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**MICRO GUIDANCE AND CONTROL
PANEL RECOMMENDATIONS**

μG&C

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WORKSHOP ON MICROTECHNOLOGIES & APPLICATIONS TO SPACE SYSTEMS

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MICRO G & C TECHNOLOGY DEFINITION



WHAT IS MICRO GUIDANCE AND CONTROL?

- MICRO-MINIATURIZED GUIDANCE AND CONTROL COMPONENTS AND SUBSYSTEM (SENSORS, ACTUATORS, CONTROL ELECTRONICS)
- MICRO GUIDANCE AND CONTROL ARCHITECTURE REALIZED BY INTEGRATION OF MICRO-MACHINED DEVICES, ON-CHIP VLSI CIRCUITS AND GUIDANCE AND CONTROL FUNCTIONS



MICRO G&C TECHNOLOGY PANEL SCOPE



THE GUIDANCE AND CONTROL PANEL WILL FOCUS ON EMERGING MICRO-GUIDANCE AND CONTROL TECHNOLOGIES, USERS AND SYSTEMS ISSUES WITH THE FOLLOWING EMPHASIS.

- MICRODEVICE G&C SUBSYSTEMS FOR SPACECRAFT WILL BE EXAMINED WITH EMPHASIS ON COMPONENT TECHNOLOGY, ATTITUDE AND ARTICULATION CONTROL CAPABILITIES, HEALTH MONITORING AND RECOVERY.
 - MICROSENSOR AND MICROACTUATOR DESIGN AND THE ATTENDANT ELECTRONICS, POWER AND INFORMATION PROCESSING WILL BE ADDRESSED. ALSO INCLUDED WILL BE VEHICLE HEALTH MONITORING FOR TRANSPORTATION SYSTEMS.
 - FABRICATION TECHNOLOGIES, INCLUDING SILICON PROCESSING, MICRO-MACHINING, TUNNELING TECHNOLOGY, MATERIAL SCIENCE, VLSI OF DEVICES AND SUPPORTING CIRCUITRY "ON-CHIP" WILL BE COVERED.
 - DISTRIBUTED ARCHITECTURE ISSUES WILL BE DISCUSSED INCLUDING DATA HANDLING, POWER TRANSMISSION AND DISTRIBUTED MICROSENSING ARCHITECTURES.
- PLATFORM APPLICATIONS WILL INCLUDE
 - SYSTEM IDENTIFICATION, HEALTH MONITORING, AND REMOTE SENSING APPLICATIONS
 - VEHICLE GUIDANCE, NAVIGATION AND CONTROL, AND SHAPE CONTROL FOR MULTI-USE VEHICLES AND LARGE INSTRUMENTS LIKE RADIOMETERS
- THE SCIENCE MISSION APPLICATIONS WILL INCLUDE SYSTEM IDENTIFICATION, OPTICAL FIGURE CONTROL FOR GROUND/SPACEBORNE TELESCOPES AND INTERFEROMETERS, AND INSTRUMENT POINTING/SENSING/ISOLATION.



MICRO G & C TECHNOLOGY PURPOSE AND OBJECTIVES



OVERALL PURPOSE:

- DEVELOP NEW MINI/MICRO GUIDANCE AND CONTROL SYSTEM ARCHITECTURES AND COMPONENTS THAT MEET THE NEEDS OF FUTURE SPACE SYSTEMS

KEY OBJECTIVES:

- DEVELOP THE GUIDANCE AND CONTROL MICRO-SENSING, COMPUTATION, AND CONTROL ARCHITECTURES AND COMPONENTS THAT WILL ENABLE:
 - INCREASED RELIABILITY VIA
 - SOLID STATE TECHNOLOGY
 - MASSIVE REDUNDANCY OF MICRO-COMPUTERS

REDUCTIONS

- 100/1 OR MORE IN SIZE, MASS AND POWER
- 10/1 OR MORE IN RECURRING COST AND COST GROWTH RATES

• ARCHITECTURES WITH

- ROBUST PERFORMANCE OVER TEMPERATURE, VIBRATION, AND RADIATION RANGES
- EMBEDDED HEALTH MONITORING
- VIABLE DISTRIBUTED FAULT TOLERANT G & C



