HAWC CDR

February 1-2, 2001

OptoMechanical System

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Outline

- OMS Requirements
- Design Overview
- Design Changes since delta-PDR
- Analysis Performed
- Developmental Hardware/Software Testing Performed
- Test Plan Outline
- Current Status
- Open Issues

OMS Requirements

Environmental

Temperature	**Condition**	**Verification**
Operational	4.2°K to 300°K	Test
Non-operational	4.2°K to 330°K	Test
Cool-down time to LN_2	6-8 hour (goal)	Test
Cool-down time to He_4	6-8 hour (goal)	Test
Static Load		
Worst Expected	3.4g	Test
Design factor of safety	3	Analysis

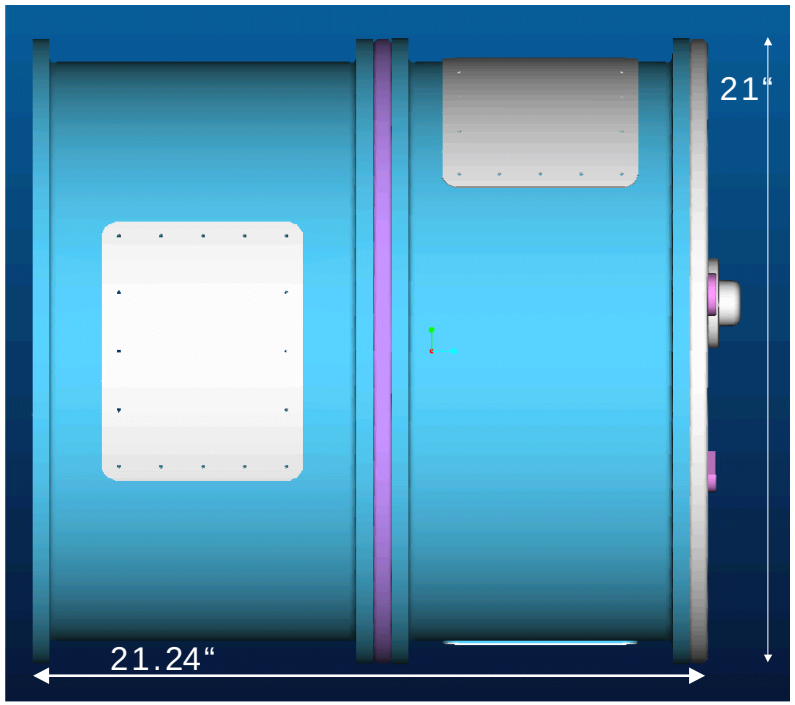
OMS Requirements

Optomechanical

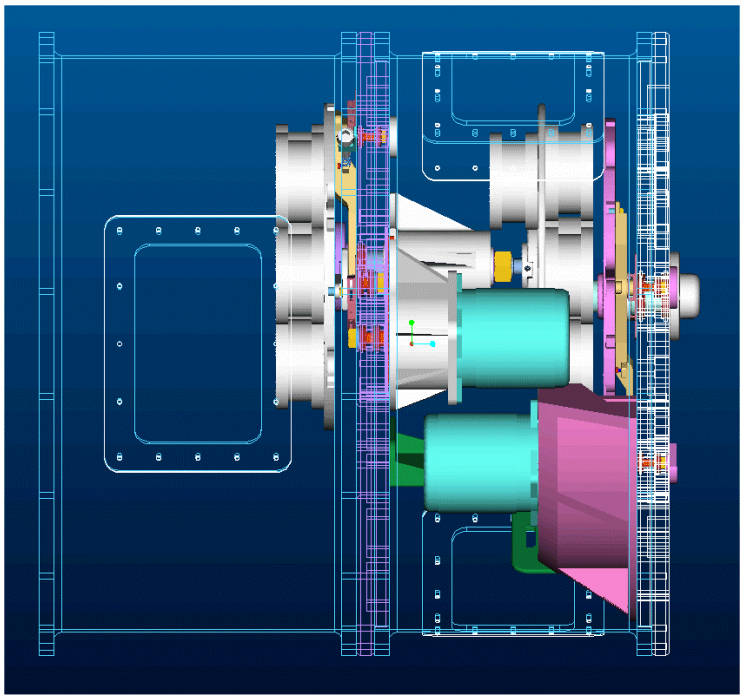
	Condition	Verification
Number of mechanisms	2	N/A
Optics indexing time	< 30 seconds	Test
Repositioning of optical elements in x,y	+/- 50 μm	Test
Start-up sequence	Auto home position	Test
Max indexing time	30 sec.	Test
Average stand-by duty cycle	100 sec.	Test
Longest operational in-flight duration	12 hours	Operational ICD
Instrument life	5 years	Operational ICD
Estimated operation time	350 hrs	

Design Overview

Optomechanical System (OMS)



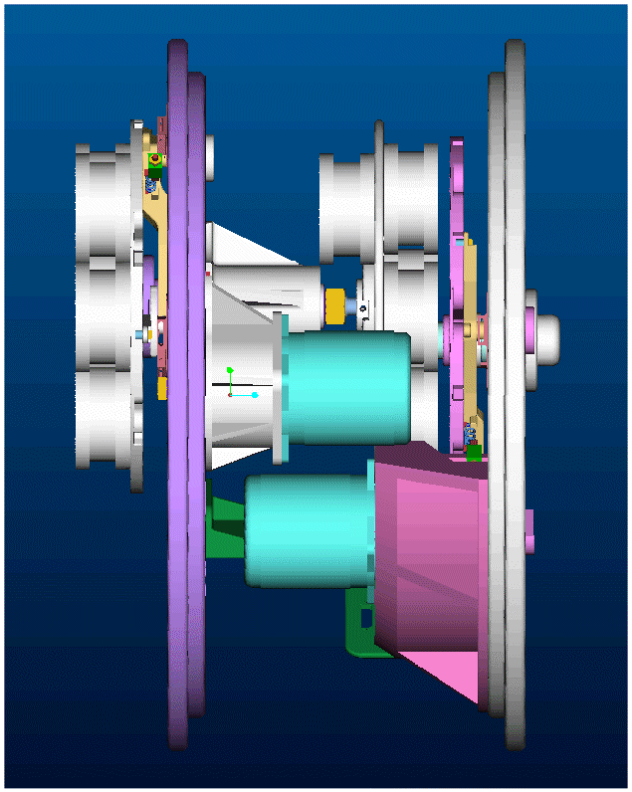
Iso View



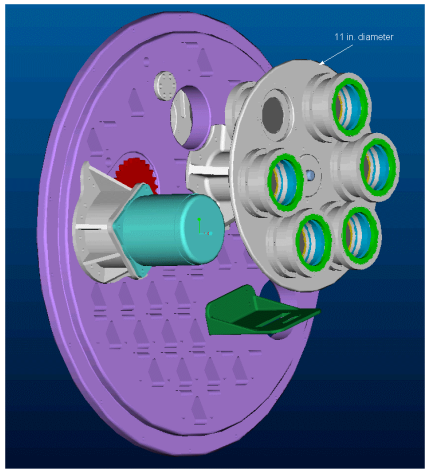
Side View (Internals)

