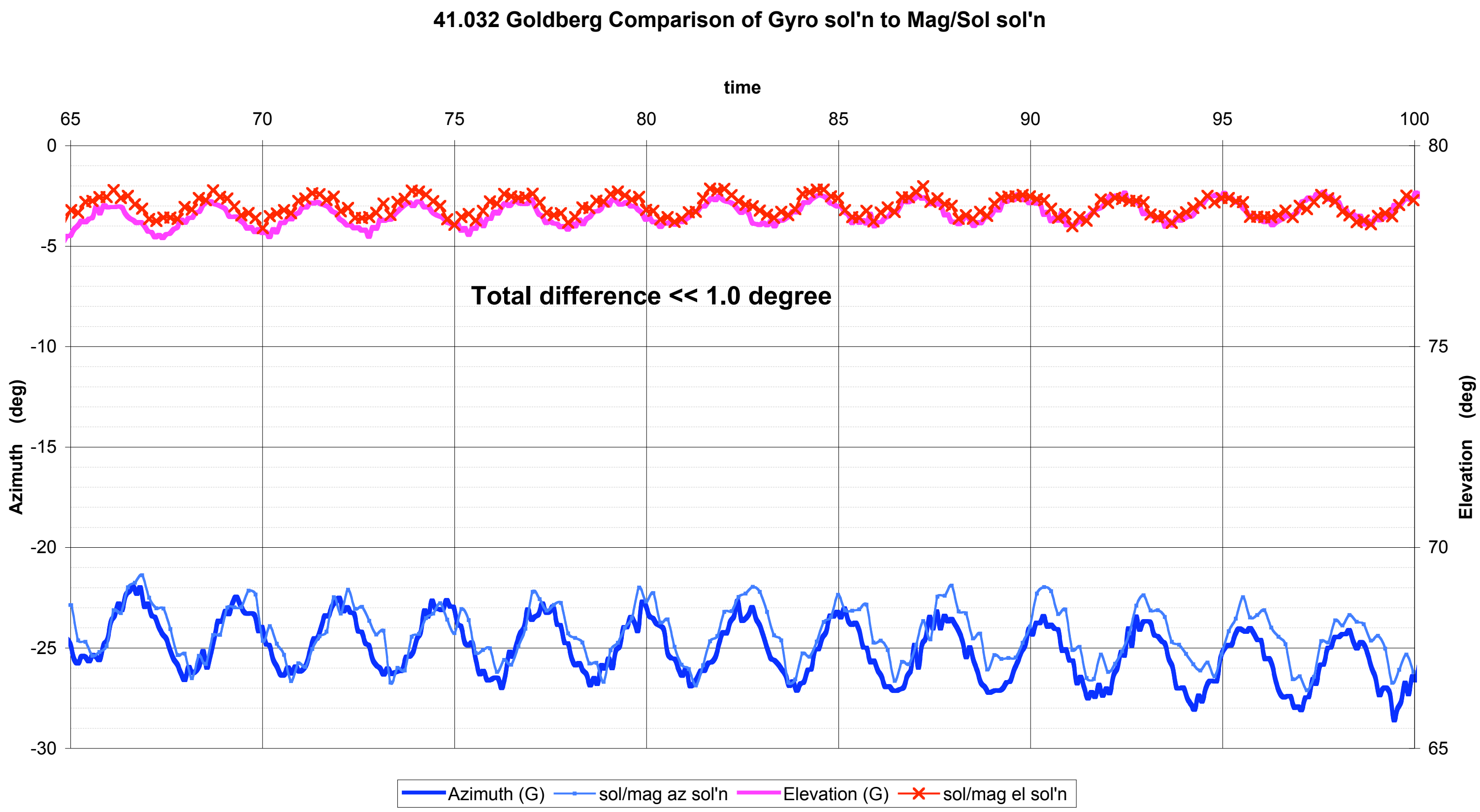

GNC: Attitude Data Analysis

- Total Attitude Solution Comparison.

A total Attitude Solution can be obtained from either a Gyro or from a Magnetometer/Solar Sensor package. Hence on the two Goldberg missions (41.032, 41.033) we had the opportunity to generate two independent Attitude solutions, and hence an opportunity to compare solutions (with and without corrections).

This also gives us the opportunity to quantify the disparity between solutions.

GNC Outlook

- GLN-MAC – Will need to bring Calibration in-house
- NIACS - NMACS Design – flexible, adaptable
- ACS Data Analysis – Fully capable, training new engineer
- NSROC(a) Sun Sensor works remarkably well
  - We Need a IR Horizon Crossing Indicator with comparable cost & performance
- LN-200 – Strap-down – Cheaper than GLN-MAC ($25k vs $75K)
  - TM Gyro Replacement
  - Candidate For Launcher Attitude Hold Boost Guidance System (BGS)
  - Navy has expressed interest in cheap BGS
  - Need Tight Tolerance on Mechanical Alignment

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