Advanced Sensors for NASA's Exploration Missions

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- **The following persons from NASA/MSFC contributed to this presentation**

  Raymond G. Clinton

  Beth Cook

  Jerry Fishman

  Donald Frazier

- **Outline of the presentation**
  - The vision of the President of the United States of America for Space Exploration
  - The report of the President's Commission on Implementation of United States Space Exploration Policy
  - Exploration Systems Interim Report
  - Major areas of sensor needs
  - Classes of material
  - Variety of Sensors for Space Exploration
  - Concluding remarks

On January 14, 2004, the President of the United States announced a new vision for the United States civil space program.

The goals of this vision are:

- Implement a sustained and affordable human and robotic program to explore the solar system and beyond
- Extend human presence across the solar system, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations
- Develop the innovative technologies, knowledge, and infrastructure both to explore and to support decisions about the destinations for human exploration
- Promote international and commercial participation in exploration to further U. S. scientific, security, and economic interests.

The President also created a Presidential Commission "to obtain recommendations concerning implementation of the new vision for space exploration."

The Commission was chartered to make recommendations regarding:

- A science research agenda to be conducted on the Moon and other destinations as well as human and robotic science activities that advance our capacity to achieve the policy;
- The exploration of technologies, demonstrations, and strategies, including the use of lunar and other in situ natural resources, that could be used for sustainable human and robotic exploration;
- Criteria that could be used to select future destinations for human exploration
- Long-term organization options for managing implementation of space exploration activities
- The most appropriate and effective roles for potential private-sector and international participants in implementing the policy
- Methods for optimizing space exploration activities to encourage the interest of America's youth in studying and pursuing careers in mathematics, science, and engineering
- Management of the implementation of the policy within available resources.

- **The Commission recognized that achieving the exploration objectives would require significant technical innovation, research, and development in focal areas defined as "enabling technologies"**

- **Exploration Systems Interim Strategy- Craig Steidle, NASA/Associate Administrator for Exploration System, August 2004**
- ***The Vision for Space Exploration: Objectives***
  - Implement a sustained and affordable human and robotic program to explore the Solar System and beyond
  - Extend human presence across the Solar System, starting with a human return to the Moon by year 2020, in preparation for the human exploration of Mars and other destinations
  - Develop the innovative technologies, knowledge, and infrastructures both to explore and to support decisions about destinations for future human explorations
  - Promote international and commercial participation in exploration to further U.S. scientific, security, and economic interests

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- **Exploration Systems Interim Strategy- Craig Steidle, NASA/Associate Administrator for Exploration System, August 2004**
- **Research and Technology Development**

  Focused Prioritized Requirements

  - **Support NASA's requirements for near-term and future exploration missions**
  - **To use the moon as a test bed for future human and robotic exploration**
  - **Employ Research and Technology Development programs to address key gaps in performance or affordability with near-term capability development**

  Space Resource Utilization

  - **Long-term goal to advance and mature technologies and systems that can extract, process, and refine materials for lunar and Martians resources**

- **Exploration Systems Interim Strategy-Craig Steidle, NASA/Associate Administrator for Exploration System, August 2004 (continued)**
- **Research and Technology Development (continued)**
  - ***Advanced Space Technology Research***
  - **Advanced Materials and Structural Concepts**
  - ***Focused Research and Development***
  - **Human System Research and Development**
  - **Crew Health**
  - **Radiation**
  - **Advanced Life Support**
  - **Fission Power Systems**

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- **Exploration Systems Interim Strategy-Craig Steidle, NASA/Associate Administrator for Exploration System, August 2004 (continued)**
- **Research and Technology Development (continued)**
  - ***Novel Modes of Participation***
  - **Innovative Technology Transfer Partnership**
  - **Research Partnership Centers**

    Research focus areas include in-space testing,power, propulsion, materials, in-situ resource utilization, imaging, communication, electronics, medical technologies, biotechnology, radiation mitigation, robotics, and sensors