Design Overview

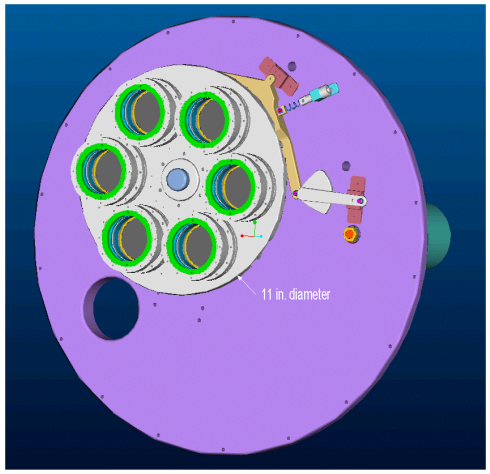
OMS Components



Side View
(no shells)

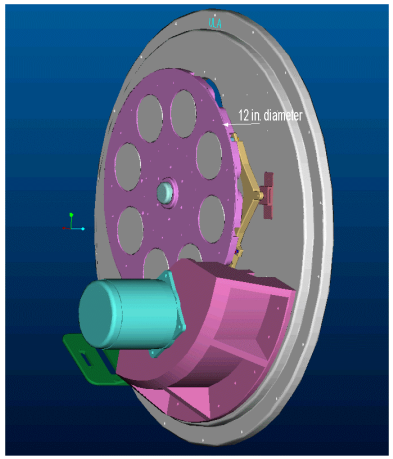


Lens Carousel (aft view)



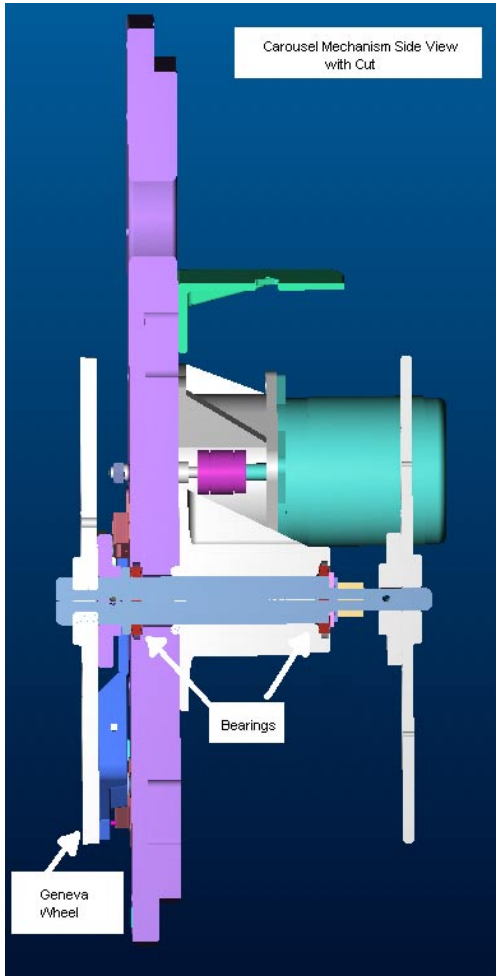
Lens Carousel (fore view)

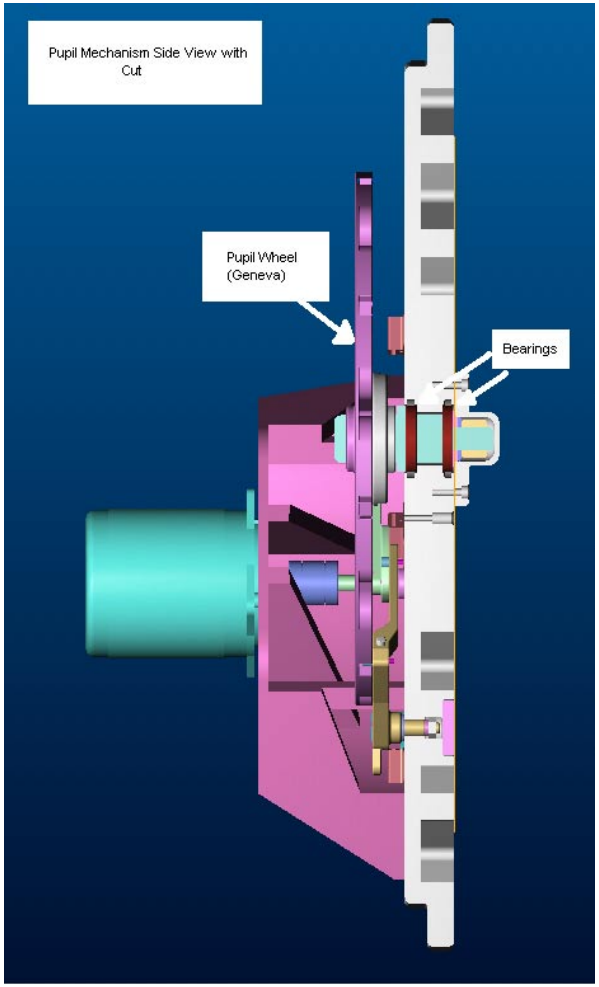
Pupil Carousel
(fore view)



