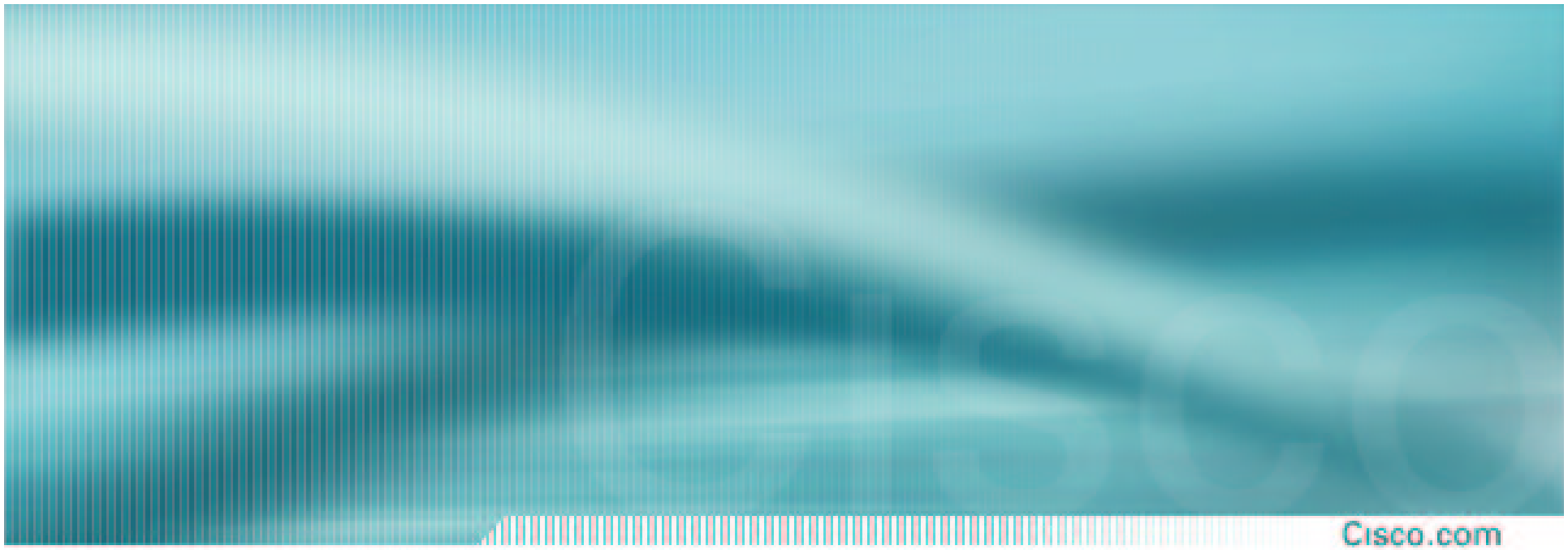


Internet 3 –Internet Protocol in Space

ITU – Workshop on Satellites in IP and Multimedia

Hugh Arif

Space Initiatives Manager

Cisco Global Defense & Space Group

December 10, 2002

Agenda

- Introduction – Cisco Global Defense & Space Group
- Internet 3 – Vision for “IP in Space”
- Why IP in Space?
- Who wants to do it?
- How to do it?
- Benefits
- Challenges
- Cisco’s involvement in IP in Space
- Conclusions and Future steps

Introduction – Cisco GDSG

- Vertical defense and space market – US $1.4 Trillion over 10 years
- Addresses space segment, space/ground network, applications
- Supports missions and programs of global space community
- Leverage Cisco's terrestrial technologies into space
- Technology infusement, new products and service development
- Partnerships with civilian, commercial, intel and defense space
- 54 members now, US $2.5 B annual revenue projections in 4 years

