Goddard Space Flight Center

Developing a Software Technology Roadmap to Enable NASA's 21st Century Missions

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Agenda

Goddard Space Flight Center

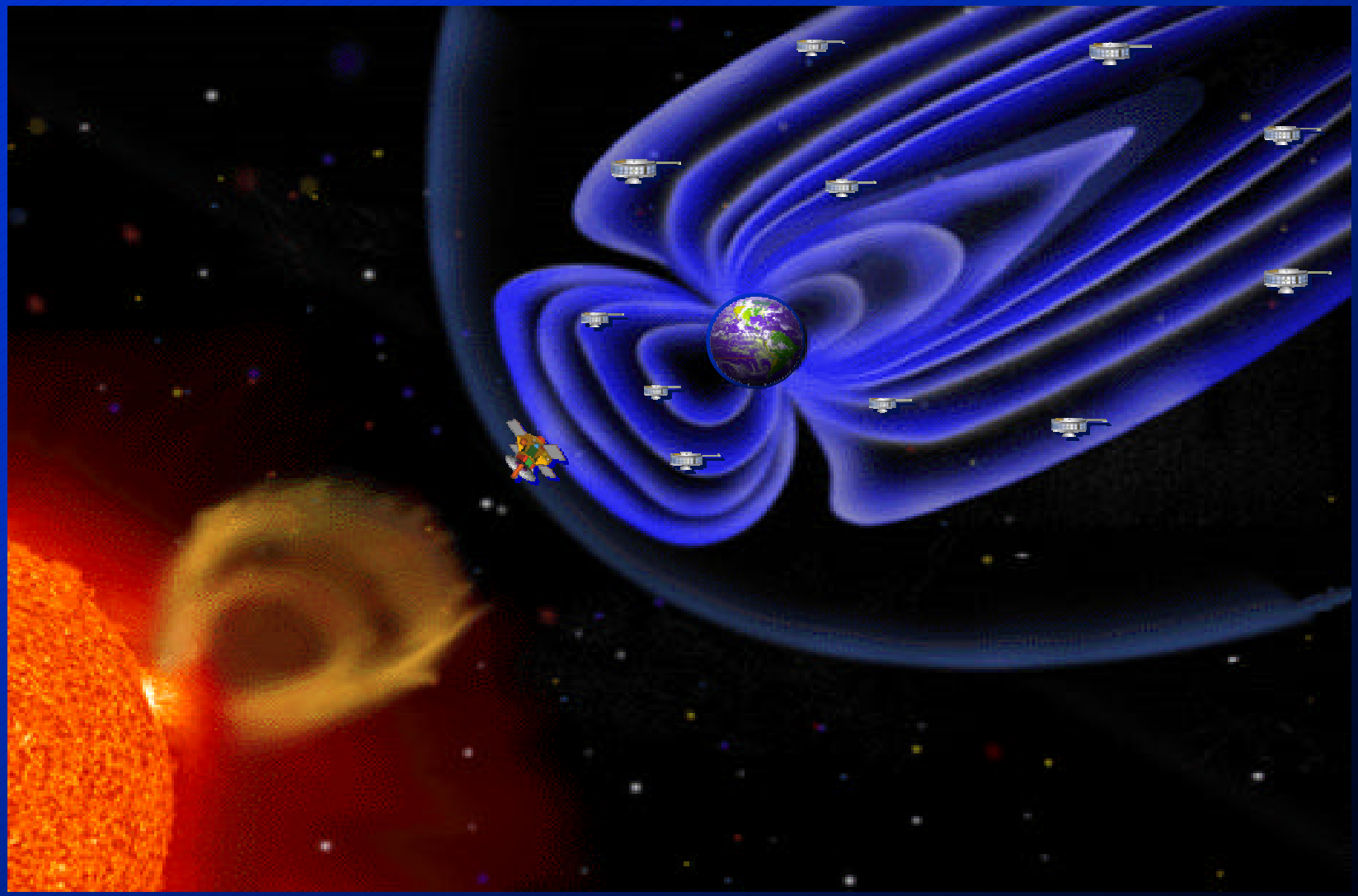
- GSFC Space Missions of the 21st Century
- Information Technology Challenges
- Components of a GSFC Solution
- Conclusion

NASA's Technology Program Challenges

Our operating environment has changed significantly...

