Sections 3 through 6 Overview: Space Acceleration Measurement Systems (SAMS)

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Overview Presentation Agenda

- **Purpose and History**
- **Space Acceleration Measurement Systems (SAMS)**
  - Vibratory Sensors
  - Quasi Steady Sensors
- **Current Missions and Customers**
  - **International Space Station**
  - **Shuttle**
  - **Aircraft, Sounding Rockets, Ground Facilities, and more**
- **Future Development**

SAMS Purpose

Develop, deploy, and operate acceleration measurement systems to measure, collect, process, record, and deliver selected acceleration data to researchers & other customers that require control, monitoring and characterization of a microgravity environment on platforms such as drop towers, aircraft, Shuttle, and ISS.

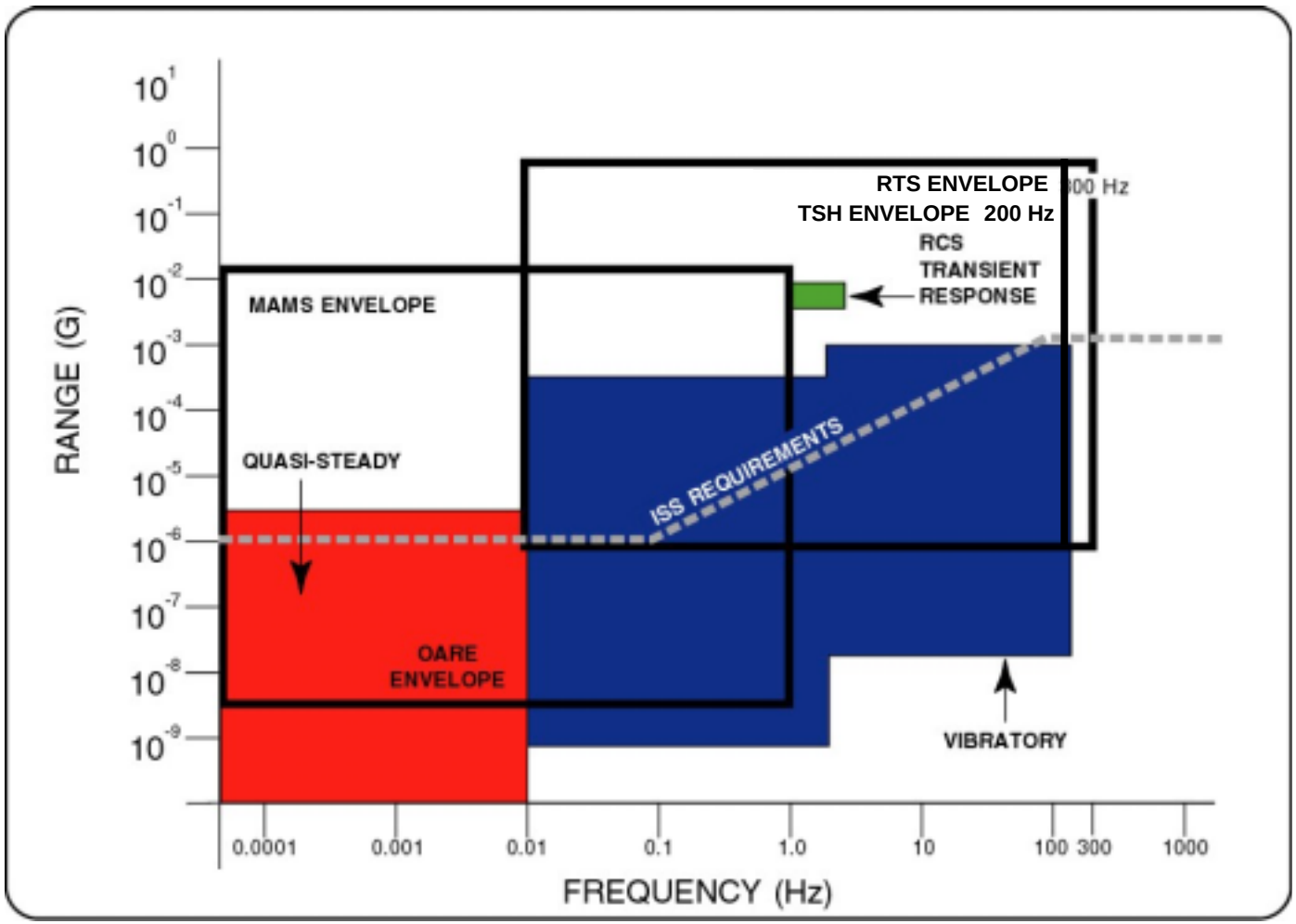
Acceleration Measurement History

- **NASA Glenn Systems**
  - **Space Acceleration Measurement System (SAMS)**
    - 20 Shuttle Flights, 7 Units (1991 to 1998)
    - Measured Acceleration Range: 0.01 to 100 Hz
  - **Orbital Acceleration Research Experiment (OARE)**
    - 8+ Shuttle Flights, 1 Unit (1991 to Present)
    - Measured Acceleration Range: DC to 1 Hz
- **Microgravity Environment Description Handbook (NASA TM 107486)**