OMS Top Level

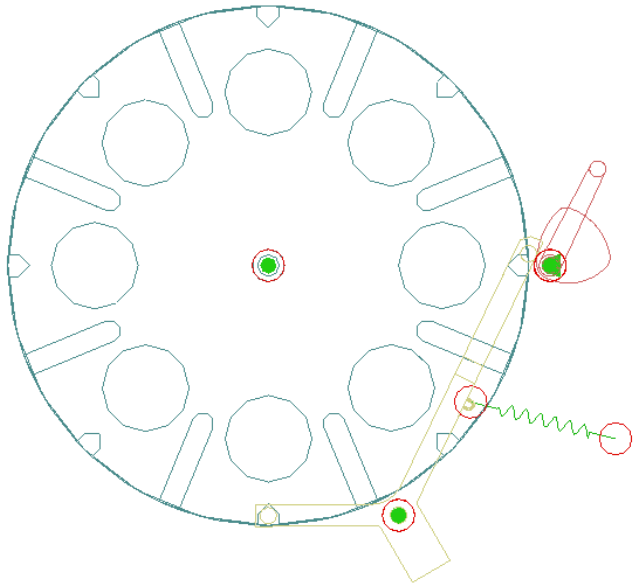
OMS Components Side View





OMS Top Level

Geneva Mechanism



Design Overview

Mechanical Aspects

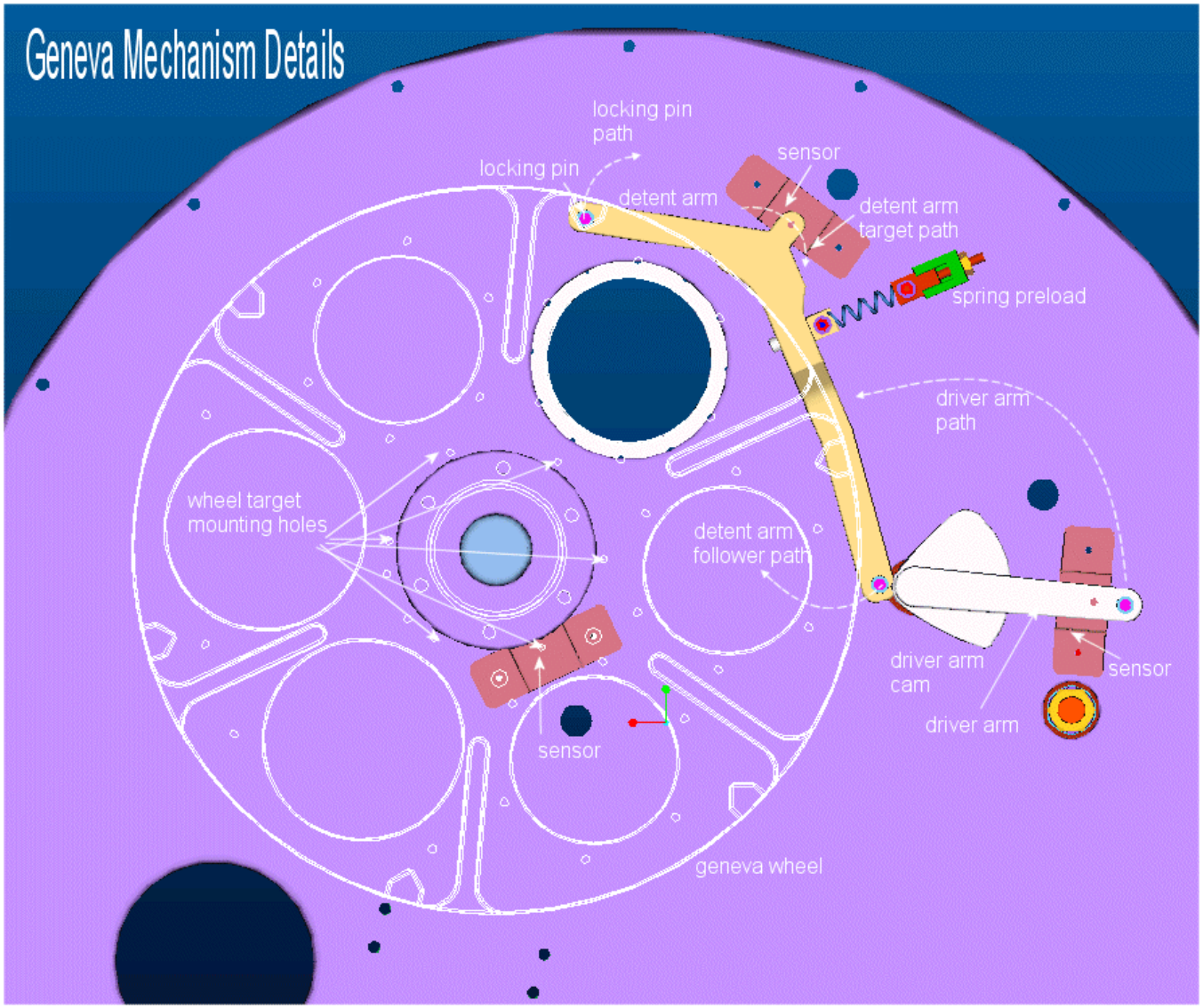
- OMS acts as He shield
- OMS overall dimensions of 21” (diameter) x 21.24” (length)
- Carousel and Pupil mechanisms driven using a Geneva configuration
  - Carousel – 6 positions
  - Pupil – 8 positions
  - Each wheel has a locking feature
- Both mechanisms can perform full revolutions in either direction
- Three position sensors are located at each mechanism
- Carousel mechanism uses gears with backlash to prevent gear jamming
- Pupil mechanism is direct driven

Design Overview

Mechanical Aspects

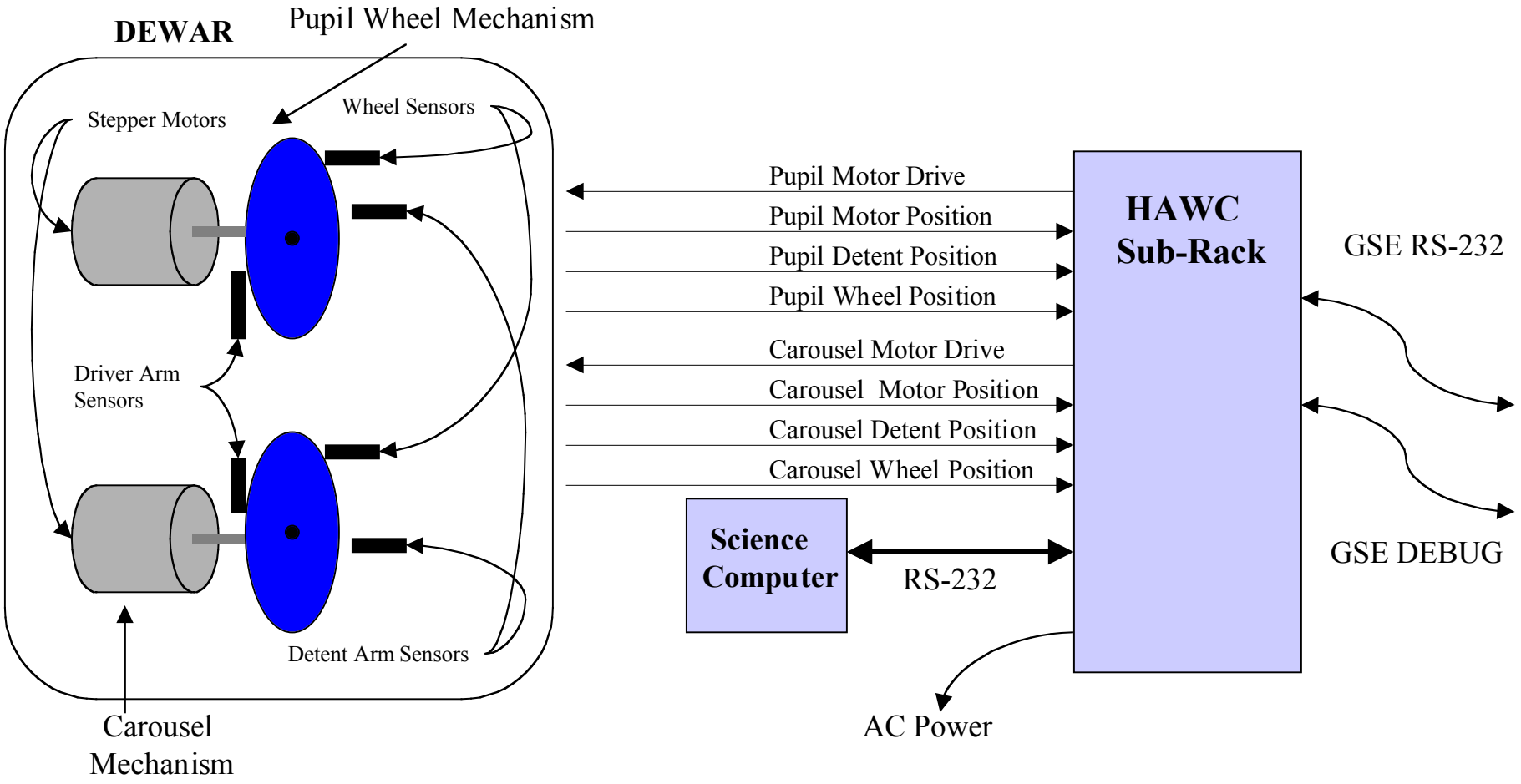
Materials	Used on
•6061-T6 AL	OMS structure
•Inconel 718	wheel shafts
•Steel Nuts and Flat Washers	everywhere
•CRES 302, Inconel 718	belleville washers ,bearings preloads
•2024-T4 AL	gears
•Inconel 750	springs
•Kel-f screw and loktite screw lock	
•Phosphor Bronze Helicoils	all parts
•A286	keenserts, kevlar straps
•Viton for O-rings	bearings setup
•Steel 440C Bearings by MPB/Timken	wheels
•Barden “Bartemp” (duroid-like) self lub. retainers	
•MOSO2 Lubrication	