- **NASA is more openly "competing" technology funds**
- **Shift from "technology derived from missions" to "missions enabled by technology"**
- **NASA has established a goal to significantly decrease mission formulation and implementation time**
- **Shift focus of in-house work from implementation of current flight missions to development of advanced technologies for future missions**
- **Funding and Validation Opportunities for mid-TRL technologies**
- **Increased focus on efficiency, results, and ROI**
- **"Internet" time scale for technologies and technology development**

Advanced Space Systems (2000 - 2010)



Constellations for Distributed Multipoint Sensing

Space Science Enterprise- Sun Earth Connection Constellation Missions Roadmap

Near-term Missions:
- Magnetospheric Multiscale
- Geospace Electrodynamic Connections

Mid-term Missions:
- Magnetospheric Constellation
- Inner Magnetospheric Constellation
- Dayside Boundary Constellation
- Global ITM Constellation

Far-term Missions:
- Solar Flotilla
- Inner Heliospheric Constellation
- Outer Heliospheric Radio Imager
- Planetary Constellations

Revolutionize the multi-point remote and in-situ scientific investigations.

NMP ST5 (Nanosat Constellation Trailblazer) Project Concept

Technologies to be Validated:

Miniature Spacecraft

- Systems Design Integration and Test Technologies

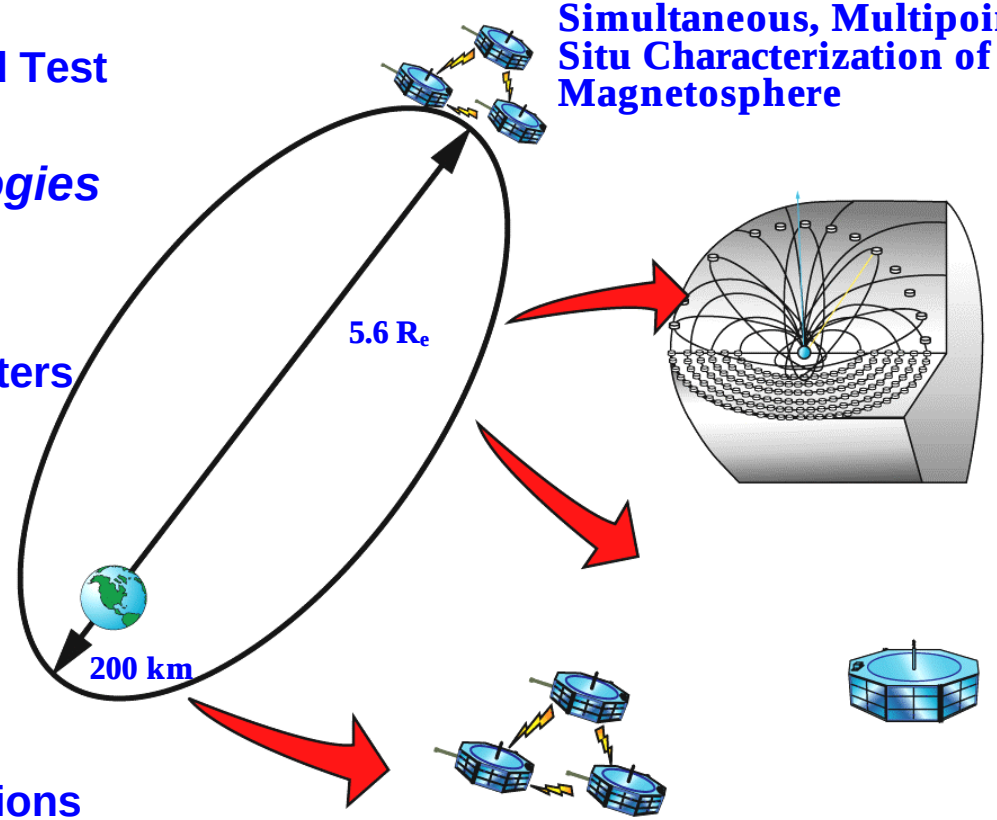
Candidate Spacecraft Technologies

- 5V bus - 1/4V logic
- Li-Ion batteries
- Miniature Transponder & Thrusters
- Multi-functional structure