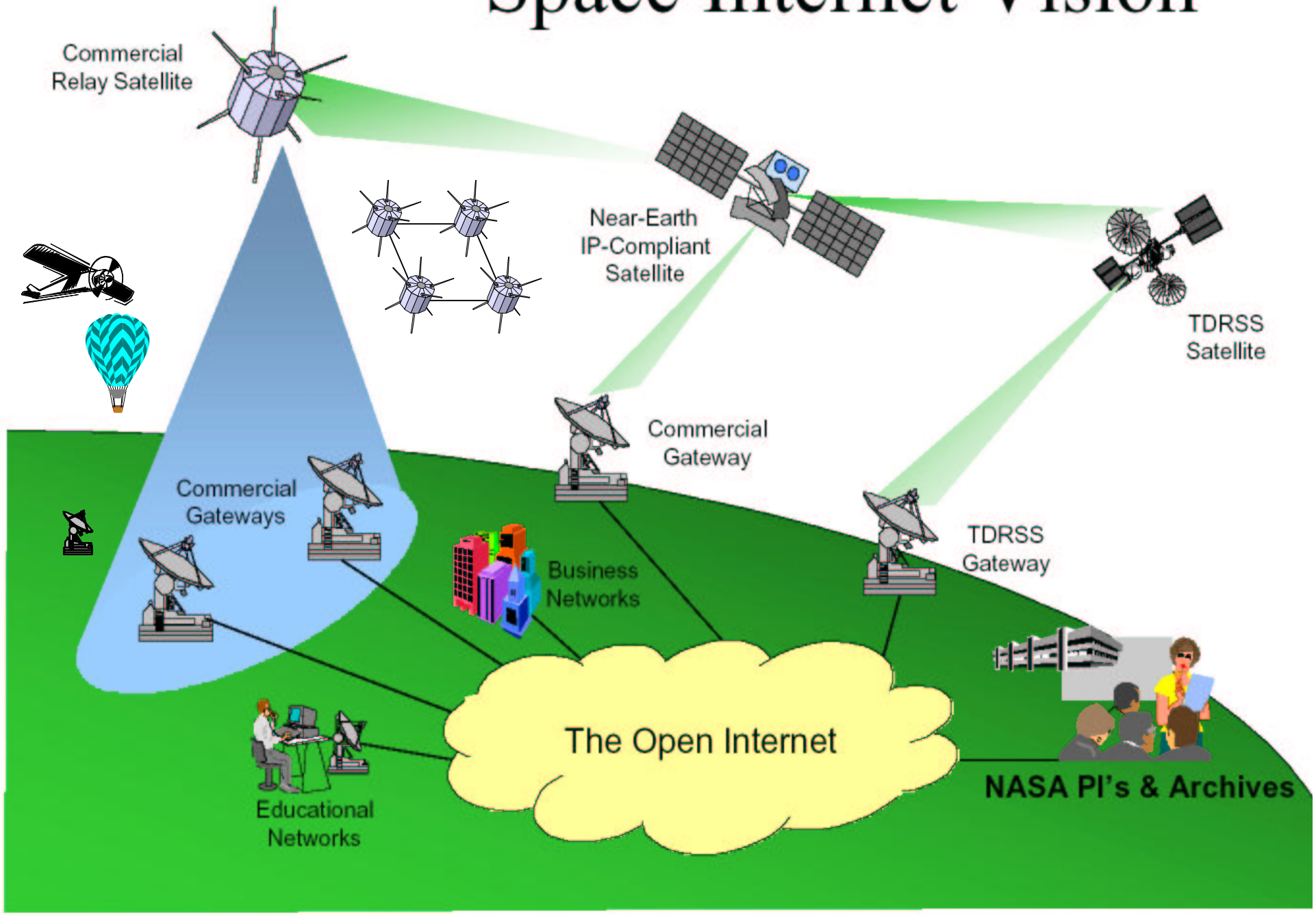
"Change the way people think about the space business"

Internet 3 – Vision for “IP in Space”

Cisco.com

- **A new, integrated space operations architecture based on the Internet Protocol (IP)**
- **Every satellite a “node on the Internet”**
- **Both primary satellite bus and payloads**
- **Seamless interoperability between space and ground systems**
- **Extension of IP-converged Voice, Video and Data architecture from terrestrial into space**

Space Internet Vision



Vision for IP in Space

- 70% KOTS Solution for Spacecraft Bus & Payload Architectures
- Space Standards
- Space/Ground Integration
- Internet 3
  - ✓ Constellation cross links
  - ✓ Constellation-to-Constellation
  - ✓ Ground infrastructure expansion
  - ✓ Remote Access Availability
- Ground Enhancement
- Cost savings
- Market enabler

Why IP in Space?