Design Overview



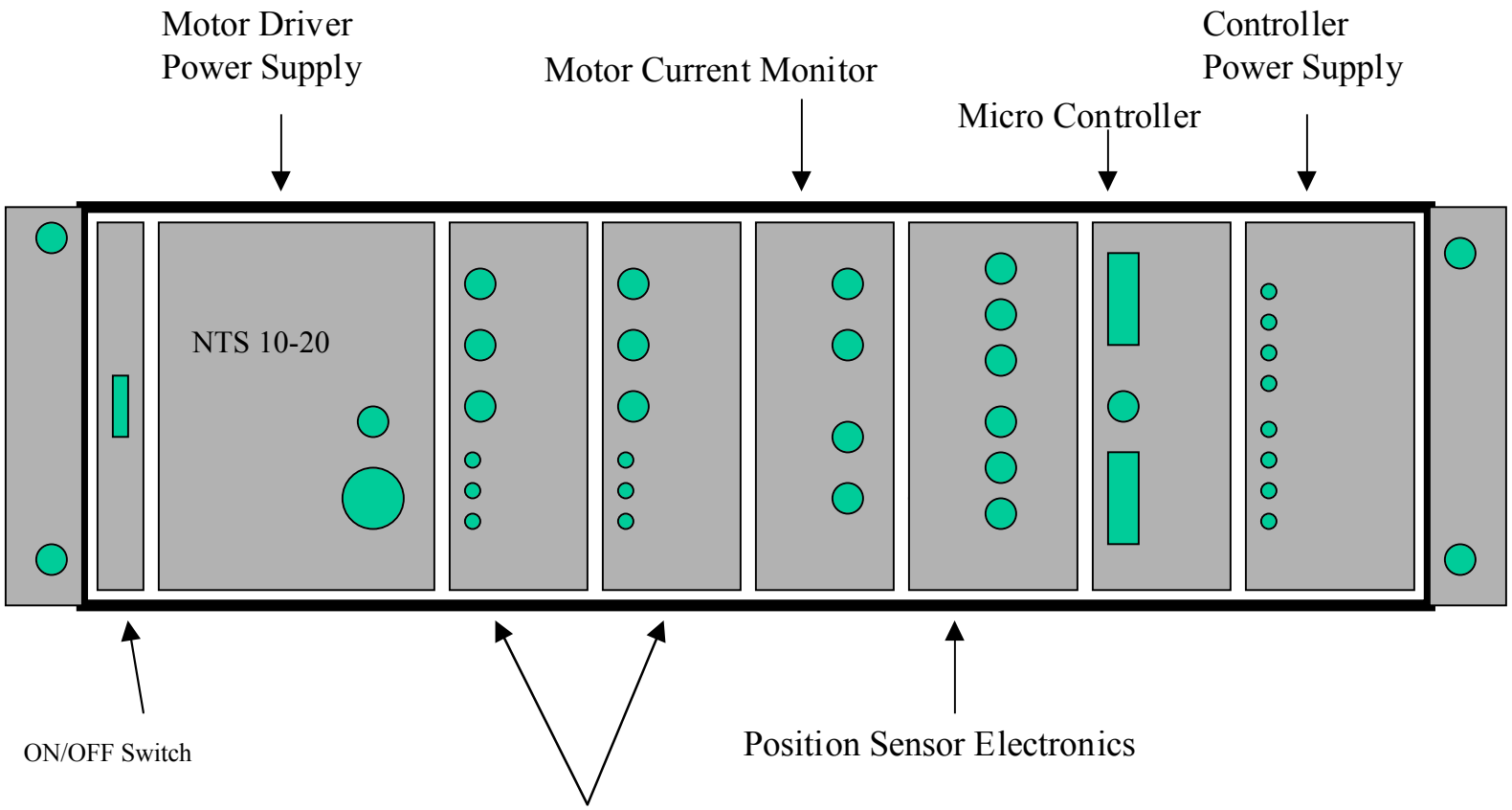
OMS Design Overview

Electrical Diagram

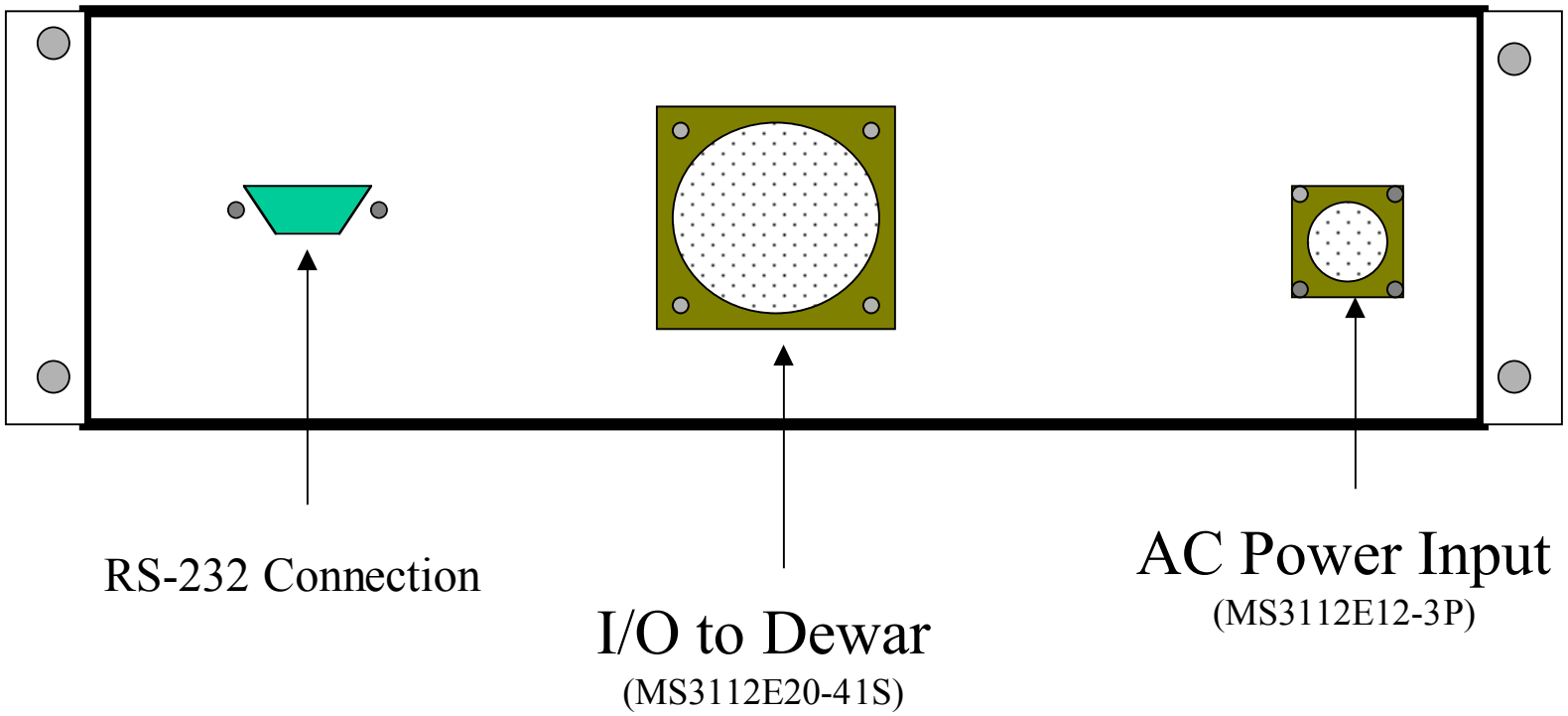