- **Acceleration Data Stored on Web Server**
- **Other Systems**
  - **High Resolution Accelerometer Package (HiRAP), JSC/LARC**
  - **3-Dimensional Microgravity Accelerometer (3DMA), UAH**
  - **Microgravity Measurement Device (MMD), JSC**
  - **Quasi-Steady Acceleration Measurement (QSAM), DLR**
  - **Microgravity Measurement Assembly (MMA), ESTEC/ESA**

SAMS Present Systems

- **SAMS Vibratory Systems**
  - **Remote Triaxial Sensor (RTS) - Connection to a control unit**
    - Ethernet, distributed system, SECTION 3
    - Modular expandable system to support ISS
    - Initial deployment on ISS-6A, April 19, 2001
    - Measured Acceleration Range: 0.01 to 300 Hz
  - **Triaxial Sensor Head (TSH) - stand alone system**
    - Compact and Stand Alone, SECTION 4
    - Goal to reduce size of the sensor for Sounding Rockets
    - Replaced original SAMS on shuttle
    - Will be deployed on ISS in the Fluids and Combustion Facility
- **SAMS Quasi-Steady Systems**
  - **Orbital Acceleration Research Experiment (OARE)**
    - Shuttle, SECTION 5
  - **Microgravity Acceleration Measurement System (MAMS)**
    - OARE repackaged for ISS, SECTION 6
    - Deployment on ISS-6A, April 19, 2001
    - Measures Acceleration Range: DC to 1 Hz