  - **University Research, Engineering, and Technology Institutes**

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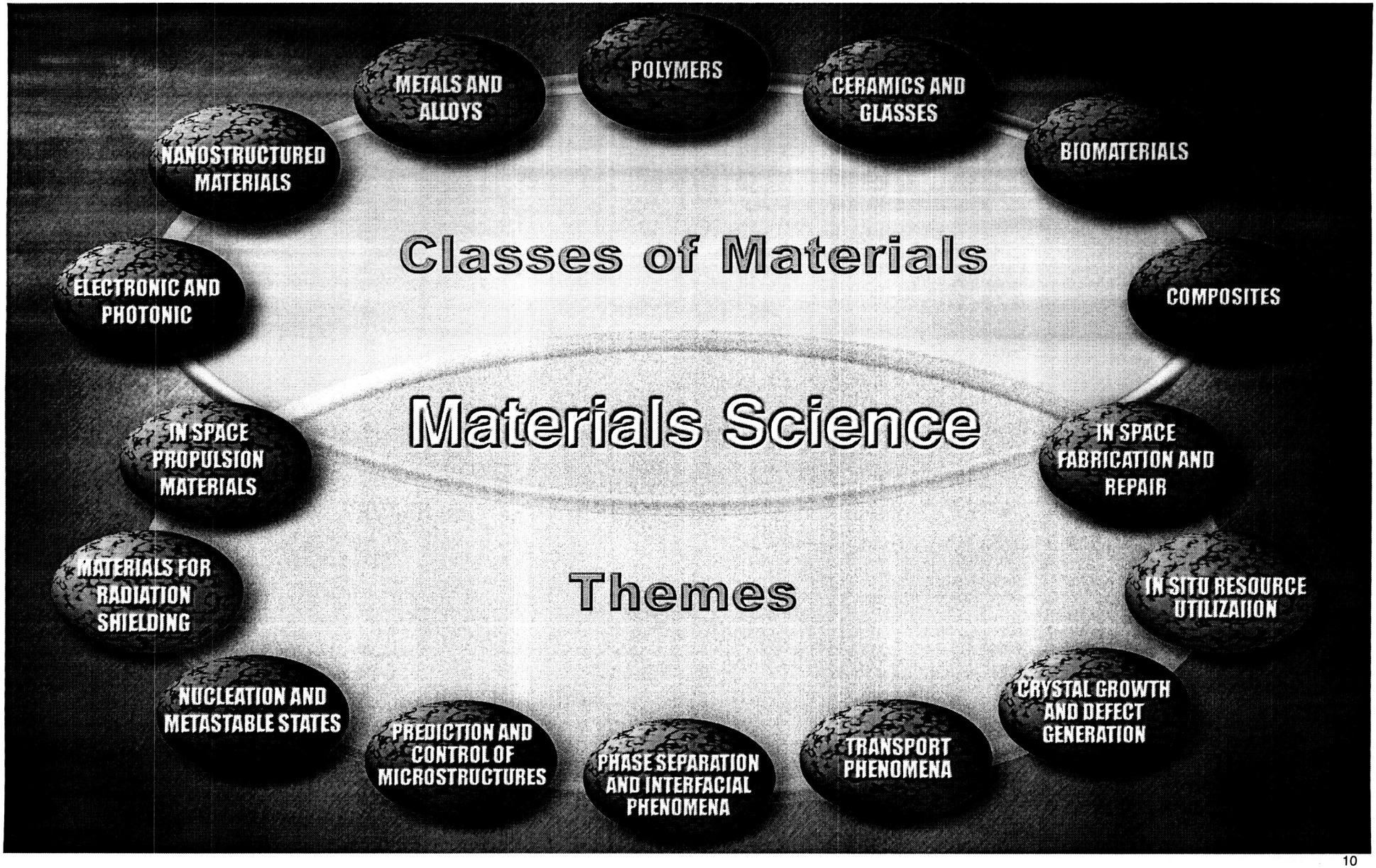
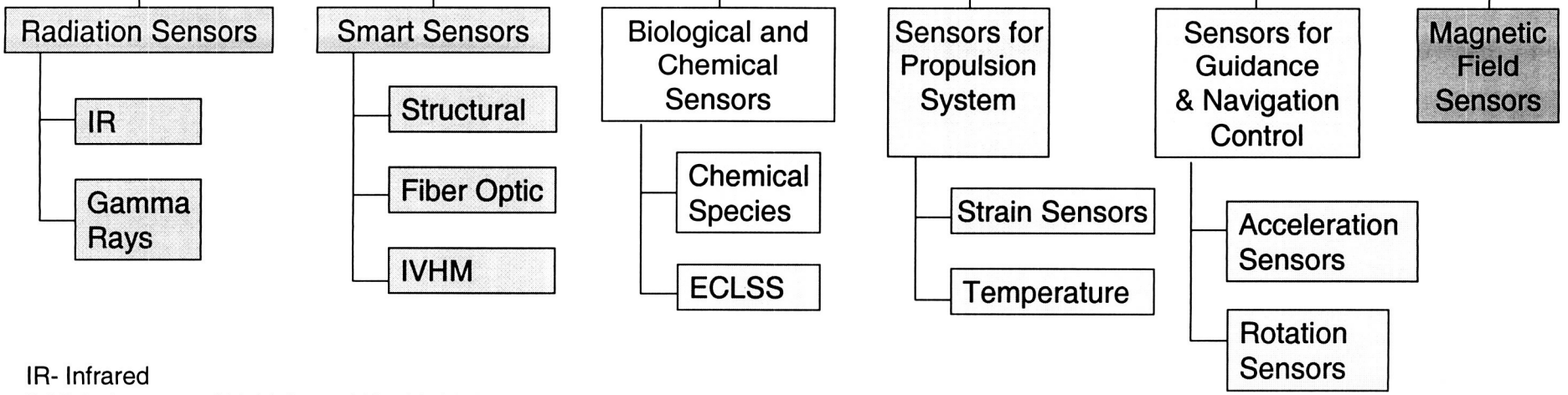