OMS Design Overview

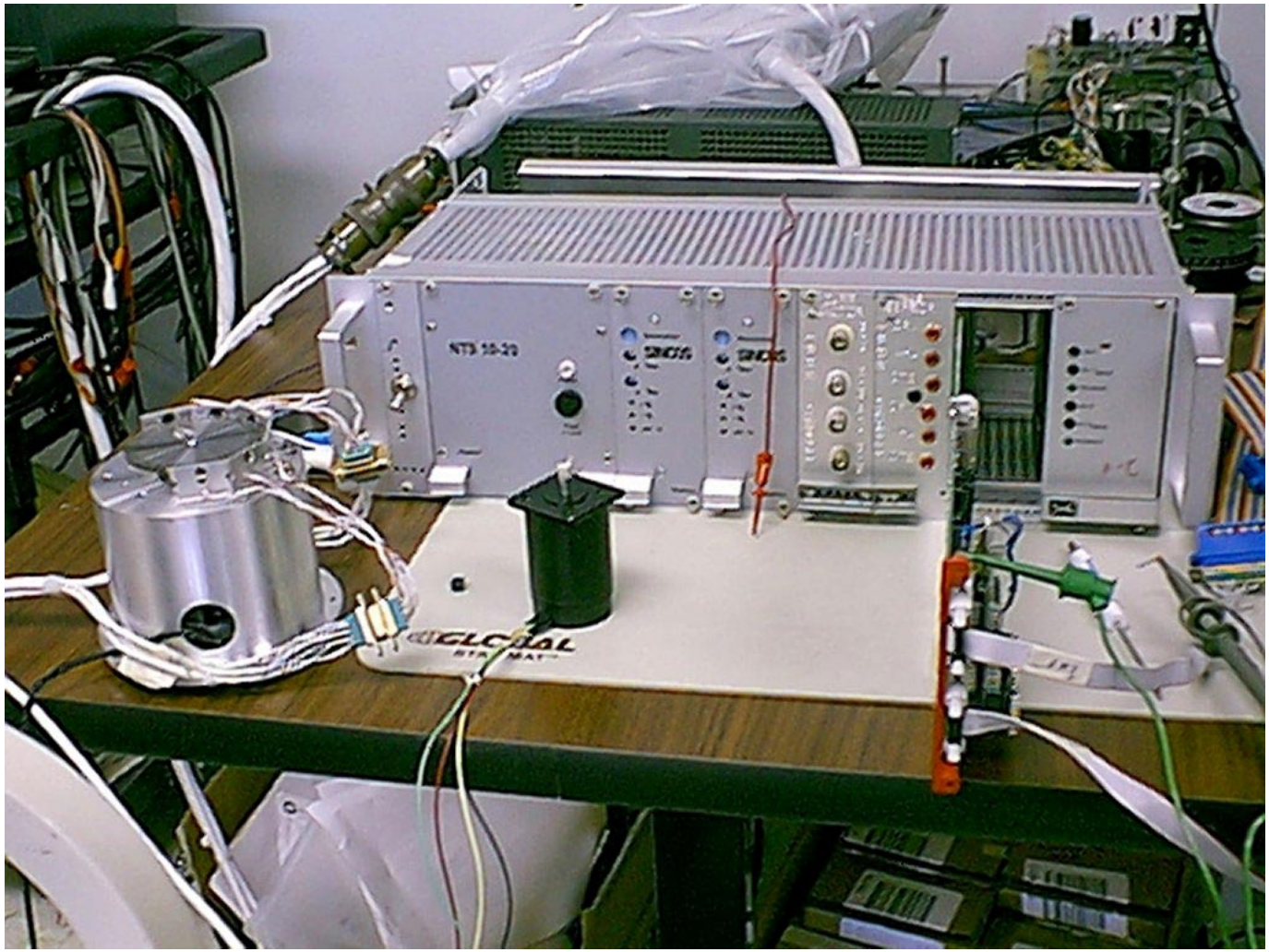
Electronics Sub-Rack



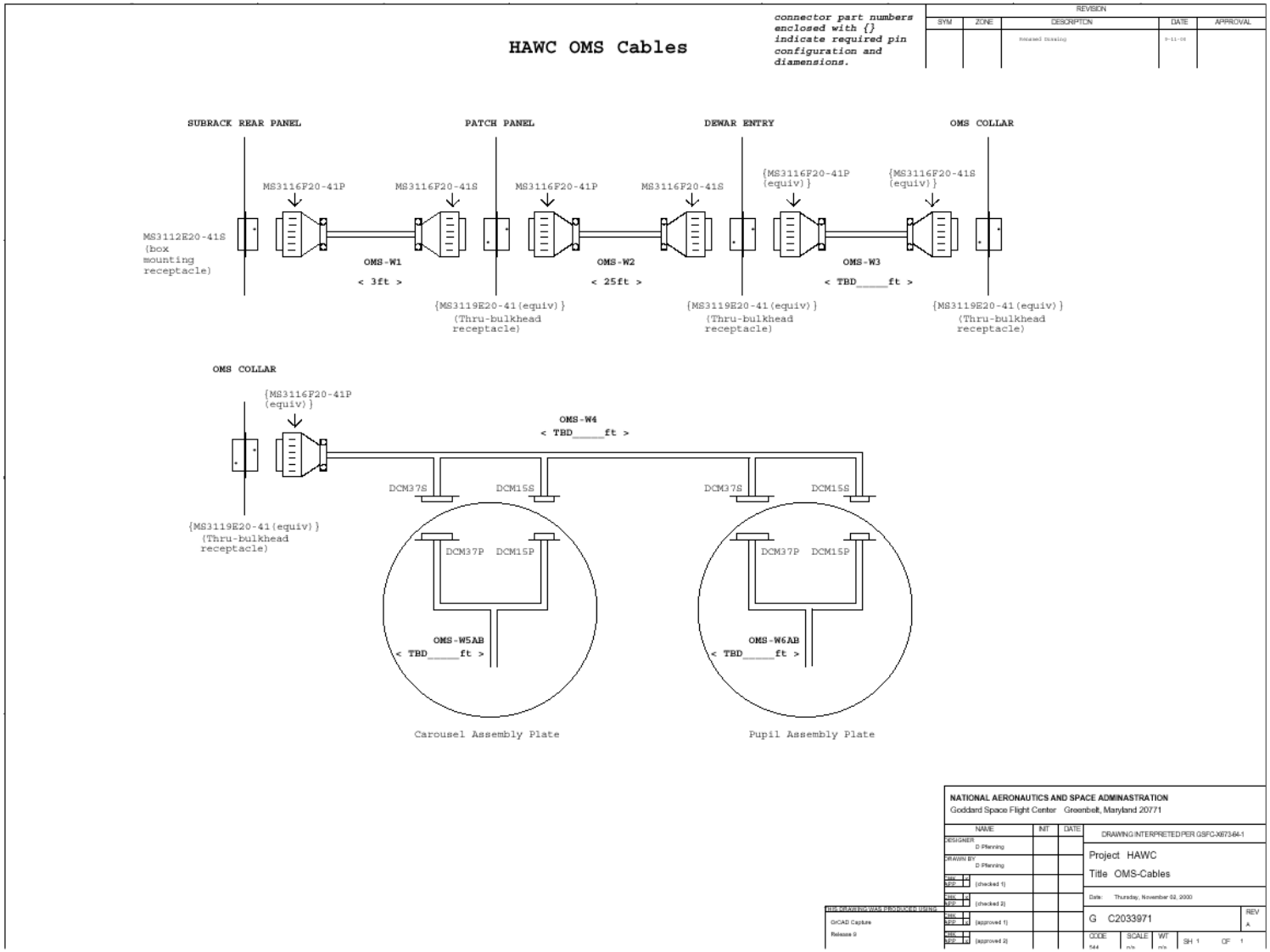
HAWC Sub-Rack
(rear view)