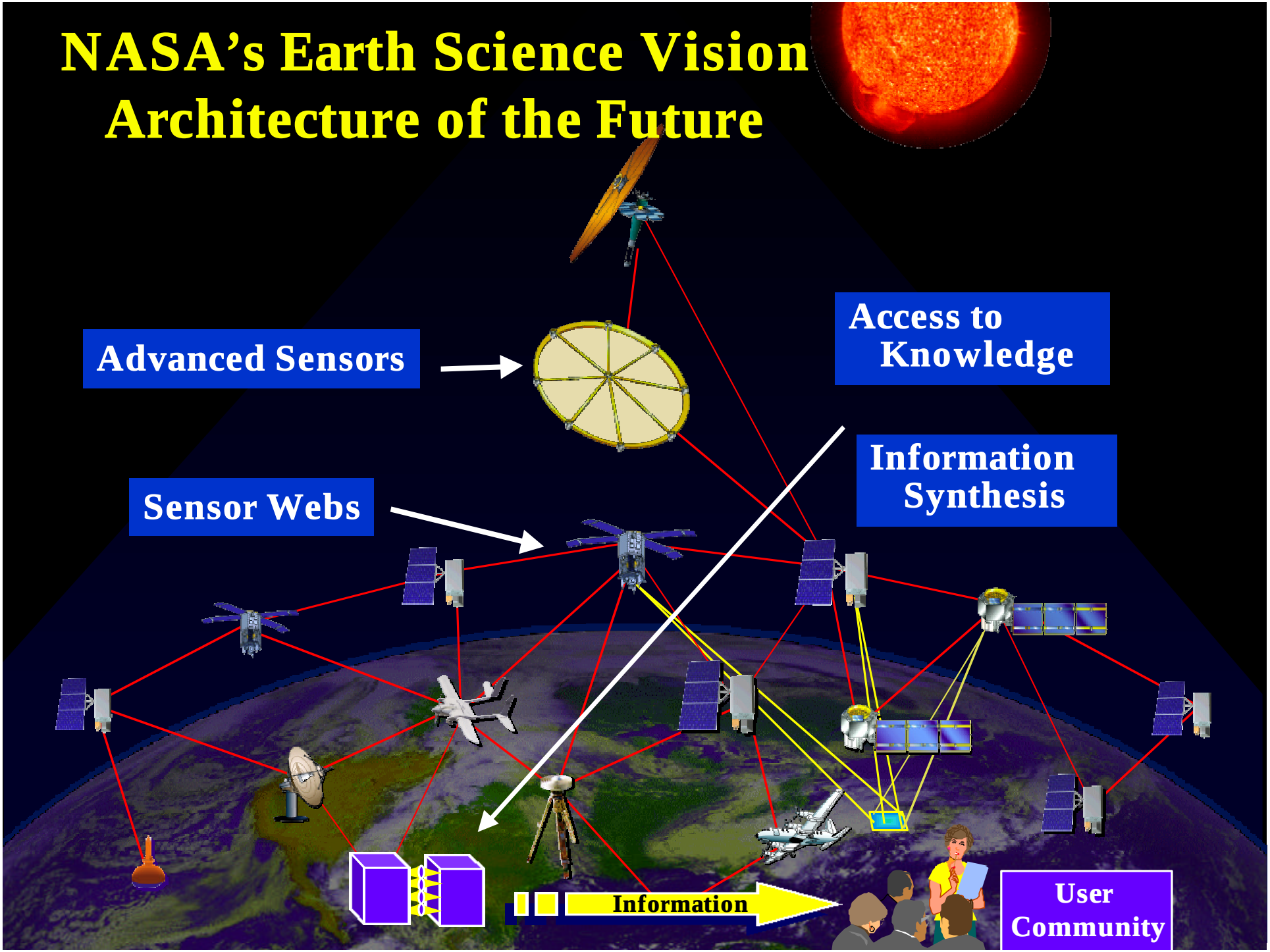
Constellation Control, Coordination, and Operations Architecture

- Ground system autonomy
- Relative ranging
- Intra-constellation communications

Constellation Class Missions
Simultaneous, Multipoint, In-Situ Characterization of the Magnetosphere



NASA's Earth Science Vision Architecture of the Future



Summary of GSFC Space Missions of the 21st Century

- These missions are characterized by
  - constellations of miniaturized spacecraft
  - advanced sensors & instrumentation
  - innovative communication schemes
  - increased levels of automation
  - onboard processing
  - mission autonomy

- Programmatically, these missions will be noted for dramatically decreased budgets and mission development lifecycles.

- The process by which we conceptualize, research, develop, validate, and infuse technologies must be dramatically improved and accelerated.

To achieve these future challenges, advanced technology–especially IT –will provide a critical role for the formulation, implementation and execution of these missions.

Future Mission Information Technology Needs

- Advanced on-orbit data processing/compression techniques
- Advanced Information Systems architectures
- Autonomy technologies
- Large-scale modeling/simulation/image visualization
- Large-scale data management (archival, retrieval, transportation, transformation)
- Advanced communications
- Next Generation Software engineering
- Advanced Scientific Tools and Systems
- Advanced Human/Computer Interface (HCI) Technologies

Significance of IT to NASA's Future

"When people think of space, they think of rocket plumes and the Space Shuttle, but <u>the future of space is information technology</u>. We must develop a virtual presence, in space, on planets, in aircraft and spacecraft."

