GSAW 2003

Session 3:

InterPlaNetary Internet

Scott Burleigh, JPL
Vint Cerf, WorldCom Inc.
Robert Durst, MITRE Corporation
Kevin Fall, Intel Research
Adrian Hooke, JPL
Keith Scott, MITRE Corporation
Leigh Torgerson, JPL
Howie Weiss, Sparta Inc.

04 March 2003

Session 3

"Interplanetary Internet"

Adrian Hooke
Jet Propulsion Laboratory

"Advanced Internet Technologies for Spacecraft TT&C"

Keith Scott
The MITRE Corporation

"CCSDS File Delivery Protocol in Delay-Tolerant Networking"

Scott Burleigh
NASA Jet Propulsion Laboratory

1970 | 1980 | 1990 | 2000

NASA Telemetry Standardization

"Packet" Spacecraft Telemetry and Telecommand

NASA/ESA Working Group

Basic Space/Ground Communications Standards for Space Missions

02 January, 1996
STRV-1b
IP address:
192.48.114.156

Consultative Committee for Space Data Systems (CCSDS)

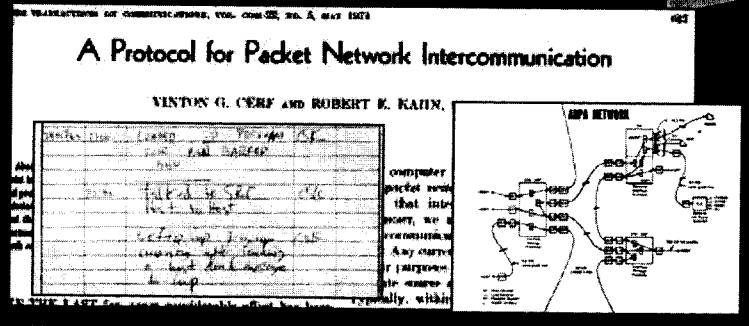
CCSDS Recommendation for Advanced Orbiting Systems

International Space Station

File Transfer: FTAM
Transport: TP4
Network: ISO 8473

Extension of the Terrestrial Internet into Space

Evolution of space standards


A Protocol for Packet Network Intercommunication

VINTON G. CERF AND ROBERT E. KAHN,

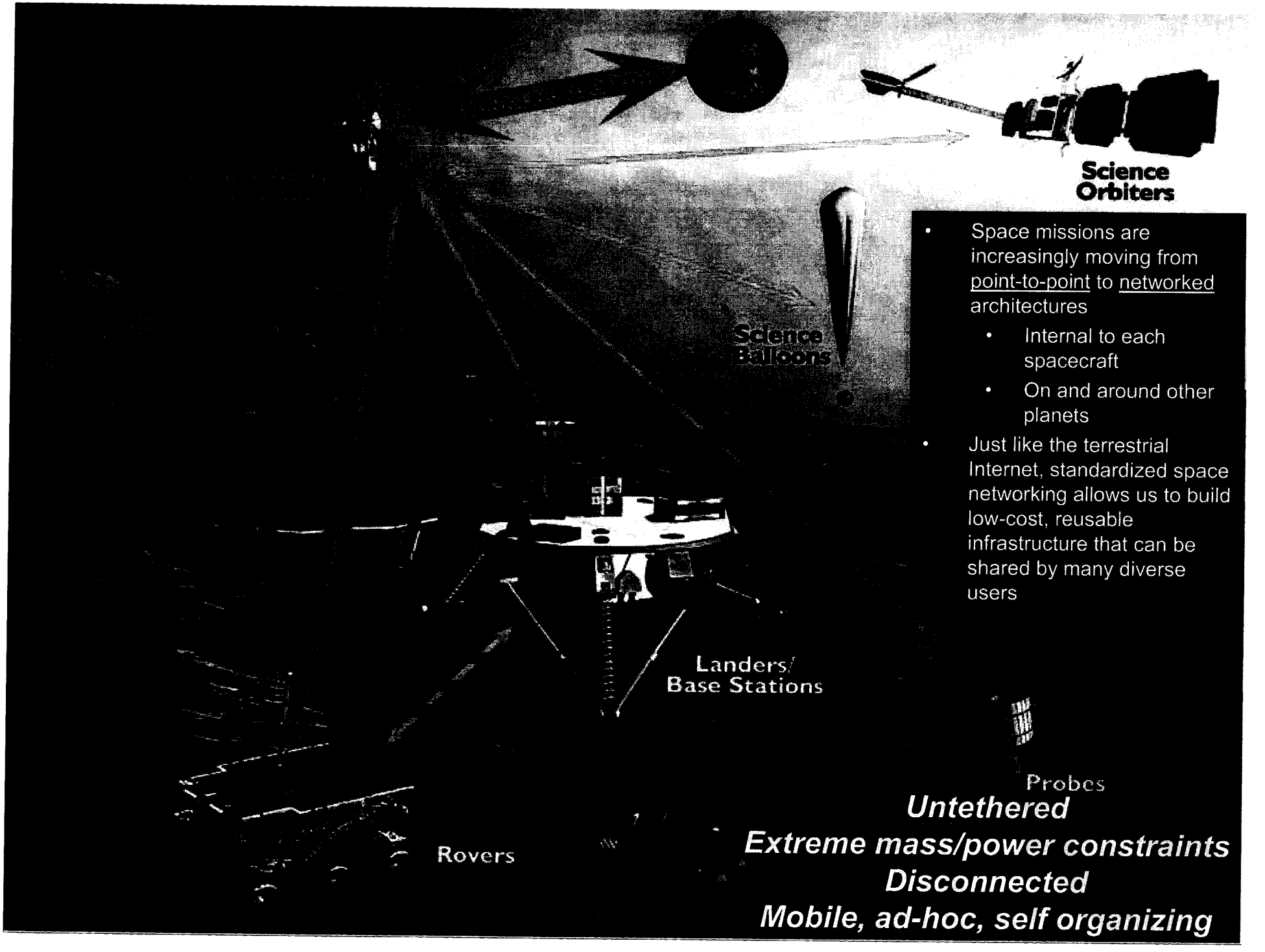
NASA/DOD/CCSDS Space Communications Protocol Standards (CCSDS-SCPS) Project

File Transfer: FTP
Transport: TCP
Network: IP

605 million users worldwide

InterPlaNetary Internet (IPN)