Cisco.com

Legacy/Current

- "Closed standards" solutions
- Proprietary designs
- Fixed solutions
- Higher costs
- Long schedules
- Limited access
- Complex GSE/ops
- Non-interoperable

Future/Vision

- "Open standards" solutions
- Defined interfaces
- Modular designs - COTS
- Lower costs
- Shorter schedules
- Easier access
- Commercial operations
- Interoperable/mobile

Who wants to do it? – Example: NASA's 2020 Vision

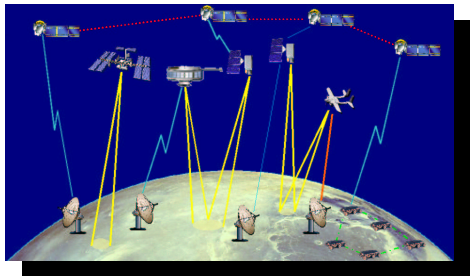
Cisco.com

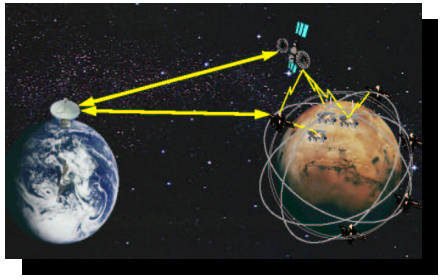
Objective

"Enable broad, continuous presence and coverage for high rate data delivery from ground-, air-, and space-based assets directly to the users."

Performance Goal: Develop and demonstrate innovative technology products for space data delivery enabling high data rates, broad coverage, internet-like data access that will vastly expand the reach of space and earth science…

Performance Goal: Develop distributed communication architectures, networks, and communications technologies to provide broad coverage and intelligent-based real time data delivery from Air, Earth, and Space and to obtain and distribute information and knowledge throughout the universe directly to the user.





Example: NASA Space Communications Program

Technology Development:

- High Power, High Efficiency Power Transmitters
- Low Mass Power Efficient Phased Arrays
- Optical Communication Technologies
- Space Network Technologies and Efficient Protocols
- Miniature Comm./Sensor Modules

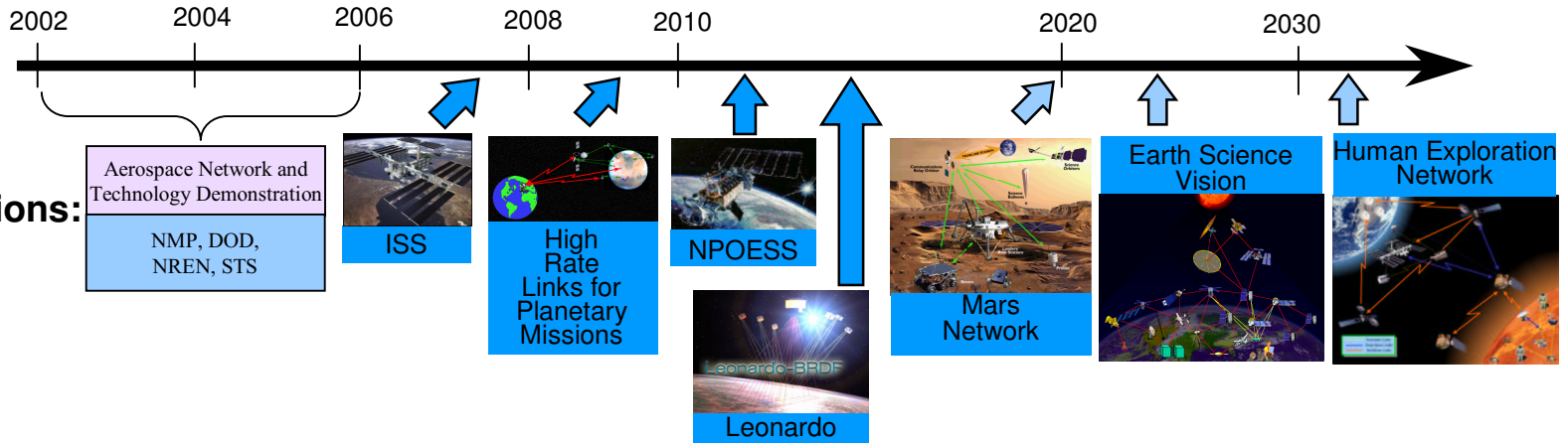
- 10 Gbit-Rate Comm. Systems
- On-Board Processing
- Low Cost, Miniature, Low Power Integrated Components
- Ad-Hoc Networks for Multiple Spacecrafts
- Reconfigurable Antennas

- Seamless High Data Rate Information Delivery
- Intelligent, Ad-Hoc User-Centric Communication Networks
- Communication Technologies for Multiple Spacecraft Networks Connected to Deep Space Backbone

Capabilities:

Point-to-Point Communications | Point-to-Multipoint Communications | Autonomous, Ad-Hoc Multiple Comm.