- Daniel S. Goldin, NASA Administrator

Components of a GSFC Solution

- Community Building
  - Friends of IS, IT- Federation,
  - Cross-Center Alliance - GSFC, JPL, JSC, Ames
- Maintaining and enhancing IS core competency
- IT Infrastructure Investments
- Strong IT R&D Program and Technology Infusion Plan
  - University collaborations
  - Seed funding for IT research initiatives
  - Term appointments of IT industry/academic leaders
- Create a Mission Software Process
- Computer Science/Information Systems Professional Track and Training Curriculum
- GSFC IS Strategic Plan and Implementation
- IT Roadmaps

GSFC Information Science &Technology (IS&T) Mission

Our mission is to innovate and exploit rapid changes in information science and technology to strengthen GSFC's leadership in NASA's Earth and space science.

GIST Mission Themes

Science has no future without IS&T in today's environment

Move IS&T from a perceived mission cost which must be controlled to a valuable and critical mission resource to be capitalized upon

Unify IS&T community to magnify GSFCs ability to achieve its mission

Provide IS&T leadership, integrated planning and technical expertise to capture and implement GSFC's missions and programs

Create an environment that fosters IS&T "breakthroughs"

Strengthen critical IS&T core competencies to establish competitive advantage

Research, invent, and infuse innovative technology

Facilitate low-cost, robust IS&T systems and services to meet or enhance mission requirements

Leverage IS&T's potential to provide opportunities and sharing of knowledge with the public

ISC Strategic Technology Focus Areas
Objectives and Visions

The ISC Strategic Plan is based on 3 major technology focus areas:

1. <u>Rapid Mission Formulation, Design & Execution</u>:
Enabling revolutionary mission concepts through rapid mission formulation, implementation and execution
Vision: Mission scientists and engineers seamlessly evolve science objectives into mission concepts through virtual model to an operational science system

2. <u>End-to-End System Autonomy:</u>
Enabling effortless science collection through autonomous mission systems

Vision: Mission scientists operate, maintain and reconfigure systems from anywhere in order to optimize an on-board observation and maximize science return

3. <u>Advanced Scientific Analysis Tools & Data Systems:</u>
Enabling science knowledge discovery through seamless and transparent access to information
Vision: Academic and research community has continuous and transparent access to data and information for scientific research

ISC Strategic Technology Capability Roadmap*

(Key Capabilities for future Mission Information Systems)

ISC Technology Focus Area	*Near (2003)*	*Mid (2006)*	*Far (2010)*
Rapid Mission Formulation, Design, and Execution	•Low Cost, Internet-based, Secure Distributed Computing Architectures. •Data interface and distribution framework for Subsystem Design and Analysis Tools •System-level, Model-based design	•Collaborative Design & Operations Environments. •Integrated Simulation and Design Systems	•Immersive Virtual Environments for Collaborative Engineering and Science
End-to-End System Autonomy	•Ground-based, Goal Driven Commanding •Science Feature Identification •Automated Spacecraft Health & Safety •Missions operate as IP nodes on the net	•On-board, Goal Driven Commanding drives Reactive Mission Execution •Constellation Management •Mission operates as mobile-IP nodes on the net	•Multi-mission collaboration for Dynamic Science Agenda •Mission operate as mobile-routering nodes on the net
Advanced Scientific Analysis Tools & Data Systems	•User selectable subscription services for Data Distibution •Feature Extraction and Identification Tools (Data Mining & Knowledge Capture) •Platform Independent Visualization & Analysis ToolsReal-time Updates to Science Models •Interface and Distribution Framework for Science Data & Science Models	•Multi-S/C (including Constellations) Data Processing, Fusion & Analysis •Advanced Information Prospecting and Capture Tools •Collaborative Visualization and Analysis tools •Collaborative (Multi-Source) Updates to Science Models	•Seamless, transparent access to distributed data, info. and knowledge ("Virtual Data Communities") •Knowledge Extraction using Natural Language Interface in an Immersive Environment

* v1.2 - 9/13/99

Conclusions

- Exciting and challenging mission concepts on the horizon for NASA & GSFC
- Significant technology research, development, and application required
- Recognition of importance of IT strategic planning to achieve future science mission objectives
- Significant mission dependency on quality software

Challenge

- Routinely produce “no surprise” software
  - 100% accurate software estimation
  - 100% on schedule and within budget
  - 100% bug-free software

plus

- Significantly reduce software development cycle and cost

plus

- Increase the usability of software systems to maximize the human/computer effectiveness (i.e., human computer interaction)