Different Sensors for NASA Exploration Missions



IR- Infrared
IVHM - Integrated Vehicle and Health Maintenance
ECLSS - Environmental Control and Life Support System

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- ***Variety of Sensors are required for Space Exploration Systems***
- **Integrated Vehicle Health Management (IVHM)**
  - Strain
  - Cracks
  - Temperature
  - Radiation
  - Fuel injector sensors (Hydrogen and oxygen resistant materials)
- **Environmental Control and Life Support Systems (ECLSS)**
  - Chemical sensors
  - Biosensors
  - Temperature sensors
  - Pressure sensors
  - Trace gas sensors
  - Dosimeters

- ***Variety of Sensors are required for the Space Exploration Systems (continued)***

- **Guidance Navigation and Control (GN&C)**
  - Acceleration sensors
  - Rotation sensors
- **Propulsion**
  - Fuel
  - Combustion
  - Combustion products
  - Fuel/oxidant ratio
  - Feed-back control
- **Exploration**
  - Biosensors
  - Dosimeters
  - Compact, 'handy' spectrophotometers (IR, FIR, etc.)
- **Radiation Sensors**

• *Variety of Sensors are required for the following Exploration Systems (continued)*

▪ *New Detector Materials for High-Energy Astrophysics*

Goal: To provide space-borne detectors with large area and high efficiency

Requirements: Dense, high-Z, thick (~cm) detectors with large areas (~sq. meter)

Actively pursuing both scintillation and semiconductor (room-temp.) materials

- Scintillation detectors are read out with arrays of PMTs or silicon photodetectors
- Semiconductor detectors are read out by low-noise amplifiers
- Substantial on-board signal conditioning and data processing before transmission to the ground

NASA has had a long history of significant advances in high-energy astrophysics by many missions, using the latest detector technology

To continue these advances, new detector materials and the accompanying instrumentation are needed

- *Variety of Sensors are required for the following Exploration Systems (continued)*
- ***Smart Radiation Sensors***
  - Polymer composites with Embedded Fiber-optic Bragg Grating
- High Performance Nano-particle based Chemical Sensors
  - Wide band semi-conductive metal oxide materials
  - Thick and thin film nano-composite materials
- Chemical Sensors
  - Smart Chemical sensors based on planar optical waveguide integrated with photo-elastic polymers
  - Micro-electro-mechanical-systems technology using polymers
  - Development of temperature and humidity sensors
  - Rare-earth powders/doped glasses/fibers
  - Other materials

- *Variety of Sensors are required for the following Exploration Systems (continued)*

- Sensor System for Effective Integrated Vehicle Health Monitoring
  - Required for diagnostics, prognostics, and risk mitigation of all vehicle systems to support replacement of failed or near failure components
  - To greatly reduce ground maintenance costs
  - Assess structural strain, fatigue, and failure
  - To enhance the effectiveness and safety of the mission
  - Low weight/volume, spatial resolution
  - Types of Sensors
    - All types of optical sensors
    - Fiber-optic Bragg Grating embedded sensor systems
    - Triboluminescent Material Sensors

- *Variety of Sensors are required for the following Exploration Systems (continued)*

- ***Infrared Sensors***
  - **Sensors for 3-5 and 8-14 and 15-60 micron wavelength ranges**
  - **Low cost un-cooled infrared sensors**
  - **High sensitivity broadband infrared sensors for satellite-based systems**
  - **Soil studies**
- ***Magnetic Field Sensors***
  - **New materials to improve the sensitivity of Giant Magnetoresistance (GMR) Tunneling Magneto-resistance (TMR) Sensors**
  - **Increase in resistance change with magnetic field using amorphous alloys**
- ***Sensors for Propulsion System***
  - **High temperature and strain sensors Integrated with material**
  - **Chemical and gas sensors**
  - **Impact Sensors**

- *Variety of Sensors are required for the following Exploration Systems (continued)*

- *Sensors for Ionizing Space Environment*
  - Radiation resistant polymer based photo-detectors (PPDs)
    - Incorporation of Quantum Dots into polymer matrix
    - Increase in radiation resistance
  - Development of InP and CdSe or other QD PPDs operating at near - IR wavelengths
  - Development of new and emerging QD materials for improving PPD performance