Applications/Missions:



Impacts (TRL 3-6):

- 4 times the data rate
- External wireless sensor network

- 4 times the data rate

Enable Inter-Spacecraft Networks

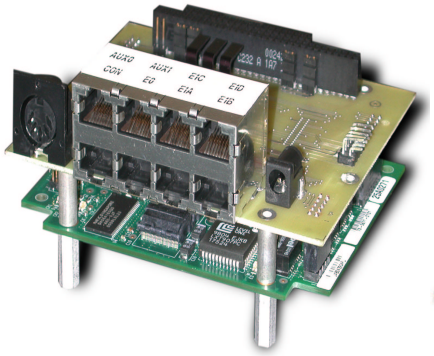
- 10 times the data rate

- 10 times the data rate
- Common interfaces
- Distributed Communication networks

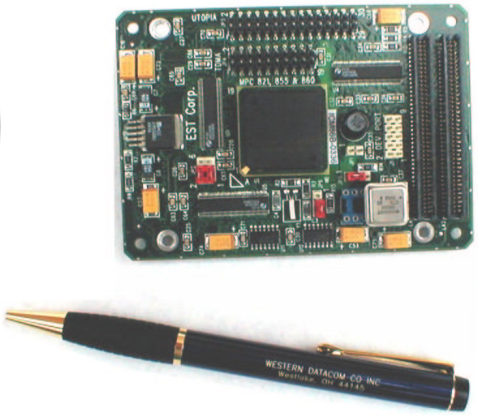
How to do it? Space Internet Program

Cisco.com

- Spacecraft network simulation and emulation
- Mobile routing test bed – Cisco 3251
- "Virtual" mission operations test bed
- IP characterization for space
- Spacecraft hardware (NIC, LAN, Router) development

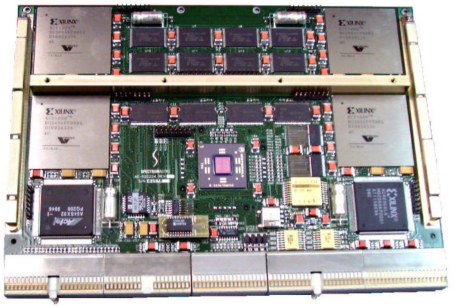


Mobile Access Router Cisco 3251



Western DataComm KIV212 Encryptor

ITT Lower Power Transceiver



Spectrum-Astro NIC/Hub

Benefits of IP in Space

- Reductions in Costs and Schedule
- OBP has advantage of signal regeneration (+3dB)
- Robust, Fault-Tolerant Architecture
- Higher Speed Communications
- Seamless Internet-like End-to-End Connectivity
    - •Ground-to-Space
    - •Subsystem-to-Subsystem Across the Spacecraft
    - •Spacecraft-to-Spacecraft in Formation Flying Constellations

Benefits of IP in Space

- Satellite Vendors
  - Standardizes satellite network interfaces
  - Simplifies bus harness and weight
  - New ways for interface verifications/system checkouts
  - Allows early software dev using non-flight COTS equipment.
  - Reduce time to design, I&T satellites
- Satellite Payload Users - Enables true Telescience
- Survivable satellite command and control / remote data collection
- Interoperability
- Data mining

Challenges

- Network security.
  - An issue for both open and closed networks.
- Need for flight validation.
  - Who will fly unproven technology?
- Noisy links/Doppler.
  - Link errors versus simple network congestion.
- Limited bandwidth.
  - Contention on a shared medium.
  - Protocol overhead.
- Highly asymmetric data paths and long path delays (GEO+).
  - IP is not just TCP/IP. IP is a suite of protocols…

Cisco's involvement in IP in Space

- Mobile Router testing on ships using satellite
- SSTL –Disaster Monitoring Constellation
- NASA GSFC Gigabit Ethernet NIC - SDO
- STS/ISS Demo using Cisco 3251
- NASA GRC Space Comm. Program
- ISS Space Comm. System Upgrade
- TCP/IP enhancement for satellite
- Router/IDU integration?
- New Ka band DVB-RCS/DOCSIS networks

SSTL DMC Cisco 3251 Integration

- SSTL DMC Cisco 3251 integration opportunity to fly COTS router in space as fully functional unit
- WHY?
  - The space industry does not accept adoption of new flight technology until proven
  - Usually done by ESA/NASA first, then by MOD/DOD, and finally commercial sectors adopt or accept the new technology as a viable option for future space projects
- CONOPS for Cisco 3251: all mission and housekeeping data will be transmitted and received via the IP link

