International Telecommunication Union

NASA's IP-over-Satellite Technology Development

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Topics

- Briefing purpose
- Motivation
- Activities
- Results
- Issues
- Conclusions

Briefing Purpose

- To review NASA's development activities related to the use of Internet technologies…
  - For communication with a spacecraft (Mission Operations)
  - For communication via a spacecraft (SATCOM)

Background and Motivation

- Motivation for Internet communication *with* a spacecraft
  - Hypothesis 1: Internet/Intranet interfaces to spacecraft will simplify spacecraft bus and payload development and test
  - Hypothesis 2: Internet/Intranet access to spacecraft will reduce operations costs
  - Hypothesis 3: Internet/Intranet access to spacecraft will improve the quality, quantity, and timeliness of science data

Background and Motivation (Cont.)

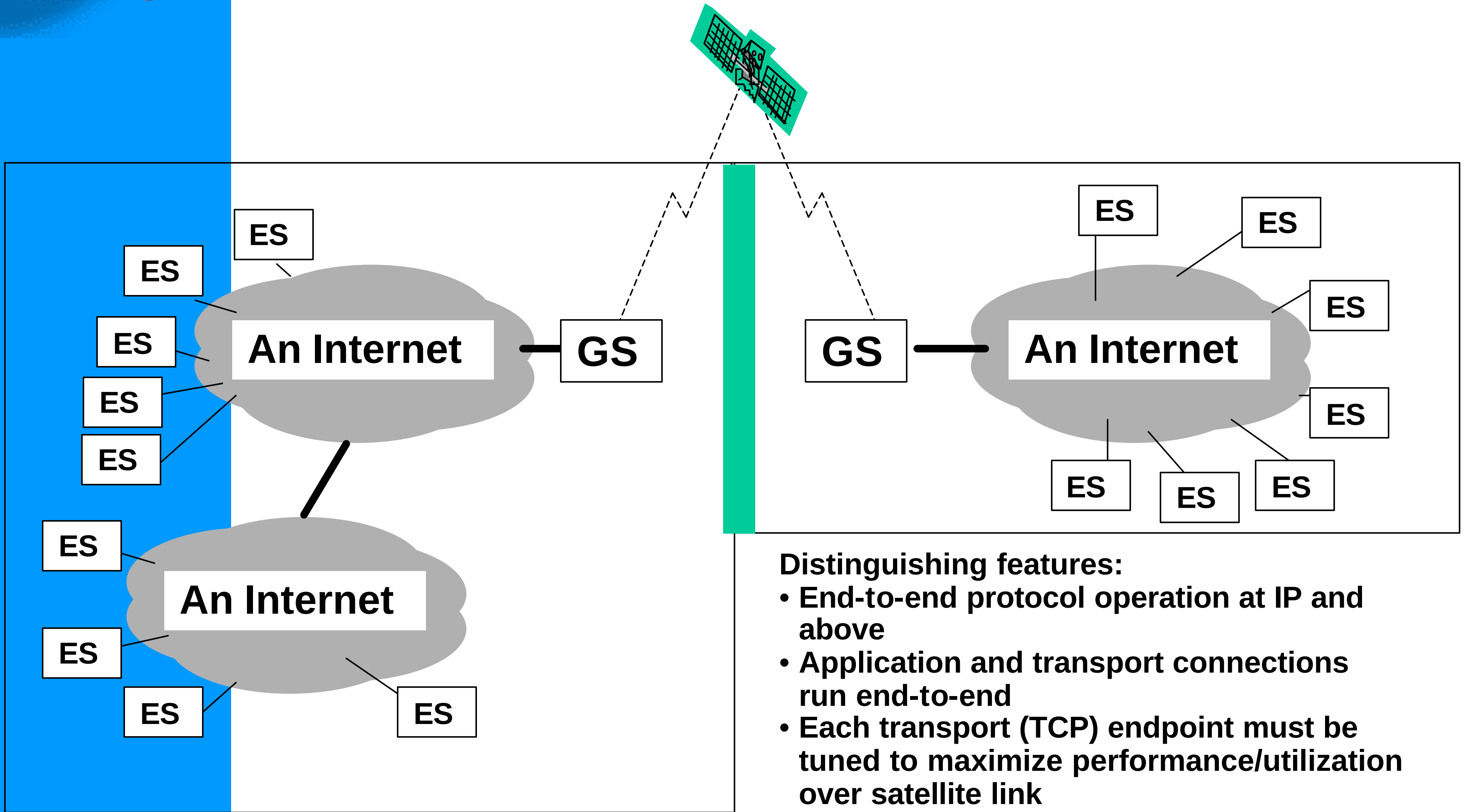
- Motivation for Internet communication *via* spacecraft
  - Satellite communications to remote regions
  - Exploitation of broadcast technology