SAMS Sensor Comparison

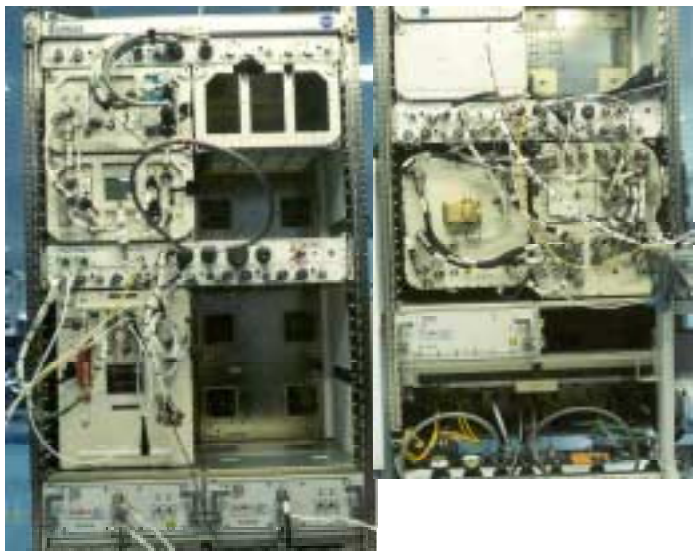


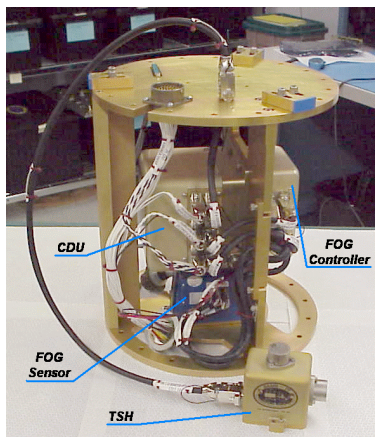
Sensor Comparison Table

	RTS	TSH	FOG	OARE	MAMS
Description	3 QA-3100 Allied Signal Accelerometers	3 QA-3100 Allied Signal Accelerometers	Fiber Optic Gyroscope (Fibersense)	MESA Sensor, Calibration Table STS only	MESA and HIRAP Sensors, Calibration Table ISS only
Measured Quantity	Linear Acceleration	Linear Acceleration	Roll Rate	Linear Acceleration	Linear Acceleration
Dimensions (inches)	5.6x4.0x4.3 (SE) 9.1x9.3x4.7 (EE)	2.9x2.9 x2.8	3.8x4.4x3.0 (Gyro) 4.8x5.0x2.2 (Intf)	17x13x41	21.9x18.4x23.6
Weight (lbs)	2.2 (SE) 9.5 (EE)	1.1	3.75	117	117
Power (W)	2.25 (SE) 8 (EE)	1.6	~10	110	79
Data Interface	Ethernet	RS-422	RS-232	STS	Ethernet
Bandwidth	0.01-300 Hz	0.01-200 Hz	10 Hz Sampling	DC (10^{-5}) to 1 Hz	DC (10^{-5})-1 Hz (MESA) 10-4-100 Hz (HIRAP)
Maximum Scale	1.1 g at G=1 0.11 g at G=10	1.25 g	190°/sec	10-25 mg	10-25 mg (MESA) 16 mg (HIRAP)
Resolution	0.1 µg 0.1/0.01 µg A/D	0.1 µg	0.1 arc-sec	3-4.6 ng	3-4.6 ng (MESA) 1 µg (HIRAP)

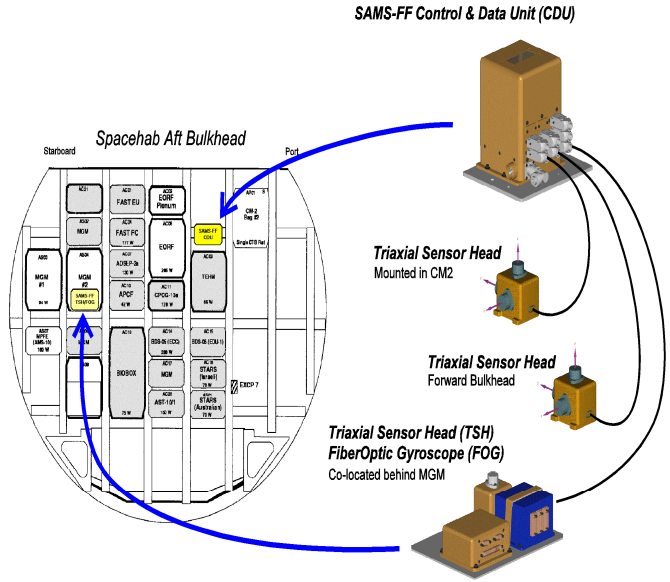
Space Flight Carriers

International Space Station
Sensors: RTS, TSH, MAMS
Control System: Interim Control Unit





Space Shuttle
Sensors: TSH, FOG, OARE
Control System: Control & Data Acquisition Unit

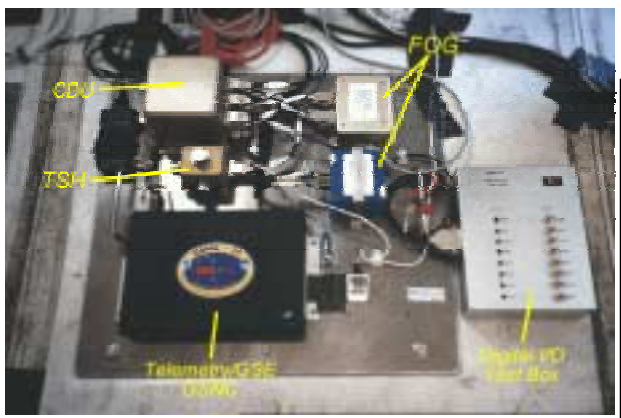


Sounding Rocket
Sensors: TSH, FOG
Control System: Control & Data Acquisition Unit