MICRO G & C TECHNOLOGY

G & C APPLICATION NEEDS FOR FUTURE SPACE SYSTEMS



MICRO-SPACECRAFT, MICRO-LANDERS, MICRO ROVERS

- ATTITUDE & MANEUVER CONTROL SYSTEM
- MICRO-INERTIAL REFERENCES
- **MICROELECTRO-OPTICS** FOR MINIATURE CAMERAS & REMOTE SENSORS
- INERTIAL/CELESTIAL NAVIGATION SYSTEMS
- HEADING REFERENCE UNITS
- MINI-CAMERA POINTING, ARTICULATION & STABILIZATION
- ANTENNA POINTING, ARTICULATION & STABILIZATION
- INTEGRATED OPTICAL TRACKING

REMOTE SENSING PLATFORMS, INTERFEROMETERS, & DEPLOYABLE REFLECTORS

- DISTRIBUTED MICRO-SENSOR SYSTEM IDENTIFICATION
- MULTIVARIABLE CONTROL OF STRUCTURAL DYNAMICS
- DISTRIBUTED SHAPE & POSITION CONTROL OF MIRROR ARRAYS
- EMBEDDED ARTICULATION AND STABILIZATION OF TELESCOPE & INSTRUMENT OPTICS
- DISTRIBUTED MICRO-INERTIAL REFERENCES
- EMBEDDED HEALTH MONITORING OF G&C EFFECTORS
- **INTEGRATED OPTICAL TRACKING**



MICRO G & C TECHNOLOGY CORE BUILDING BLOCKS



• CORE INNOVATIONS NEEDED FOR THE NEW MICRO-G & C ARCHITECTURES

- MASSIVELY DISTRIBUTED MICROSENSING FOR SYSTEM ID AND CONTROL
- LIGHT POWERED REMOTE PROCESSING NETWORK FOR MICROSENSING
- MICRO-G & C FOR MICRO-SPACECRAFT AND MICRO-ROVERS
- SIX DEGREE-OF-FREEDOM MICRO-INERTIAL MEASUREMENT UNIT
- ACTIVELY CONTROLLED MICROMACHINED DEFORMABLE MIRRORS
- EMBEDDED HEALTH MONITORING FOR G & C EFFECTORS
- NEW ARCHITECTURES FOR FAULT TOLERANCE AND TO INTEGRATE DIVERSE SUBSYSTEMS

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**MICRO G&C TECHNOLOGY
TECHNOLOGY AVAILABILITY**

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CURRENT READINESS LEVEL: 2-3 (COMPONENT), 1 (SYSTEM)

LAB DEMONSTRATION: 3 YEARS FROM FUNDING START

**FLIGHT DEMONSTRATION: 5 YEARS FROM FUNDING START
(SUBSYSTEM LEVEL)**

MICRO G&C TECHNOLOGY

JPL G & C PANEL RECOMMENDATION

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THE GUIDANCE AND CONTROL PANEL CONCLUDES THAT THE DEVELOPMENT OF MICRO GUIDANCE AND CONTROL TECHNOLOGIES WILL HAVE A REVOLUTIONARY IMPACT ON NASA SPACECRAFT AND MISSIONS.

THE PANEL RECOMMENDS THAT NASA UNDERTAKE AS SOON AS POSSIBLE THE DEVELOPMENT OF THE MICRO G&C TECHNOLOGY CORE BUILDING BLOCKS, IDENTIFIED IN THIS REPORT, IN ORDER TO EXPLOIT AND SHAPE THE DIRECTION OF INDUSTRIAL AND ACADEMIC ADVANCES IN MICROTECHNOLOGIES.



MICRO G&C TECHNOLOGY IMPLEMENTATIONS



EXPEDITE CRITICAL ANALYSIS OF MICROTECHNOLOGY VIABILITY FOR G&C

- EXAMINE STATE-OF-THE-ART IN MICRO-DEVICES ACROSS VARIOUS DISCIPLINES AND AGENCIES FOR LEVERAGING INTO G & C INCLUDING MEDICAL, AUTOMOTIVE, BIOLOGICAL, AVIATION AND CONSUMER PRODUCT ADVANCES
- CONDUCT G & C BENEFITS, APPLICATIONS AND CONCEPTUAL STUDIES TAKING INTO ACCOUNT THE MULTIDISCIPLINARY TECHNOLOGIES INVOLVED

FABRICATE

- PURSUE AND **SUCCOR** PROMISING DEVICES, CONCEPTS (E. G., ELECTROSTATIC, ELECTROMAGNETIC, ETC.)
- **BUILD AND TEST PROTOTYPE INTEGRATED SYSTEMS**

VALIDATE

- **SUBJECT PROMISING SUBSYSTEMS TO REALISTIC ENVIRONMENT**
- CONDUCT FLIGHT EXPERIMENTS (GET-AWAY SPECIALS, PIGGY-BACK, ETC.) FOR VALIDATIONS