NASA has been working to establish and optimize Internet communication *with* spacecraft and *via* spacecraft since 1992

Activities

- Architectural alternatives
- Protocol development and tuning
- Commercial product development
- Commercial product integration
- Operations concept development
- Testing / Demonstrations

Architectural Alternative: End-to-End Architecture

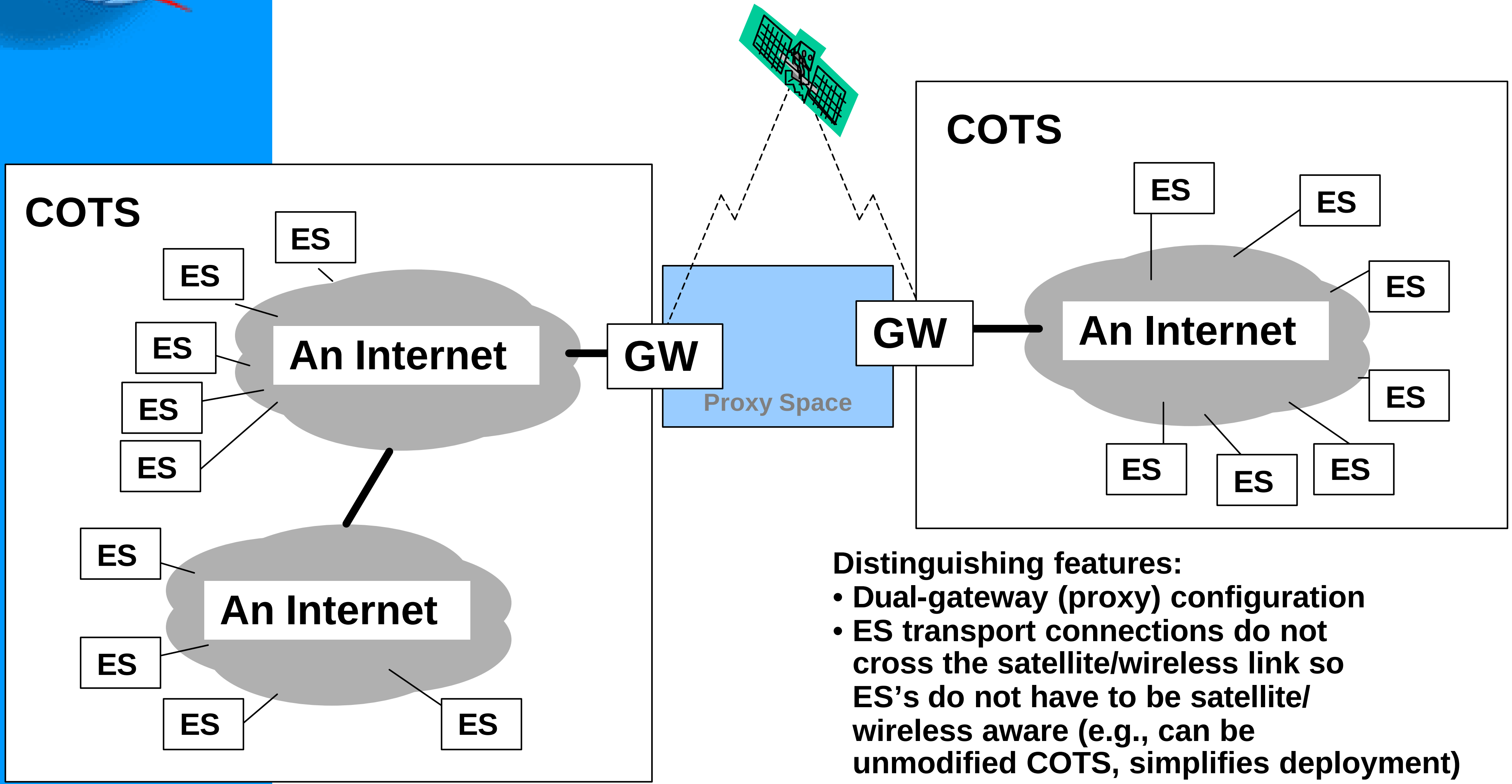


Distinguishing features:

- End-to-end protocol operation at IP and above
- Application and transport connections run end-to-end
- Each transport (TCP) endpoint must be tuned to maximize performance/utilization over satellite link
- Tunings for satellite link may be inappropriate for terrestrial links