Evolution of the terrestrial Internet

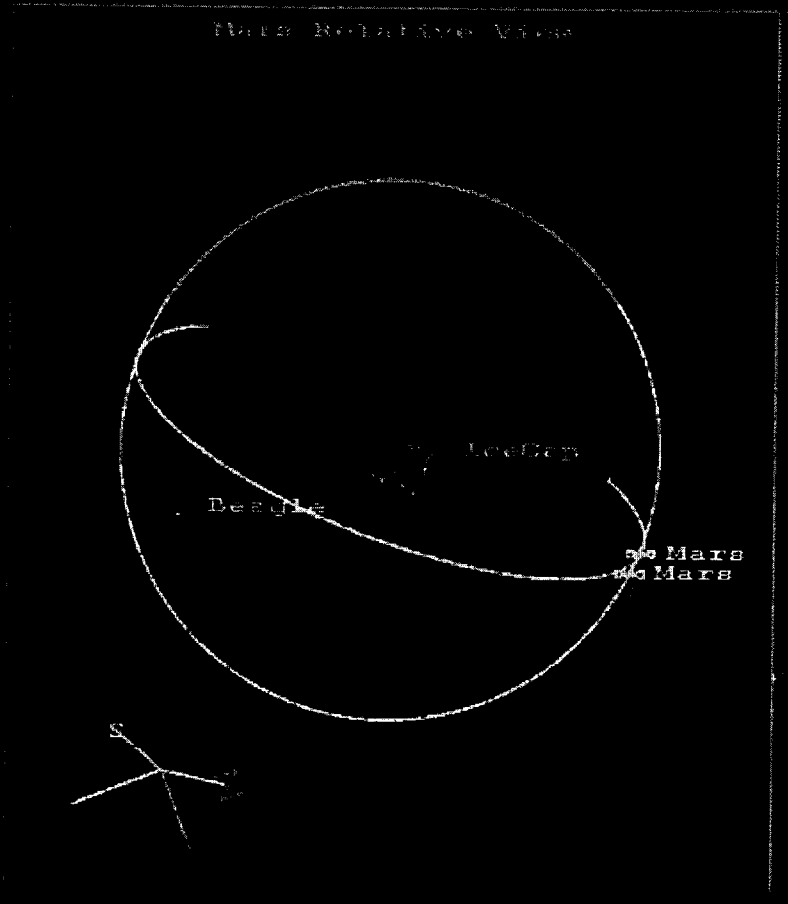


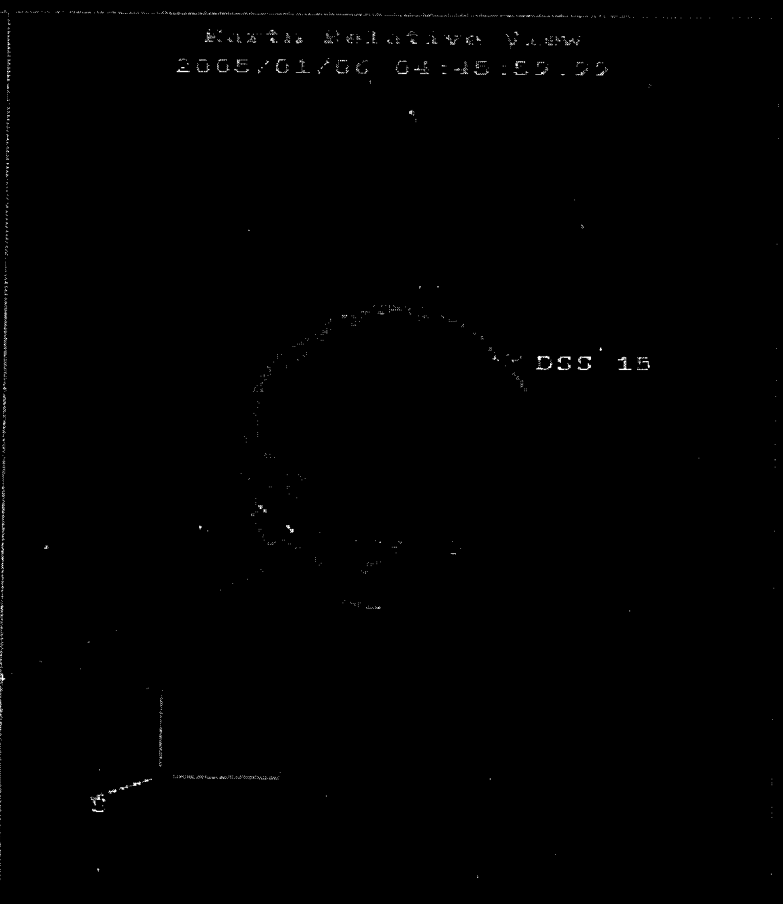
- Space missions are increasingly moving from point-to-point to networked architectures
  - Internal to each spacecraft
  - On and around other planets
- Just like the terrestrial Internet, standardized space networking allows us to build low-cost, reusable infrastructure that can be shared by many diverse users

Untethered
Extreme mass/power constraints
Disconnected
Mobile, ad-hoc, self organizing

The Internet is a connected, chatty 'network of networks' based on a wired backbone with negligible delay and errors (with untethered "edges" emerging)

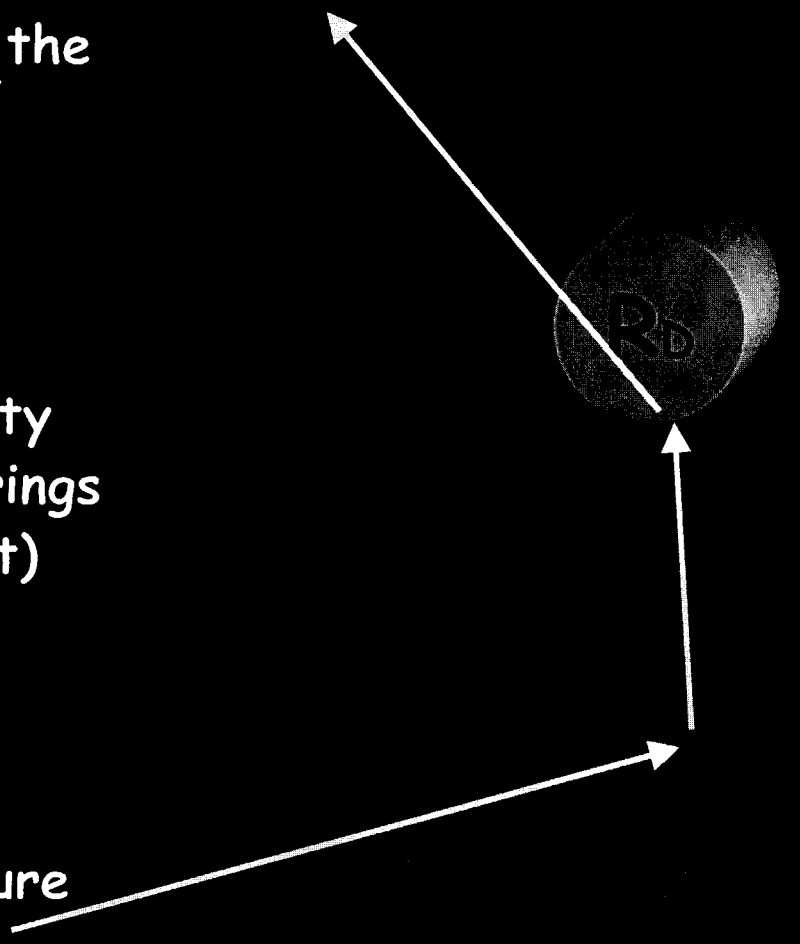
The InterPlaNetary Internet is a disconnected, store-and forward 'network of Internets' based on a wireless backbone with huge delays and error prone links