HAWC Sub-Rack



HAWC Harness Diagram



Design Overview

Electrical and Control Aspects

•Mechanisms are commandable by means of a microcontroller

•Commands sent by Science computer are handled by OMS "smarts"

–Small microcontroller handles commands

–Keeps track of indexing position and status of all electronics

–Supplies science and debugging info when requested

•Programmed algorithms in the microcontroller can use alternate methods of maintaining system operational in case of problems

-If a sensor is damaged, it can bypass it and use remaining sensors

–If all sensors are damaged

– it can use internal step counting methods

–can be directly commanded by science computer at a more "primitive" method

Design Overview

Electrical Design Specifications

Motors

- •Mission Research (AMS) 2 phase stepper motor, NEMA 34
- •400 oz-in torque warm (300 oz-in at cryo)
- •2Amps per phase (max)

Motor Driver

- •Phytron Sincos linear stepper motor driver
- •10,000 step/rev max
- •200 kHz clock frequency max

Controller

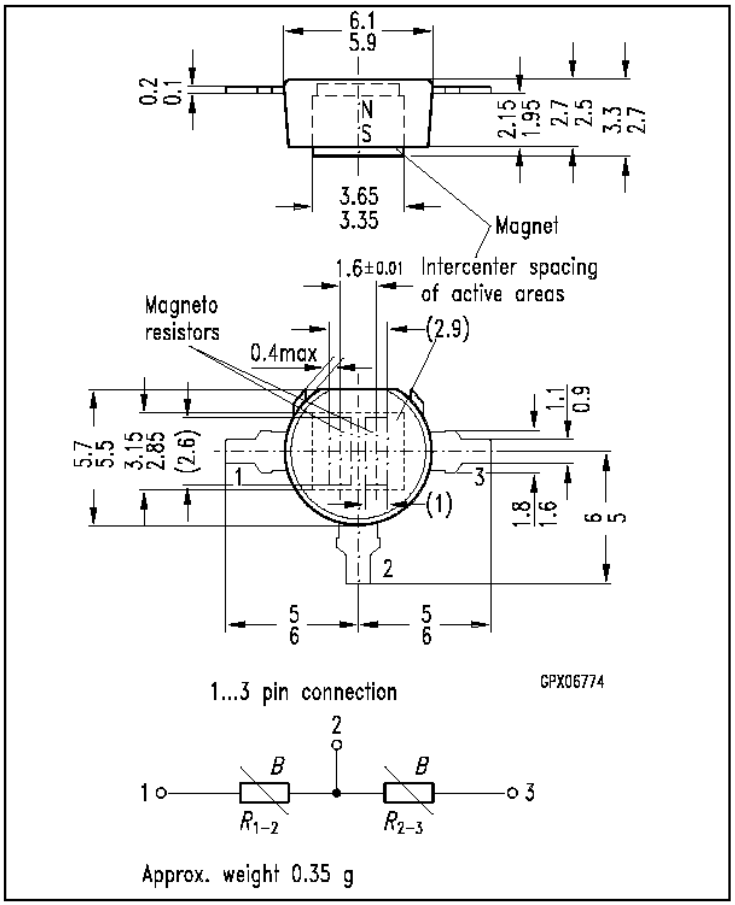
- •Freedom 16-mite MC68HC16 (Motorola) based microcontroller
- •16 bit
- •25 MHz
- •120mA (over 250mA fully loaded) @ 5 Vdc
- •8 channel, 10bit A/D @100kHz
- •RS232 serial port
- •15 programmable I/O lines (7 can be interrupts)
- •Size: 2” x 2”

Design Overview

Electrical Design Specifications (continues..)

Position Sensors

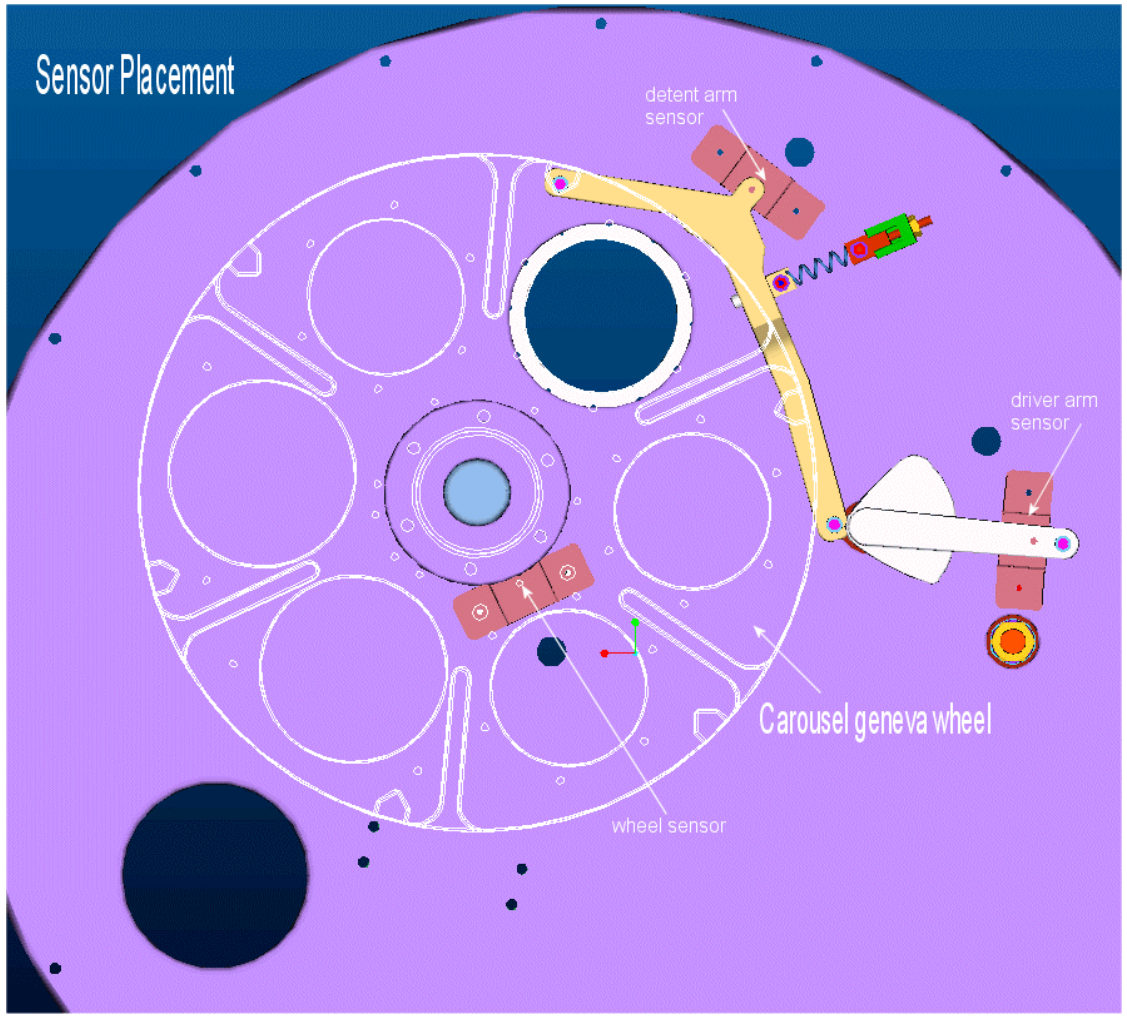
- Infineon Differential Magnetoresistive Sensor
- Model FP 212 L 100-22
- Supply: 7.5 Vdc max
- Power: 400 mW
- Output: 1.1 V or greater