ES = End System
GS = Ground Station

Architectural Alternative: Proxy-Based Architecture

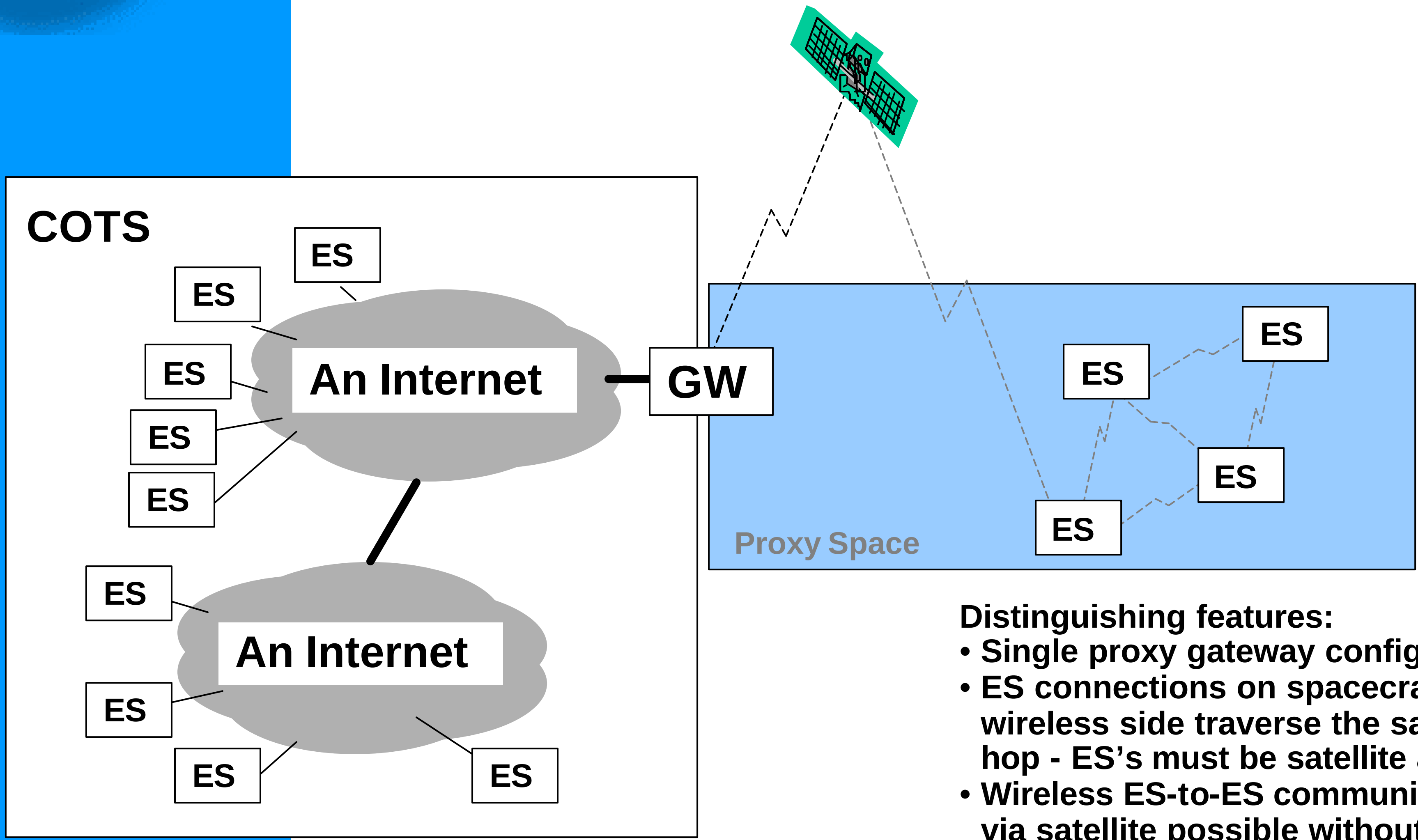


Distinguishing features:

- Dual-gateway (proxy) configuration
- ES transport connections do not cross the satellite/wireless link so ES's do not have to be satellite/ wireless aware (e.g., can be unmodified COTS, simplifies deployment)
- Application layer connections run end-to-end
- Security above transport or via trusted gateways

ES = End System
GW = Transport Layer Gateway (Proxy)

Architectural Alternative: Hybrid Proxy Architecture



ES = End System
GW = Transport Layer Gateway (Proxy)

Distinguishing features:

- Single proxy gateway configuration
- ES connections on spacecraft/ wireless side traverse the satellite hop - ES's must be satellite aware
- Wireless ES-to-ES communication via satellite possible without GW's
- Suitable for constellations or onboard use