Aircraft and Ground Facilities

Drop Tower
Sensors: TSH
Control System: Control & Data Acquisition Unit

Plum Brook Station
Sensors: TSH
Control System: Space Power Facility Computer with SAMS software



KC-135
Sensors: TSH, FOG
Control System: Control & Data Acquisition Unit

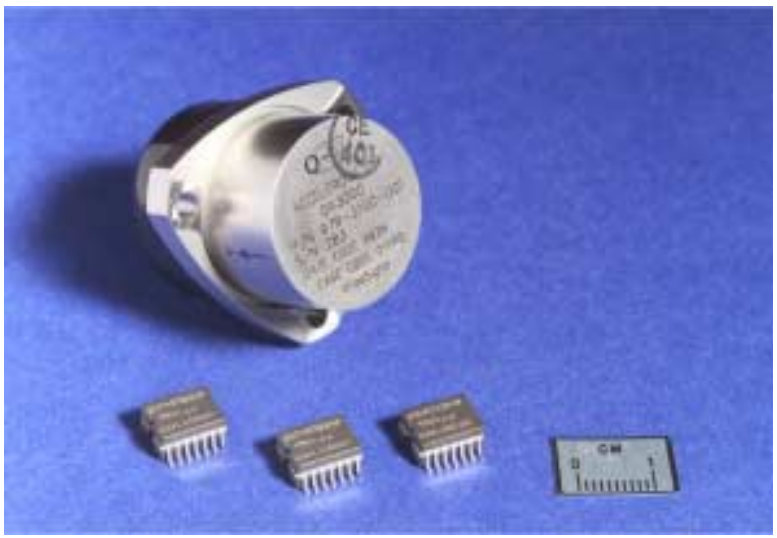
Parabolic Aircraft Rating System
Sensors: TSH
Control System: PC Laptop with SAMS Software

Current Customers for SAMS

- **PI Microgravity Services (PIMS)**
- **ISS Customers**
  - ARIS EXPRESS Racks (Four Racks Planned)
  - Physics of Colloidal Spheres (PCS) Experiment for UF-1
  - ARIS ICE
  - Microgravity Science Glovebox (MSG)
  - Combustion Integrated Rack (CIR) for UF-3
  - Material Science Facility (Under Review)
  - Bio-Technology Facility (BTF) (Under Review)
  - Fluids Integrated Rack (FIR) for UF-5
  - Low Temperature Microgravity Physics Facility (LTMPF)
- **Shuttle**
  - STS-107 Payloads
  - STS-117 Payloads (Under Review)
- **Sounding Rocket**
  - SAL
- **KC-135 (6 flights planned FY2001)**