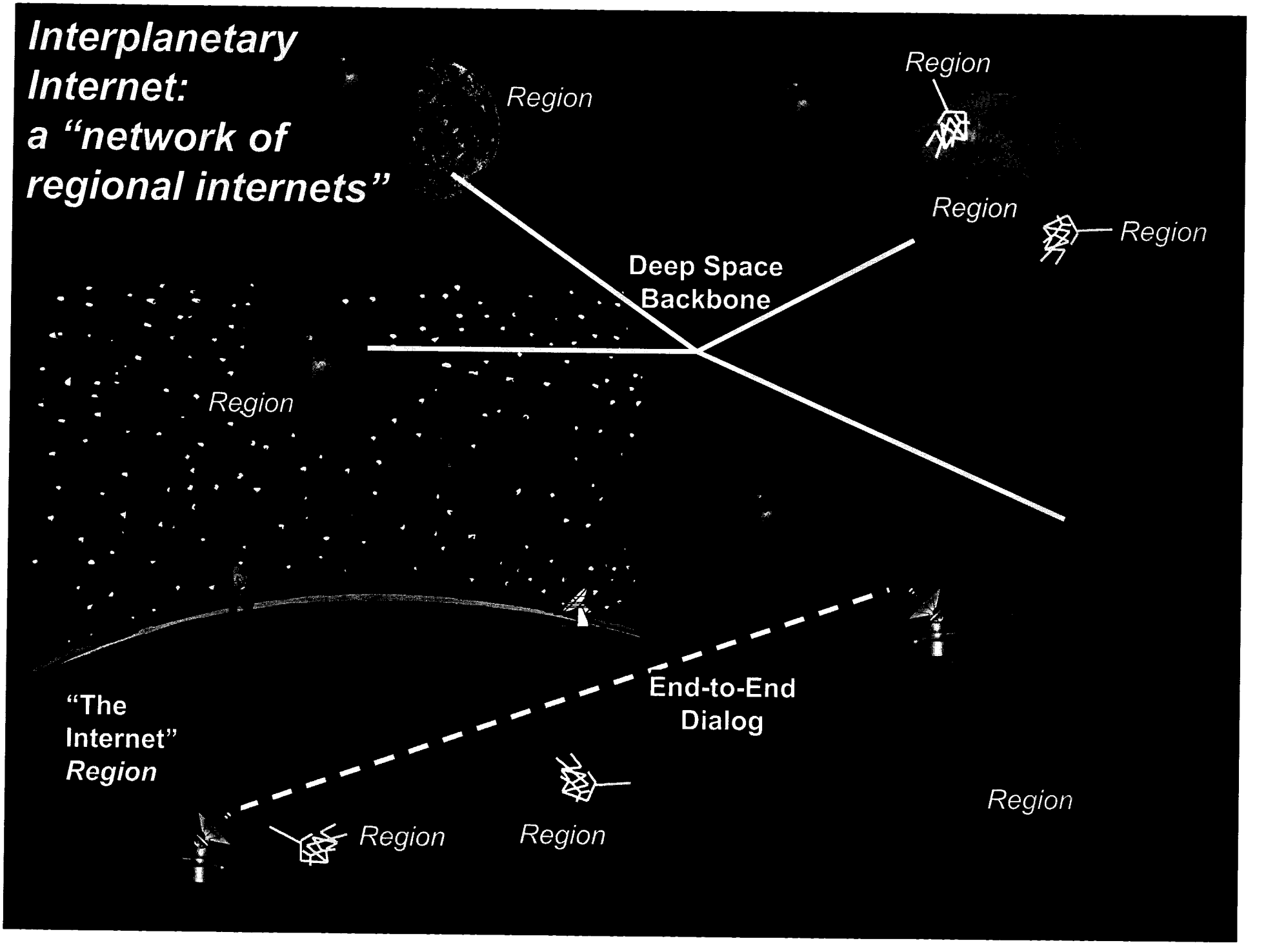


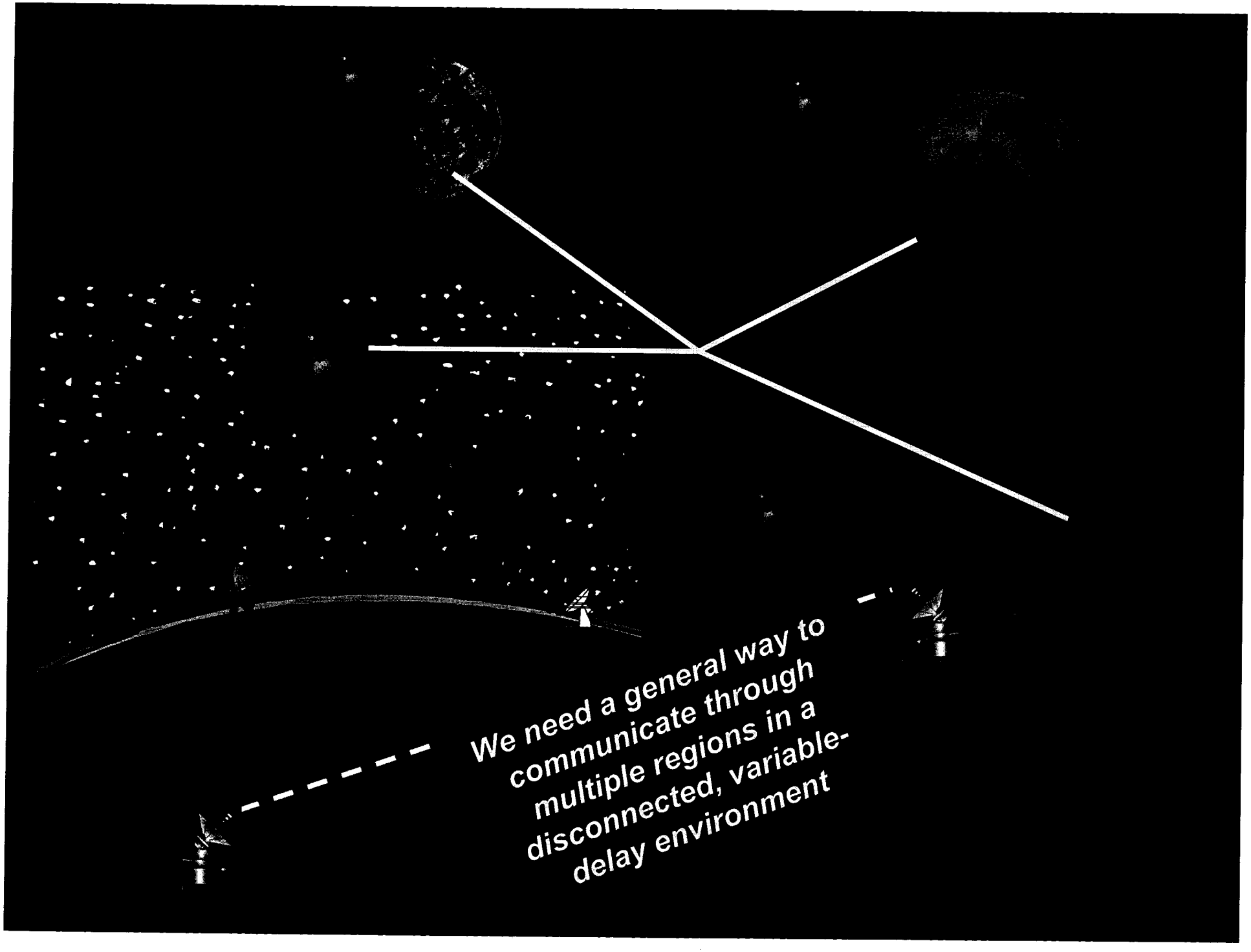
The Interplanetary Internet:

- A *region* is an area where the relevant characteristics of communication are homogeneous
- Regions are defined based upon:
  - Communications capability
  - Quality of Service Peerings
  - Security (levels of trust)
  - Degree of resource management
  - Etc.
- Traversal of two or more regions will affect the nature of communications

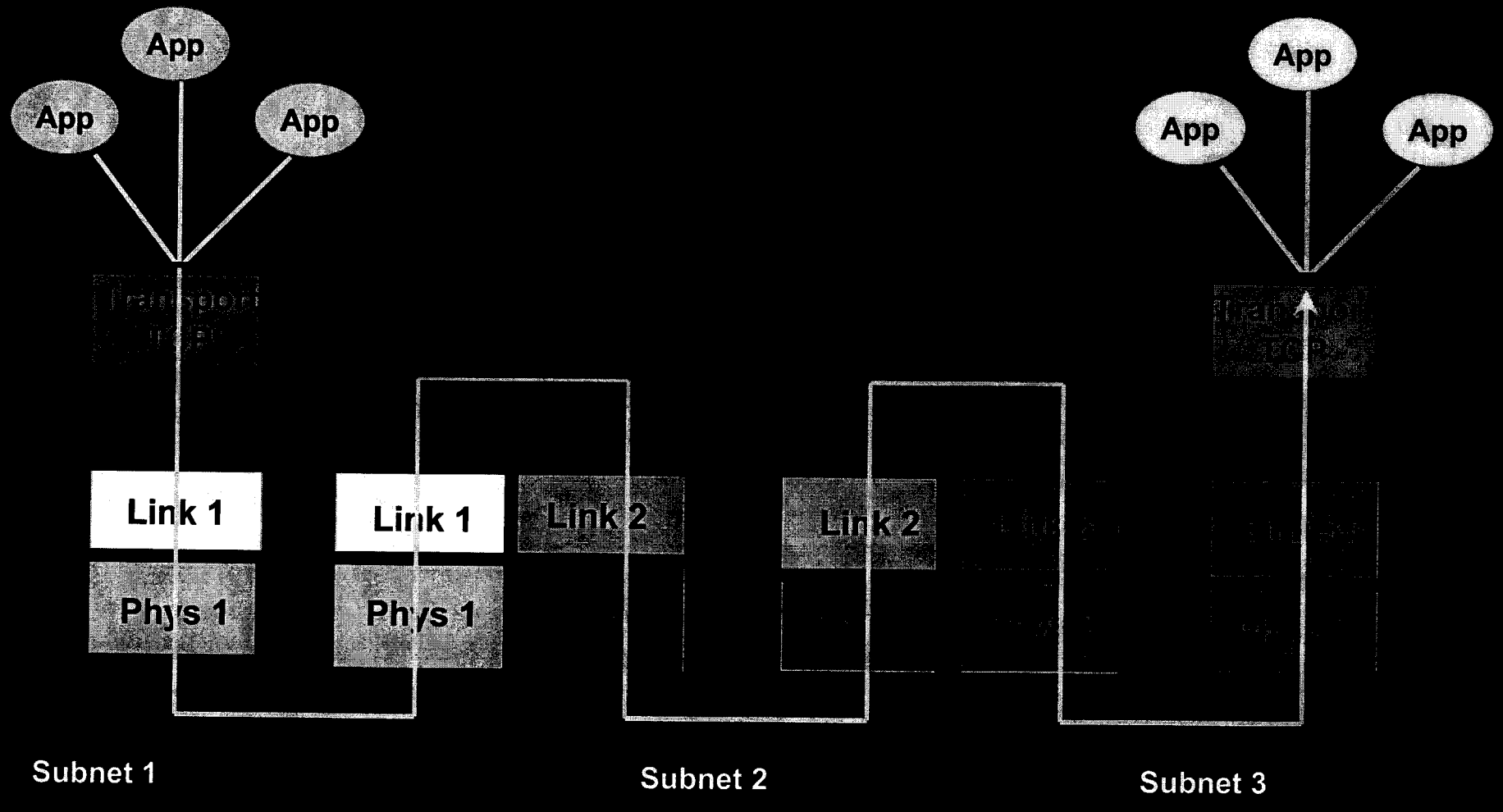


Interplanetary Internet: a "network of regional internets"



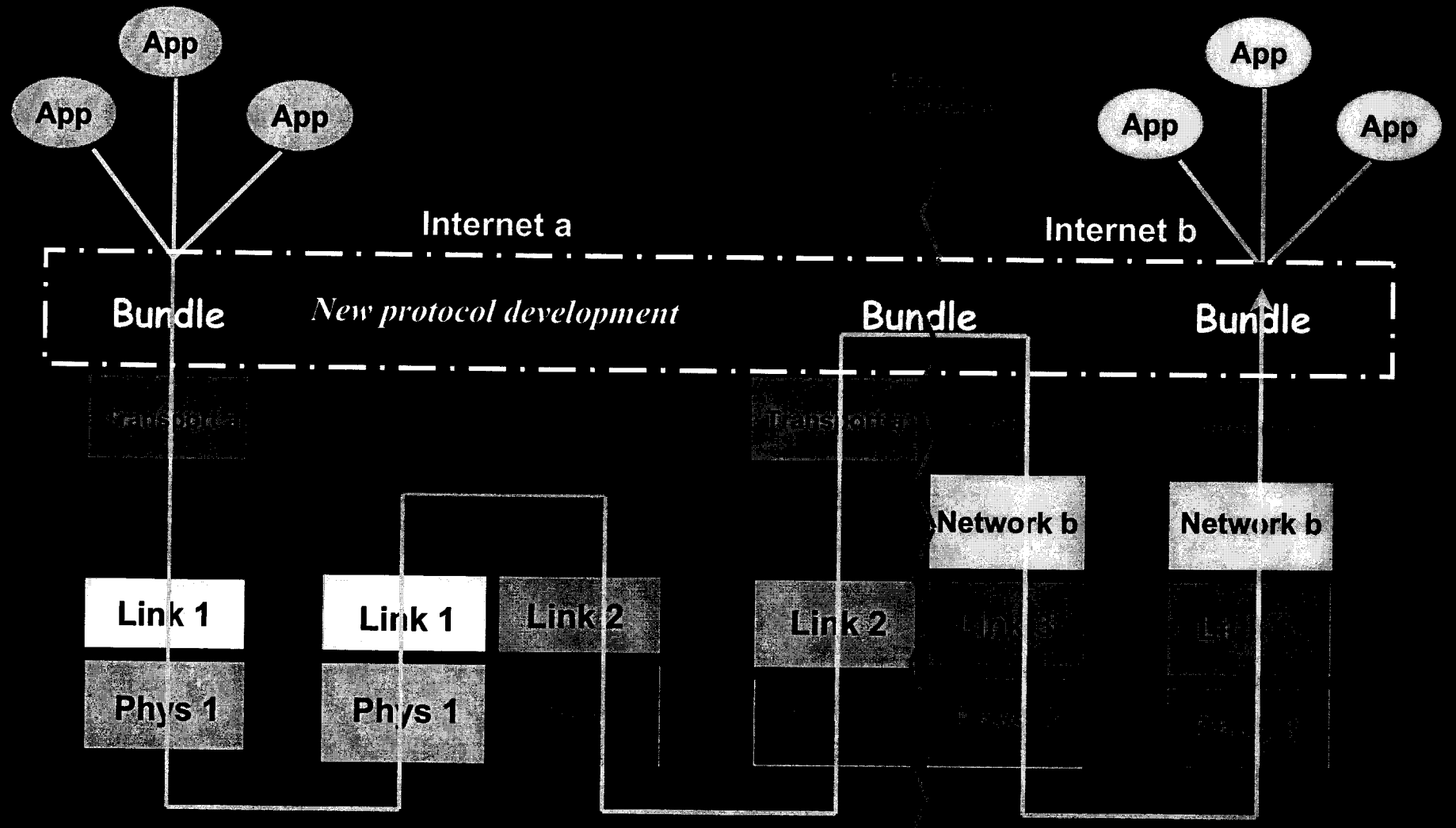

We need a general way to communicate through multiple regions in a disconnected, variable-delay environment