Activities: Protocol Development and Tuning

- SCPS
  - FTP and TCP extensions
  - Security and network layer protocol definitions
  - Performance enhancing proxies
- ACTS
  - TCP tuning for end-to-end operation over high speed satellite channels
- Quality of Service
  - Integrated Services to SC (RSVP extensions for TCP proxy gateways)

Activities: Commercial Product Development Support

- SCPS Reference Implementation
  - End-system configuration
  - TCP Performance Enhancing Proxy (PEP) configuration
- CISCO Mobile Router
  - Enhancement to CISCO's Mobile IP software in a variety of their routers
- Consultative Committee for Space Data Systems (CCSDS) Device Driver for Linux
  - CCSDS TC/TM over Ethernet / serial

Activities: COTS/GOTS Product Integration

- Custom IP Router-to-Satellite Modem interface box (Ground-Station Router Interface Device)
  - Performs custom (not standard CCSDS/ISO) Reed-Solomon encoding/decoding of HDLC-framed space link traffic
- Linux PC/RS-422 to ITT/AES Low Power Transceiver (IP over HDLC)
  - Onboard analog of above, to be flown as part of CANDOS experiment on STS-107
- Internet Key Exchange (IKE) integrated with SCPS TCP Performance Enhancing Proxies

Activities: Operations Concept Development

- “FlatSAT” activities defined notional operations concepts for Internet interaction with spacecraft
  - Instrument to Command and Data Handling Subsystem
  - Onboard storage to ground (telemetry)
  - Mission Operations Center to Command and Data Handling
  - Instrument commanding
  - Spacecraft initiated communication

Activities: Testing and Demonstrations

- SATCOM Testing
  - ACTS OC-12 (622 Mbps) satellite testbed for testing and tuning of high-speed Internet-over-satellite products
  - SCPS SATCOM testing on M22 hosted by USAF Space and Missile Systems Command and over ACTS hosted by US Air Force Research Lab

Results to date

- Standards
  - ISO/CCSDS Space Link Extension service allows replacement of NASCOM custom 4800-bit block network with standard TCP/IP-based networks (underway)
  - ISO/CCSDS/MIL standards for SCPS protocols and enhancements
  - IETF Best Common Practice on TCP tuning (RFC 2488 / BCP 28)

Issues

- Benefits of Internet spacecraft operation over current practices need to be demonstrated/quantified
  - Reliance on automation *may* significantly reduce operations costs and increase flexibility
    - “Lights-out” control centers
    - Elimination of level zero processing

Issues (Cont.)

- Cost saving resulting from change must offset ROI of incumbent approach with acceptable risk
  - Is a below-IP hardware commanding capability (still) required? Not present on CHIPSAT; present with IP over CCSDS TC/TM
- Acceptance will require/cause cultural change
- Operations concepts and architecture for end-to-end Internet-based mission operations have not been well-articulated or agreed to by the mission operations community

Observations

- For communication *with* a satellite, to some extent, a technology looking for a need
  - Consistent with NASA Code-Y Strategy to shift from "technology derived from missions to missions enabled by technology"

Observations (Cont.)

- NASA's IP-in-space efforts have produced significant spin-off products
  - Benefit to SATCOM and mobile/wireless industries
  - Continued work with similar environments (SATCOM/mobile/wireless) can produce mature technologies for use when need arises

Conclusions

- For communicating *with* a satellite, NASA has technology waiting for mission requirements and operations culture to evolve
- For communicating *via* a satellite, NASA's technology contribution has been considerable
  - Is there a way for NASA's mainstream missions to benefit?

Conclusions (Cont.)

- Feedback requested: Is continued near-term investment in these technologies beneficial?
  - Should NASA continue to spend its research money here?

Support Slides

Activities: Protocol Development and Tuning (Cont.)

- Mobile IP Extensions
  - Registration acceleration (Ground station registers on behalf of all spacecraft endpoints)
  - Mobile router -- Mobile IP registration of a subnet router
- Quality of Service
  - Integrated Services to Spacecraft (RSVP extensions for TCP proxy gateways)

Activities: Testing and Demonstrations (Cont.)

- STRV 1b
  - FTP/TCP/SCPS-TP testing on UK Defence Research Agency Satellite
- Mobile Router
  - Field trial of mobile router using US Coast Guard ship, 802.11 and commercial satellite service

Activities: Testing and Demonstrations (Cont.)