Dimensions in mm

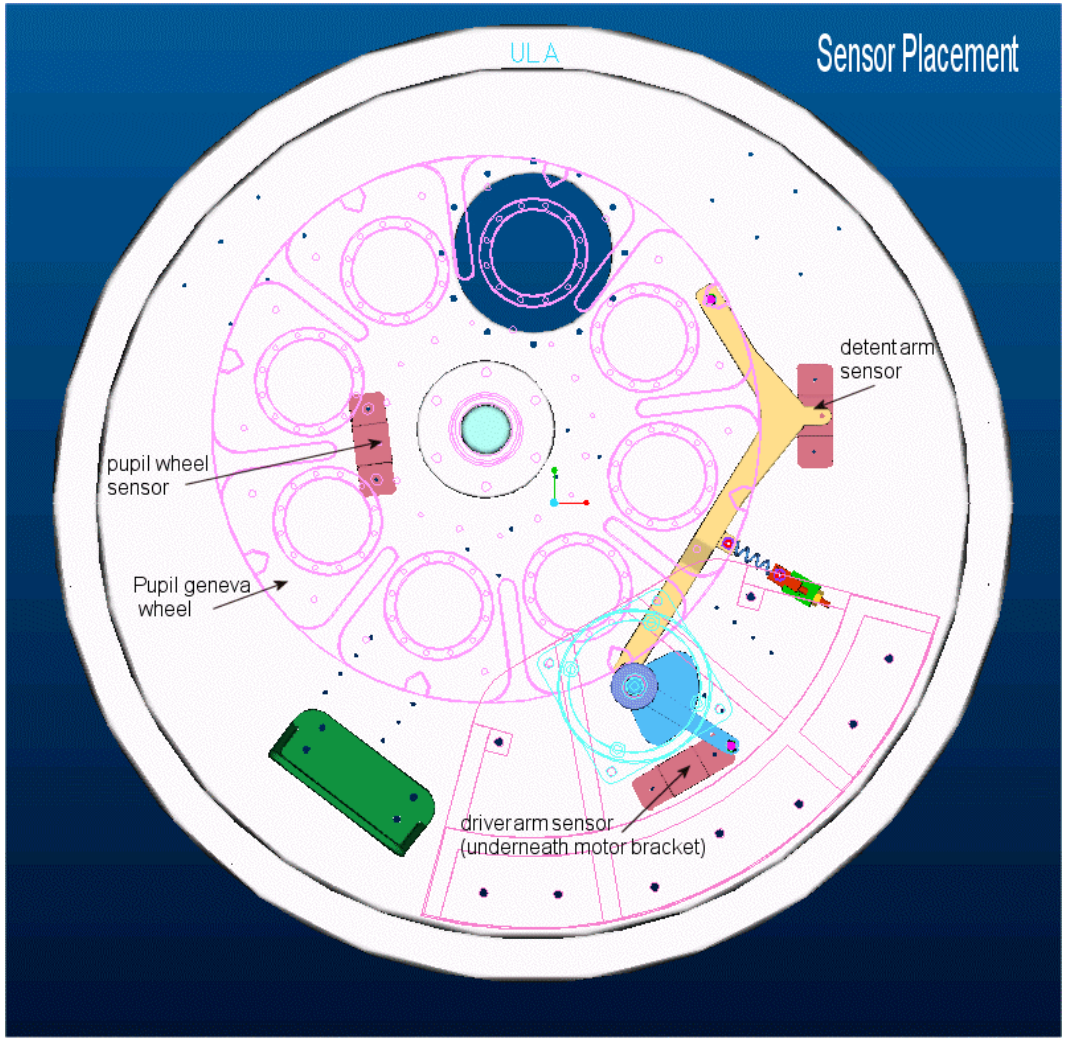
OMS Top Level

Carousel Wheel Sensor Placement



OMS Top Level

Pupil Wheel Sensor Placement



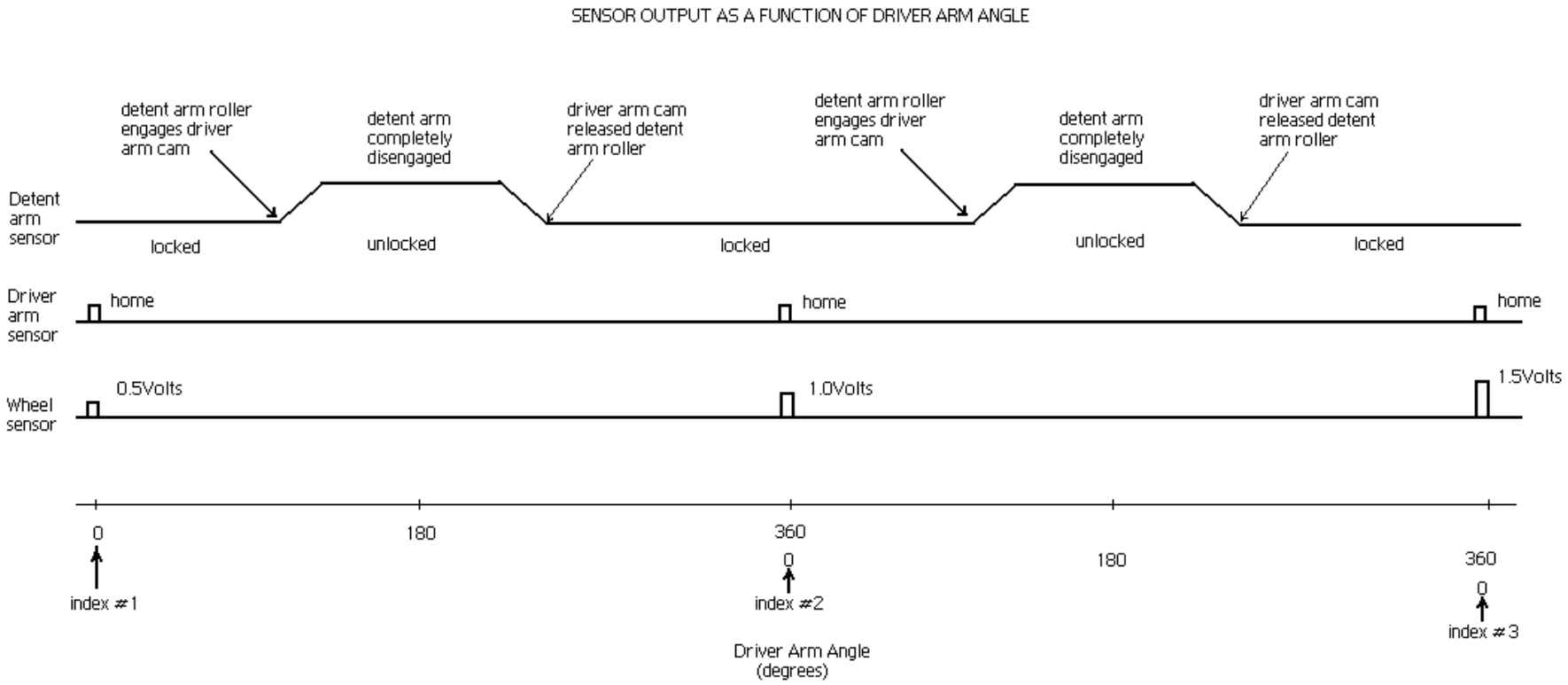
Design Overview

Sensor Details

- Each wheel has 3 sensors: driver arm, detent arm and wheel
  - Driver arm output is converted to a pulse
    - Occurs every 360 degrees (at home position, 180 degrees from wheel)
  - Detent arm output is processed as analog signal
    - Trapezoid-shaped profile output
    - Output is active when wheel is being indexed
  - Wheel sensor output is processed as analog signal
    - Amplitude of the signal indicates the actual index position