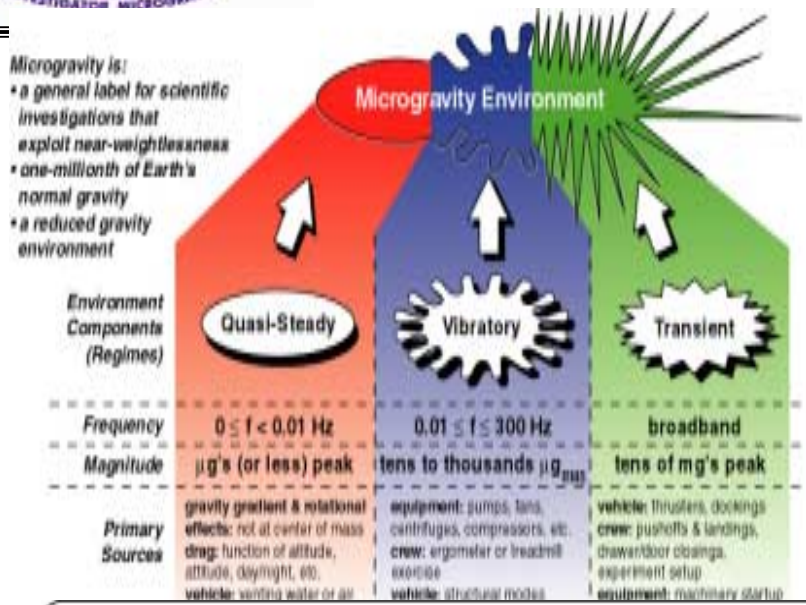
Future Development

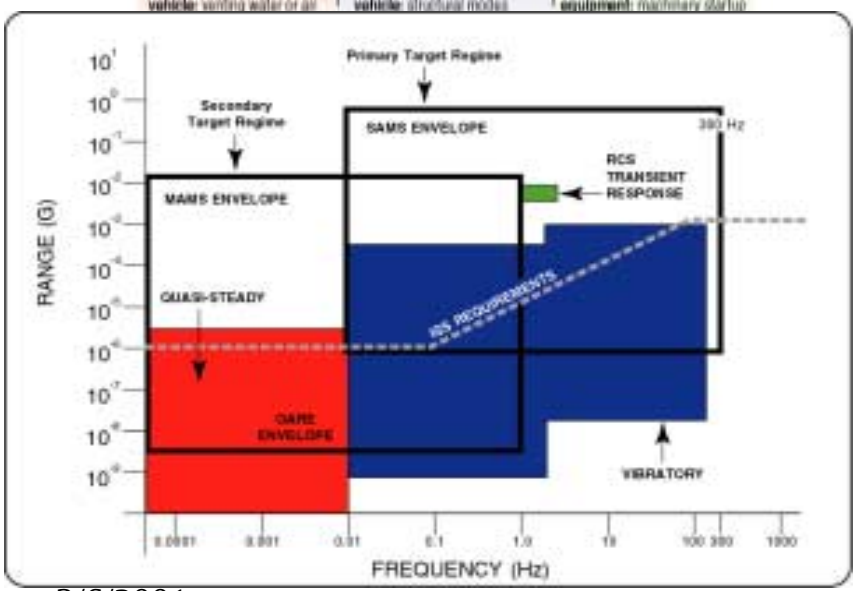
- **Develop and deploy Control Unit with increased processing capability and interfaces. Initial use ISS.**
- **Sensor Size Reduction**
  - **Packaging Improvements Utilized**
  - **Sensor Miniaturization Technology Considered**
  - **Universal Serial Port and Ethernet capabilities for TSH**
  - **Combination of existing systems and upgrades**
  - **MEMS Technology**
- **Software Modifications to support communication of other Acceleration Systems with Control Unit**
- **Package Acceleration System for External Facility on JEM Porch**
- **Identification of Disturbance Signatures on User Displays**



Advanced Microgravity Measurement Systems

- **Significant cost and resource savings may be achieved by utilizing MEMS versus SAMS (electro-mechanical) accelerometers.**
- **The SAMS accelerometers used on Shuttle missions to measure 10^{-6} g_{rms} cost $4000 each. Commercial MEMS sensors cost $25 and can resolve 10^{-3} g_{rms}. Prototypes with capabilities to 10^{-5} g_{rms} are becoming available.**
- **The primary objective is to develop, package and test a prototype acceleration measurement system capable of measuring the same sensitivity as SAMS (see page 7) and provide a standard interface to a payload's data system, in a significantly smaller package.**
- **A secondary desire (much more difficult) is to determine if the MEMS prototype sensor can be combined with a Fiber Optics Gyroscope and low frequency accelerometers to measure the entire envelope presently covered by SAMS and MAMS.**





Advanced Microgravity Measurement Systems

- The anticipated users are all disciplines in microgravity science research program, life science and vehicle communities that require local measurements of the on-orbit environment.
- The deliverable would be an advanced acceleration measurement system developed to the level that it could be tested on a sounding rocket mission and adaptable for long duration space flight.
- The impact would be a 25% to 75% reduction in required resources (volume,power & mass) to collect low gravity data on orbit.
- This development work is a new thrust for a very experienced team that has delivered multiple Space Acceleration Measurement Systems.

Conclusion

- **The SAMS Project has several systems that can be configured to support a variety of microgravity platforms**
- **SAMS and PIMS will work with you to find the best system for your purposes**

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