The Internet: a Network of Connected Sub-Networks



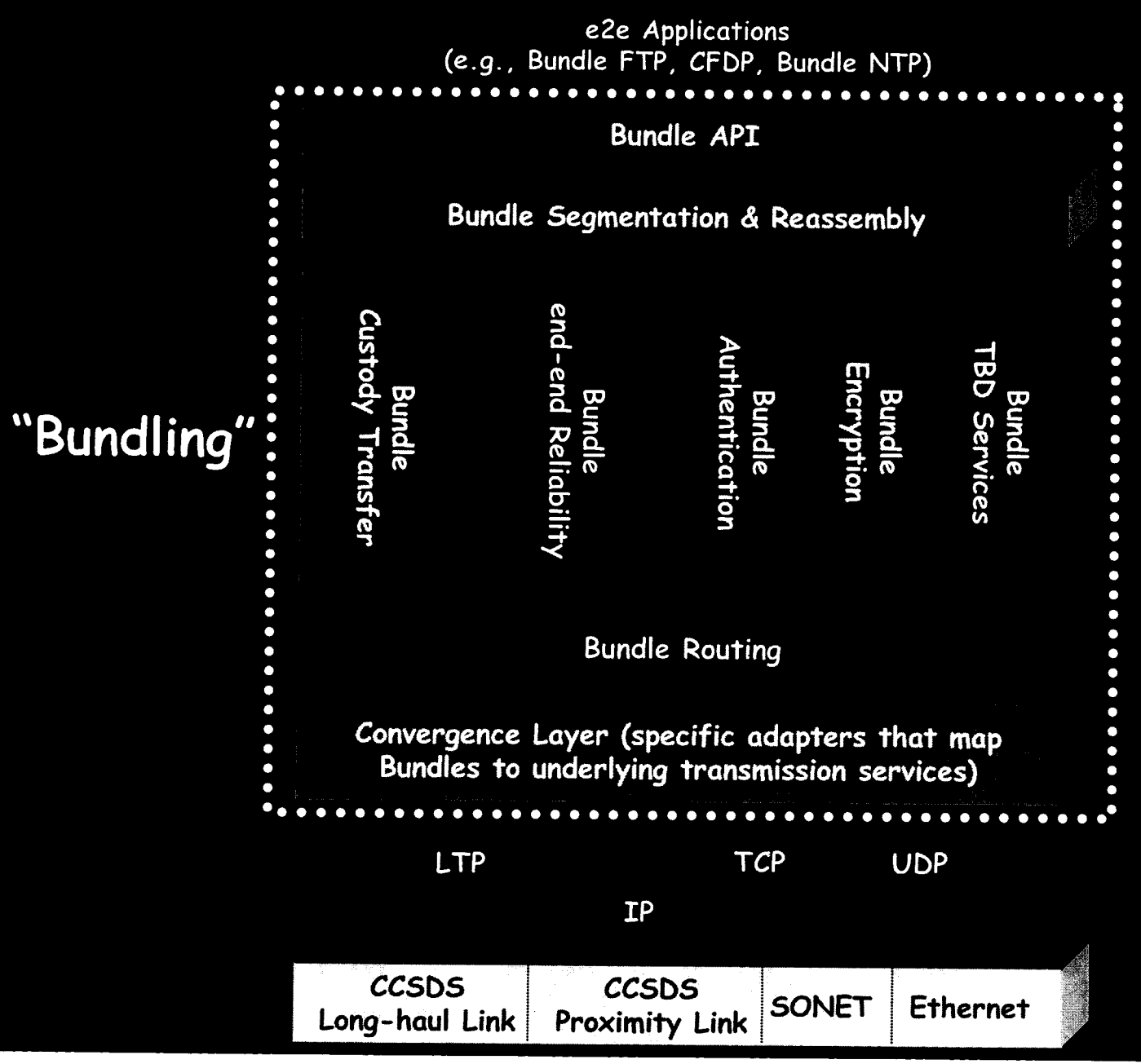
Bundles: A Store and Forward Application Overlay

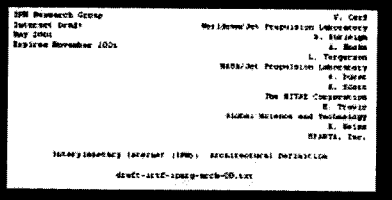
The "Thin Waist" of the Interplanetary Internet



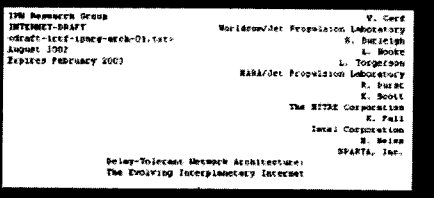
A "network of internets" spanning dissimilar environments