SSTL DMC Cisco 3251 Integration

- Limited to only four passes per day - due to power restraints onboard the DMC satellite
  - satellite has a total power budget of 60 watts and the Cisco 3251 draws 10
- Router will be powered up just prior to ground station visibility and then powered off after the satellite pass has occurred

SSTL Project Photographs

SSTL DMC Cisco 3251 Integration

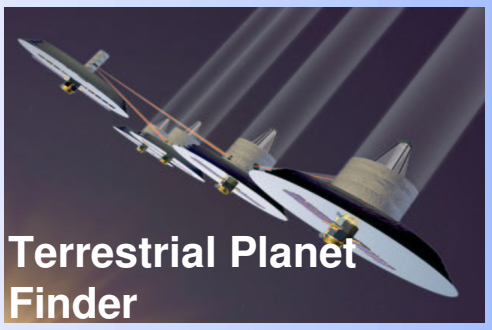
- Integration of the Cisco 3251 required several harness modifications as well as the development of an interface to other onboard devices
- Environmental testing is currently scheduled early December
- NASA Glenn will provide the CONUS based ground station, providing a gateway to the onboard router via the internet
- NASA Glenn will lead all testing efforts, link analysis and performance measurements

SSTL Conclusion

- Integration of the Cisco 3251 onboard the DMC satellite is a major milestone for the space industry.
- The members of the SSTL staff have performed integration in an extremely short timeline - requiring the juggling of very limited resources and a change to their entire testing and system preparation for the DMC satellite.
- This further defines SSTL as a pioneer in the adoption of COTS products for use in space.

www.vs.afrl.af.mil

Synthetic Aperture Radar
Distributed Cluster Formation



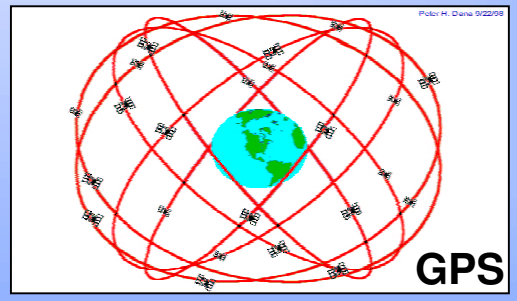
Optical Interferometer
Distributed Cluster Formation

http://climate.gsfc.nasa.gov/~wiscombe/LeoBRDF/LeoBRDFhome.html

Imaging IR Spectrometers
Distributed Formation

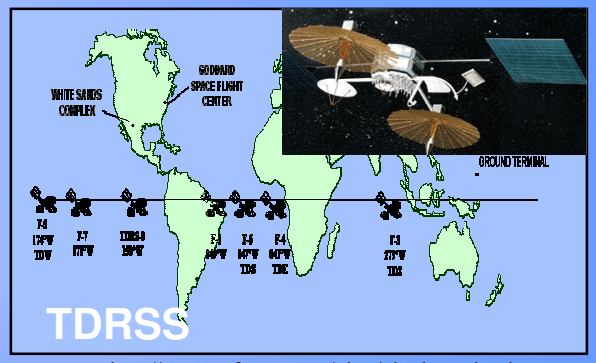
http://eo1.gsfc.nasa.gov/technology/formfly.html

Remote Sensing
Collaborative Formation



http://www.colorado.Edu/geography/gcraft/notes/gps/gps_f.html

Navigation
Formation



http://nmsp.gsfc.nasa.gov/tdrss/tdrsshome.html

Communications
Collaborative Constellation

Inter-Spacecraft Networks Will Enable These Types of Missions for NASA Enterprises

Conclusion and Future Steps

- Use of Internet Protocol in space offers significant advantages:
  - –Reduced cost and schedule
  - –Seamless interoperability
  - –Survivable / satellite command and control
  - –Virtual mission operations
- Space qualification of IP-compliant systems
- Network security
- At Cisco, we are very interested in future collaboration with the IP in Space community to both strengthen our products and facilitate the transfer of our technologies.
  - –Where do we go from here?

Contact information

Cisco Global Defense & Space Group

Space Initiatives Program

URL: www.cisco.com

Contact: Hugh Arif

Phone: 001-216-643-2511

E-mail: harif@cisco.com