Design Overview

Sensor Details



OMS Design Summary

Command List

- Get Housekeeping Packet
- Perform Sensor Self Test
- Go To Index Position ***w1,w2***
- Move Motor Steps ***m1,m2***
- Stop Motor ***m1,m2***
- Immediate Stop Motor ***m1,m2***
- Send Zero Current to Motor Driver ***d1,d2***
- Send Reset to Motor Driver ***d1,d2***
- Send Current OFF to Motor Driver ***d1,d2***
- Echo Commands ***true_false***
- Get Motor Current ***m1,m2***
- Get Detent Sensor Curve ***wheel***
- Get Wheel Sensor Value
- Get Wheel Sensor Array Values
- Set Position Sensor Status ***wheel, driver_status, wheel_status, detent_status***
- Send "Alive" Response
- Set Temp Emergency Procedure Flag ***true_false***
- Execute Temp Emergency Procedure ***wheel***
- Find Home Position ***wheel***
- Set Flag Value ***flag, value***
- Get Software Version

OMS Design Summary

OMS Housekeeping Packet

- Motor Current *motor1,motor2*
- Motor OverTemp *motor1,motor2*
- Index Position *wheel1,wheel2*
- Detent Sensor Key Positions *A,B,C,D*
- Motor Status *motor1, motor2* (standby, moving,emergency stop)
- MicroController status *stat* (Standby, Self-Test, Indexing, Send Data)
- Position Sensor values *home, detent, wheel*
- Sensor Status *home, detent, wheel* (enabled, disabled)

Analysis Performed

Mechanical

- FEM analysis on OMS structure
  - Thermal loading at 4K
  - Dynamic/static Analysis
  - 12 g in XYZ (individually) static
  - 40 degrees (+/-) rotation about optical axis
  - Estimated system mass 115.6 lbs
- Results
  - Lowest frequency 166.7 Hz drum head mode in carousel plate
  - Displacements

	x displ	y displ	z displ	x rotation	y rotation	z rotation
12g's x-axis	4.00E-03	6.82E-04	4.76E-04	0	1.99E-04	4.79E-04
12g's y-axis	1.54E-03	1.76E-03	9.16E-05	0	7.80E-05	5.24E-04
12g's z-axis	-1.23E-03	2.61E-04	2.64E-03	0	-5.96E-04	-2.36E-06

Developmental Hardware & Software Testing Performed

Electrical

- Position sensors
  - Tested at 12K - passed
  - Tested for outgassing – passed
- Microcontroller
  - Generation of stepper motor signals
  - Reading all sensor outputs

Current Status

Mechanical

•Proceeding with fabrication drawings

Electrical Status

–All boards completed

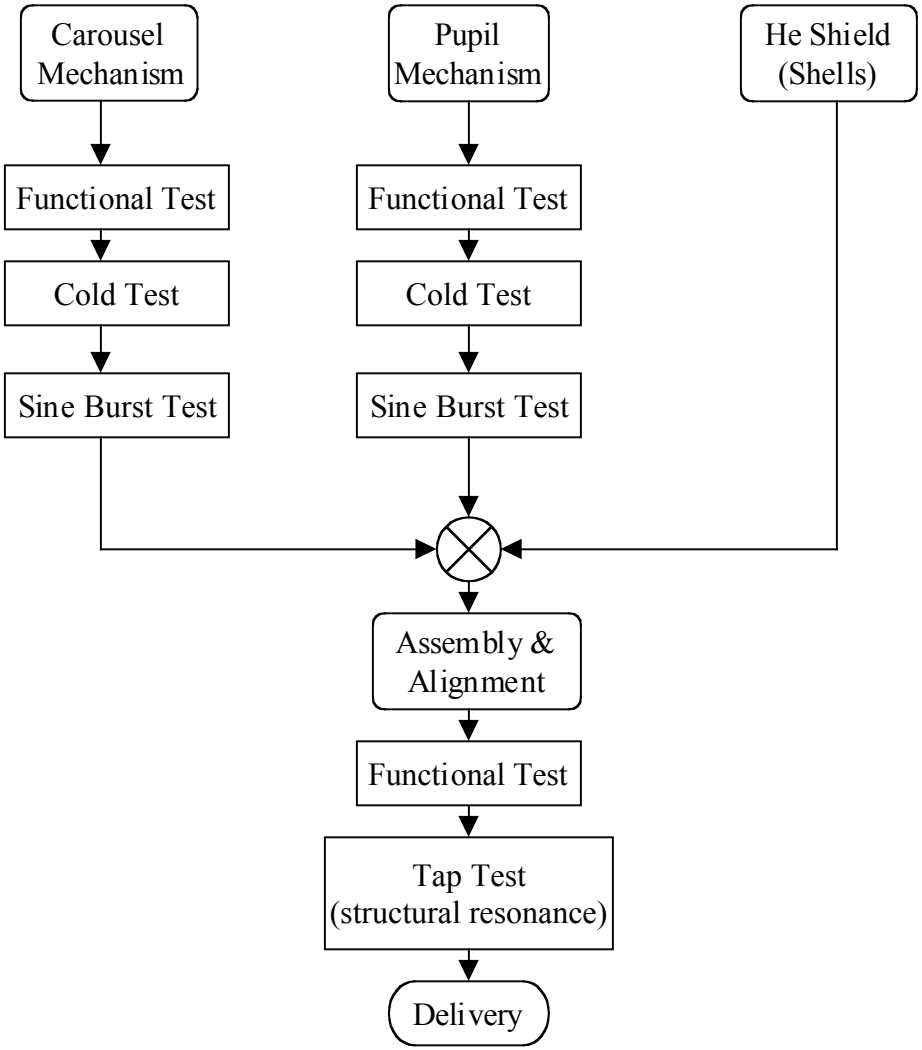
–All external harness completed (used in tests)

–Actual sensors have been tested using the flight boards

–Microcontroller board has been updated and new board will be fab

•Original board was modded and is being used in test setup

Test Plan


Carousel Mechanism
Pupil Mechanism
He Shield (Shells)
Functional Test
Functional Test
Cold Test
Cold Test
Sine Burst Test
Sine Burst Test
Assembly & Alignment
Functional Test
Tap Test (structural resonance)
Delivery

Test Plan

- **Before OMS assembly, each mechanism goes through the following tests**
  - Functional Test
    - Mechanism is connected to electronics rack
    - Calibration procedure: sensors, stepper motor driver currentsand step rate
    - Software detailed testing
  - Cold Test
    - Mechanism is taken down to 77K
    - Optics inside dewar used to detect shifts in mechanism alignment
    - Mechanism is exercised through various indexing operations
  - Sine Burst Test
    - Shine burst applied to check locking features in the detent arm
- **After OMS Assembly**
  - Tap test performed to check frequency response of structure and correlate to FEM model