Bundle Service Layering

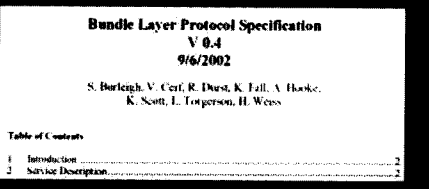




IPN Architecture (Internet Draft 1) May 2001

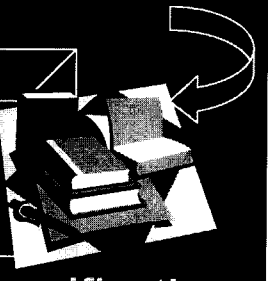


DTN Architecture (Internet Draft 2) August 2002



Bundle Protocol Specification, Draft1 September 2002

Bundle Specification

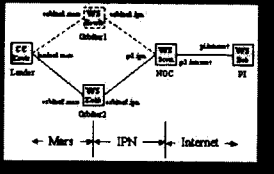


Specifications

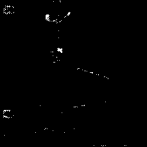
Code base

Bundle Prototyping

1st. Rough Code August 2000



2nd. Proto. Code May 2002

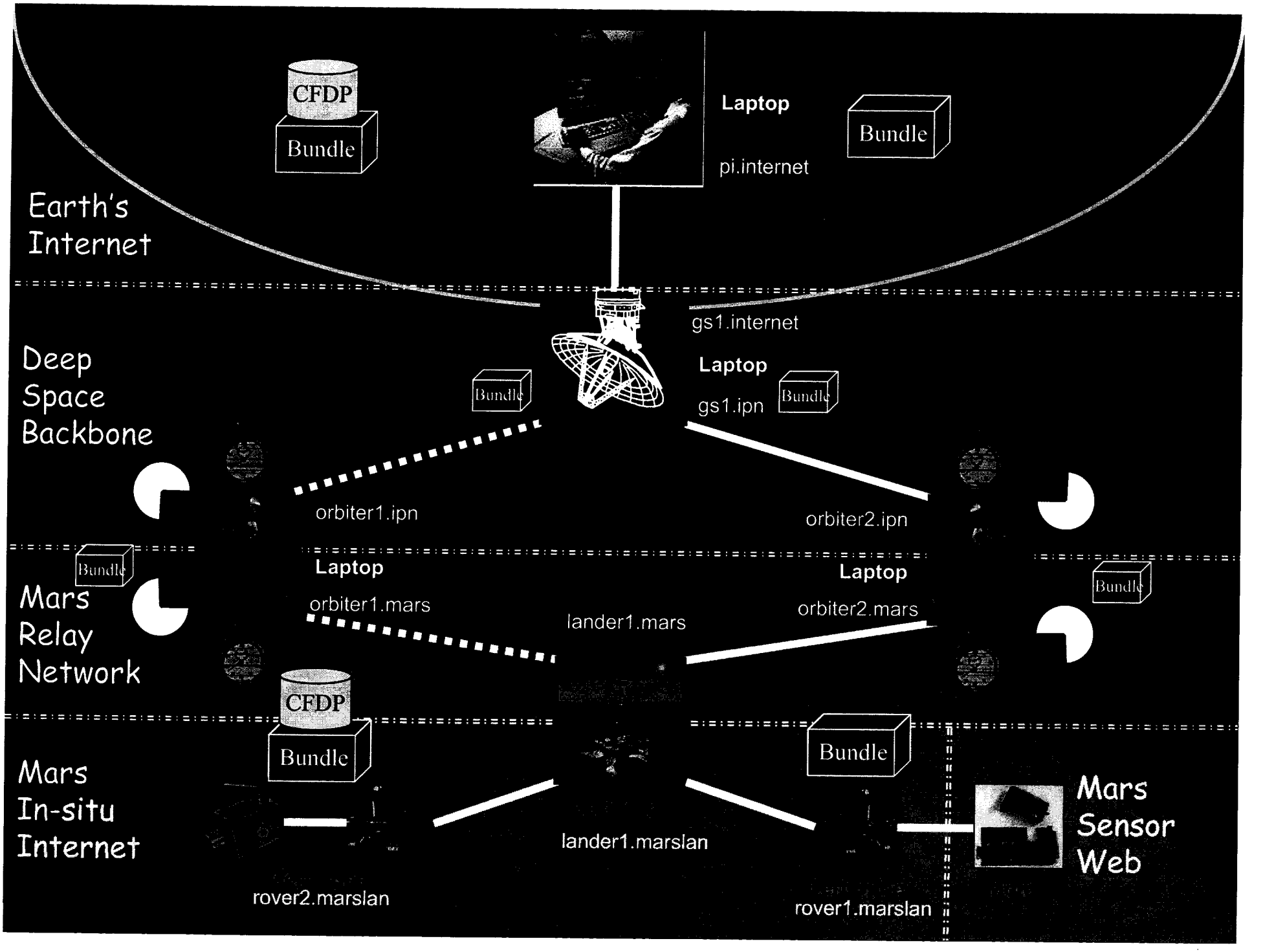


3rd. Proto. Code July 2002

4th Proto. Code Sept. 2002

5th Proto. Code Nov. 2002

Files/Images/UGS-over-Bundles Experiment


CFDP
Bundle
Laptop
pi.internet
Bundle
Earth's Internet
gs1.internet
Laptop
gs1.ipn
Bundle
Bundle
Deep Space Backbone
orbiter1.ipn
orbiter2.ipn
Bundle
Laptop
orbiter1.mars
Laptop
orbiter2.mars
Bundle
Mars Relay Network
lander1.mars
CFDP
Bundle
Bundle
Mars In-situ Internet
lander1.marslan
rover2.marslan
rover1.marslan
Mars Sensor Web

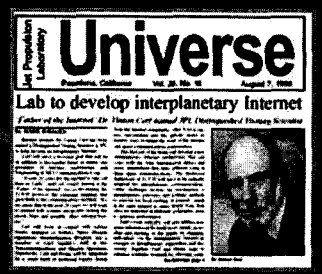
The Interplanetary Internet

1998 | 1999 | 2000 | 2001 | 2002 | 2003

DARPA-ATO

DARPA-NGI Initiative

NASA


Jet Propulsion Laboratory
Universe
Lab to develop interplanetary Internet

IPN Research Group
Internet Draft
May 2001
Expires November 2001

V. Cerf
Worldcom/Jet Propulsion Laboratory
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NASA/Jet Propulsion Laboratory
R. Durst
K. Scott
The MITRE Corporation
E. Travis
Global Science and Technology
H. Weiss
SPARTA, Inc.

Interplanetary Internet (IPN): Architectural Definition

draft-irtf-ipnrg-arch-00.txt

DTN Research Group
INTERNET-DRAFT
<draft-irtf-dtnrg-arch-00.txt>
August 2002
Expires February 2003

V. Cerf
Worldcom/Jet Propulsion Laboratory
S. Burleigh
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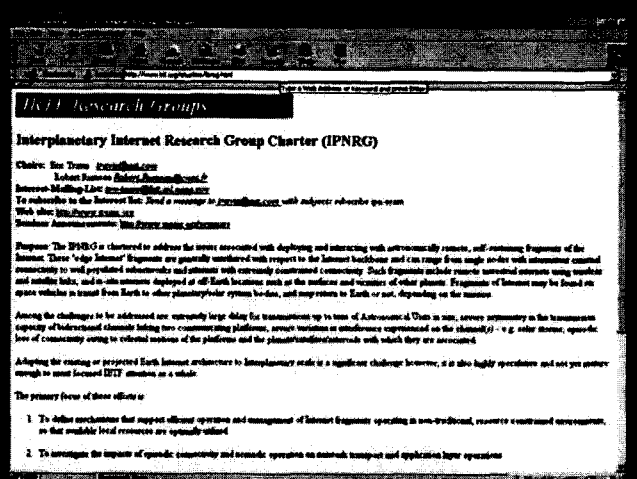
E. Travis
Global Science and Technology
H. Weiss
SPARTA, Inc.