- UoSAT-12
  - Internet stack testing on Surrey Satellite, including NTP, FTP, UDP, multicast file transfer (MDP)
- CANDOS
  - Shuttle payload to test Mobile IP to SC

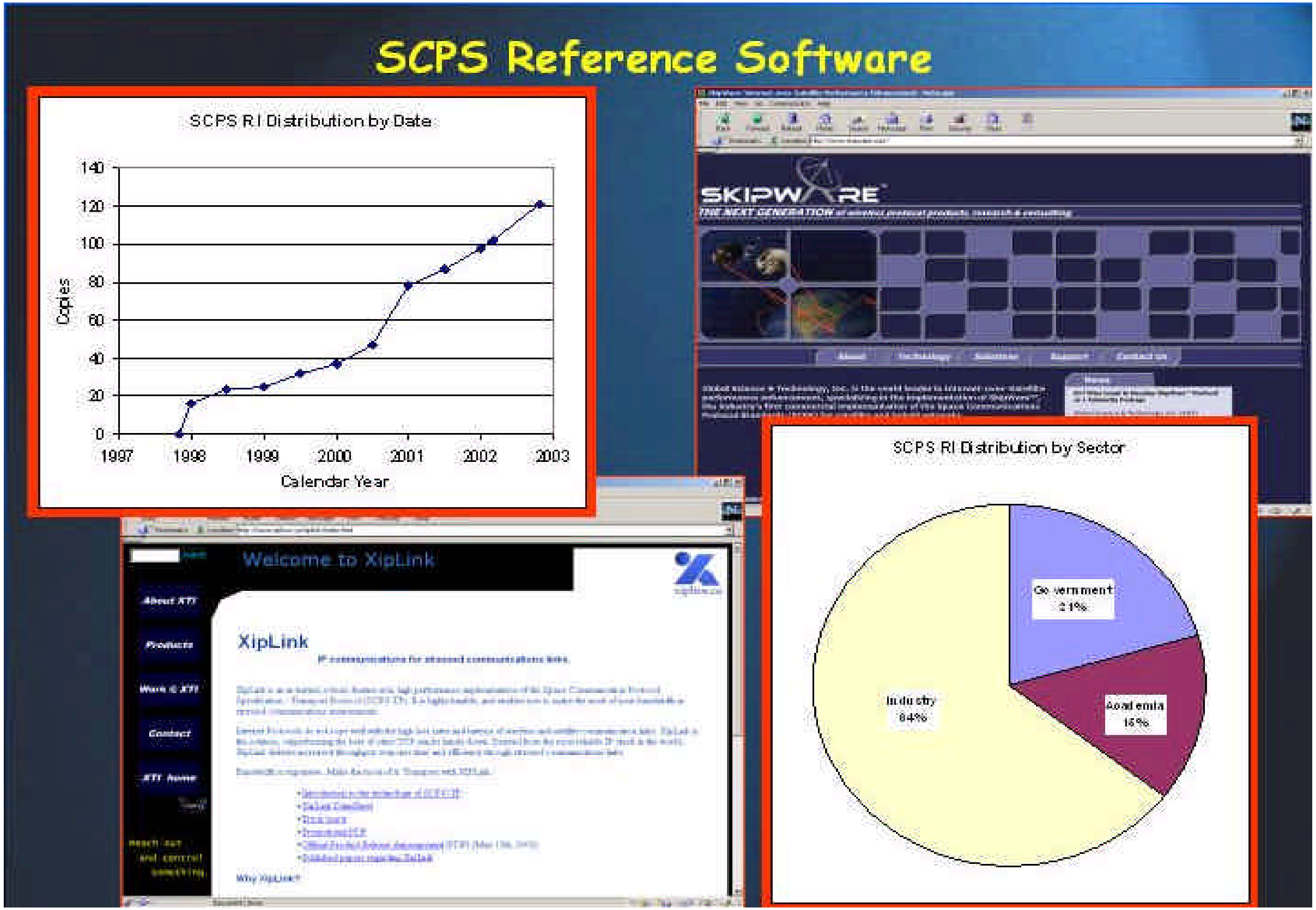
Results to date (Cont.)

- Products
  - Refinements to commercial Internet implementations for satellite paths resulting from ACTS testing
  - Open standard SCPS protocols and proxies
  - Proprietary CISCO Mobile Router
  - SkipWare and XipLink
- Interstellar Plasma Spectrometer mission (launch Dec 02)

Results to date (Cont.)

- Mission(s)
  - CHIPS/CHIPSat mission -- Internet-only spacecraft bus built by SpaceDev for UC-Berkeley Cosmic Hot

Results to date (Cont.)



Results to date (Cont.)