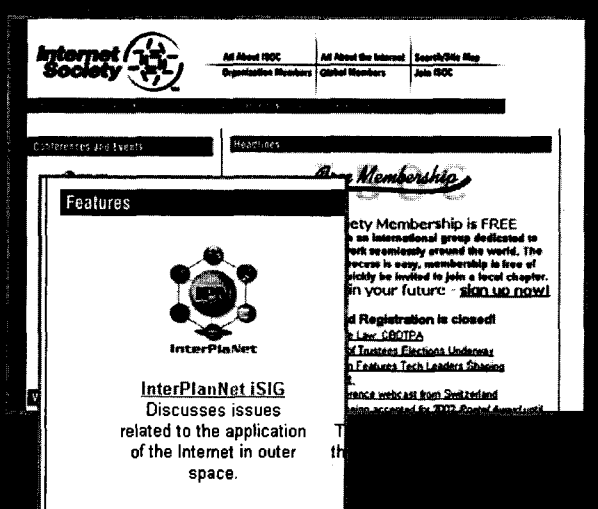
Delay-Tolerant Network Architecture:
The Evolving Interplanetary Internet
draft-irtf-dtnrg-arch-00.txt

Bundle Layer Protocol Specification
V 0.4
9/6/2002

S. Burleigh, V. Cerf, R. Durst, K. Fall, A. Hooke, K. Scott, L. Torgerson, H. Weiss


IRTF Research Groups

Interplanetary Internet Research Group Charter (IPNRG)


Internet Society
Features
InterPlanNet

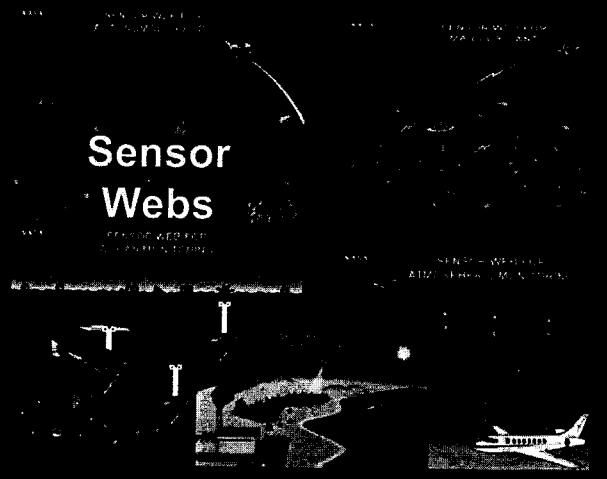
InterPlanNet iSIG
Discusses issues related to the application of the Internet in outer space.

Universe
SPECIAL ISSUE
Director Elachi's 2020 vision

Interplanetary Internet and Information Systems

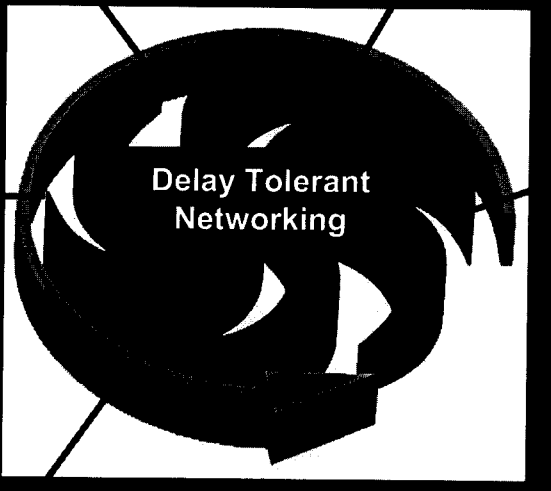
Besides listening to all of you, I also spoke to people outside of JPL who shared their advice with me. I often asked: "What is the most unique thing about JPL? What capabilities, what assets do we have that can be found nowhere else?"

I heard many answers. But one that kept coming up was the Deep Space Network. We now need to create the next generation of the Deep Space Network. And that requires creating the interplanetary Internet of the next 20 years. This is a very exciting challenge. The DSN will be the backbone for this network, and the spacecraft we will have across the solar system and around Earth are information nodes that will interconnect to our network across the Lab and to the World Wide Web.



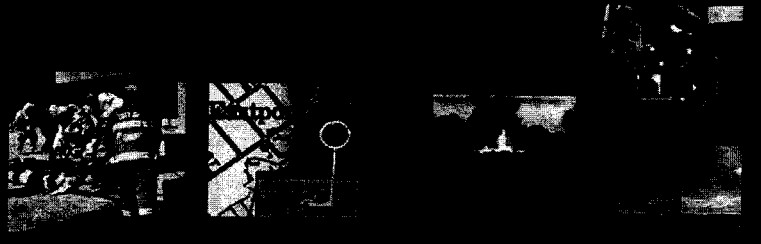
Interplanetary Internet

- "Non-chatty" message-oriented communications
- Store-and-forward between nodes
- Routing algorithms cognizant of scheduled connectivity
- Use transport and network technologies appropriate to the environment
- Integral infrastructure protection



Remote outposts

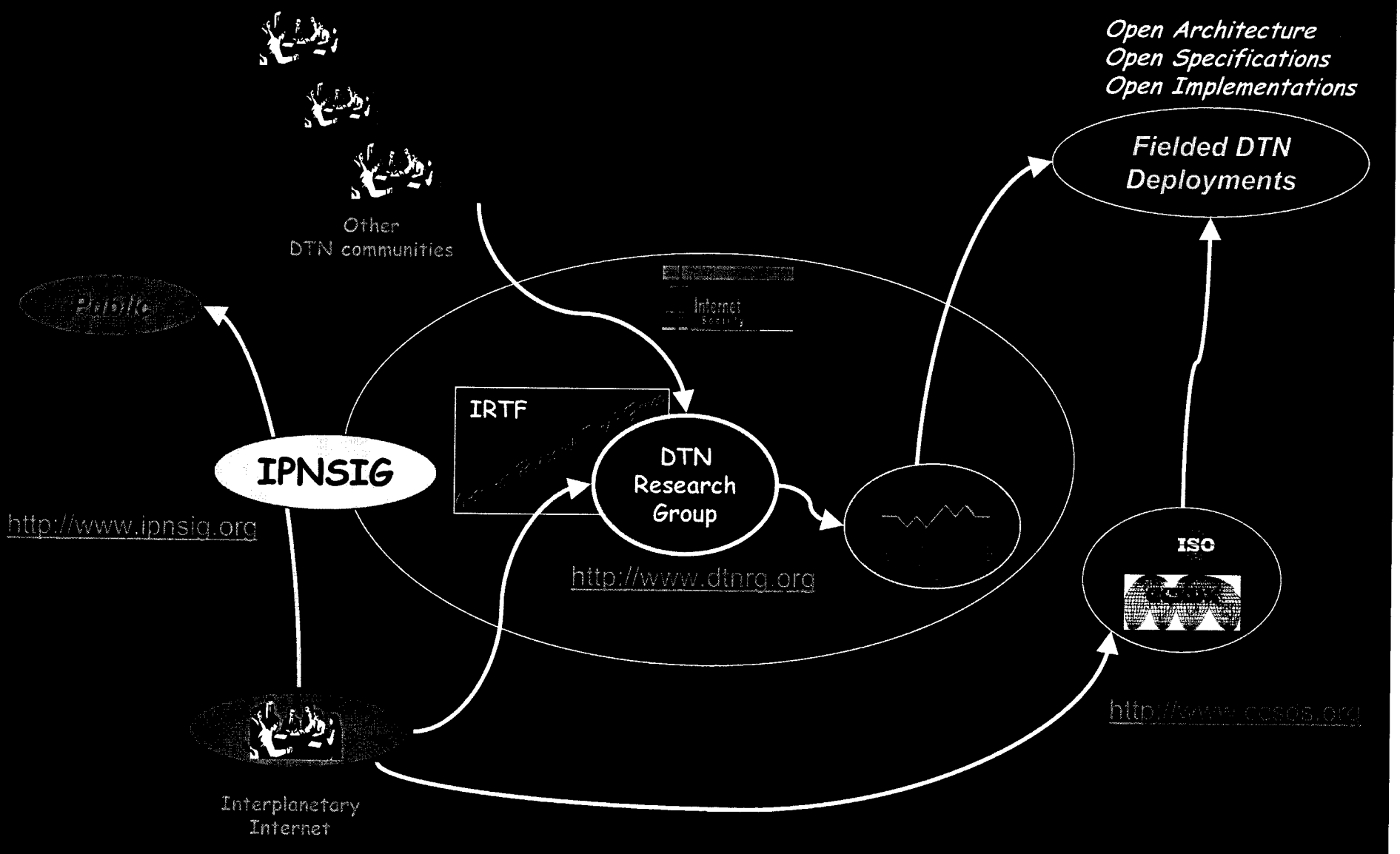
HOMELAND SECURITY

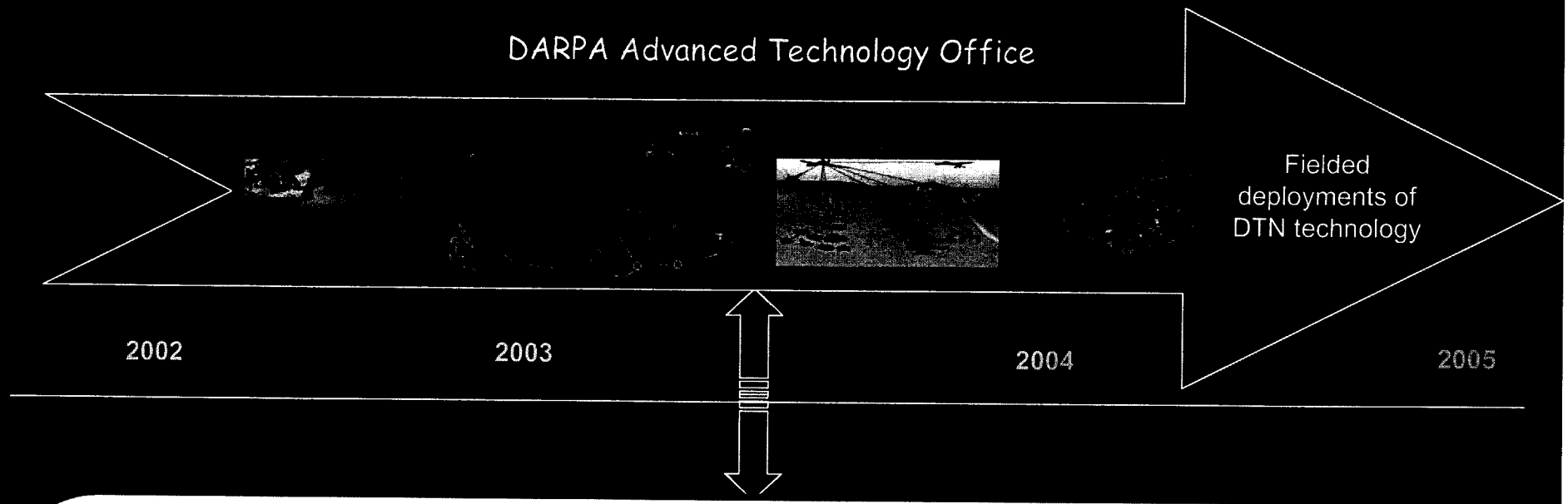


Realization:
Broader applicability
Nearer term utility
Larger research community

Delay Tolerant Networking:

a broad community effort





DTN Research Group:

Focal point for DTN

DTN Core Engineering

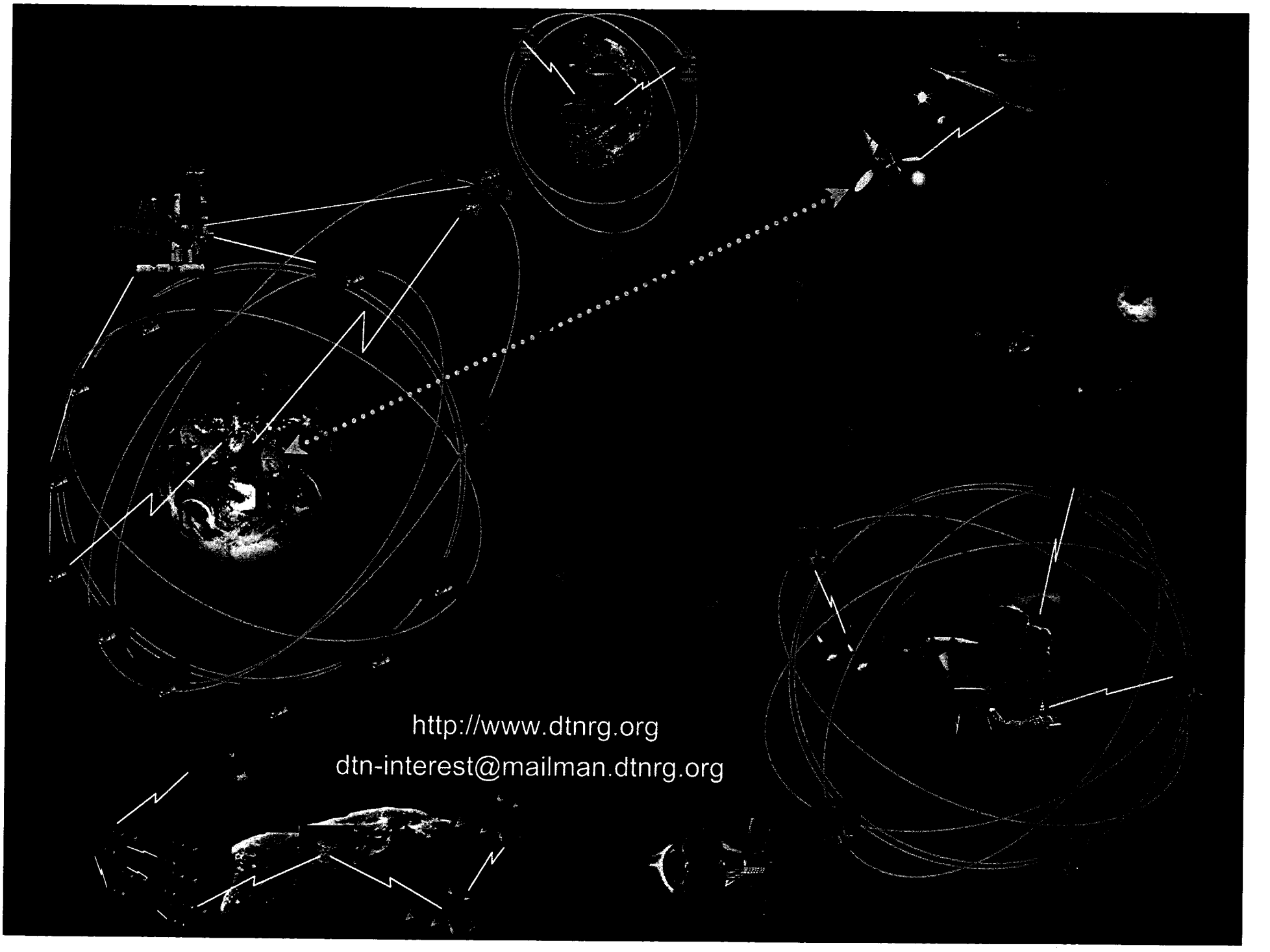
- DTN Architecture
- DTN Design Documents

DTN Open Source

- Reference Software
- Configuration Control

DTN Standardization

- International Standards


http://www.dtnrg.org
dtn-interest@mailman.dtnrg.org