

Disruption Tolerant Networking Project

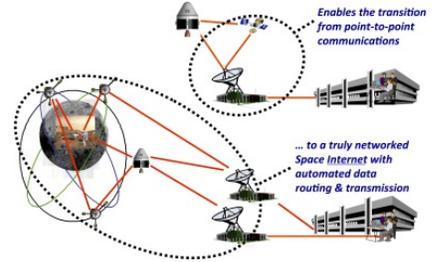
Advanced Exploration Systems Program | Human Exploration And Operations Mission Directorate (HEOMD)



ABSTRACT

Traditionally, space communication systems have relied on dedicated point-to-point or single-hop relay links. Such links are not always available, often have long time delays, and are limited in number. A networked communication architecture is desired to support future space missions, as networked communications significantly increase the operational flexibility and robustness of missions, as well as enable mission classes otherwise untenable. However, the terrestrial Internet protocols do not work well in highly disrupted and delayed environments, and new protocols are needed.

The goal of the AES Disruption Tolerant Networking (DTN) project is to develop and deploy a protocol suite that extends the terrestrial Internet capabilities into highly stressed data communication environments where the conventional Internet protocols do not work well. The DTN protocol suite is also being internationally standardized and will enable a Solar System Internet (SSI) architecture to support future space missions.



Disruption Tolerant Networking (DTN)

Table of Contents

Abstract	1
Anticipated Benefits	1
Technology Maturity	1
Realized Benefits	2
Management Team	2
Technology Areas	2
Detailed Description	3
U.S. Work Locations and Key Partners	4
Image Gallery	5
Details for Technology 1	5

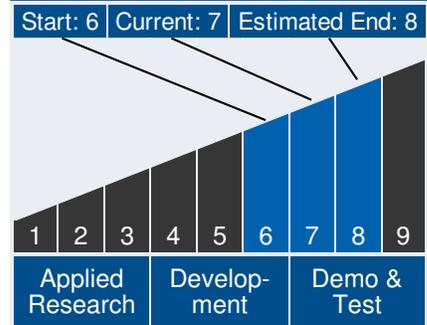
ANTICIPATED BENEFITS

To NASA funded missions:

- **Improved Operations and Situational Awareness:** The DTN store-and-forward mechanism along with automatic retransmission provides more insight into events during communication outages and significantly reduces the need for ground-based scheduling.
- **Interoperability and Reuse:** A standardized DTN protocol suite enables interoperability of multi-agency communication assets and also allows NASA to use the same communication stack for future missions (low Earth orbit, near earth objects, or deep space).

Continued on following page.

Technology Maturity



Disruption Tolerant Networking Project

Advanced Exploration Systems Program | Human Exploration And Operations
Mission Directorate (HEOMD)



To NASA funded missions: *(cont.)*

- **Space Link Efficiency, Utilization and Robustness:** DTN enables more reliable and efficient data transmissions resulting in more usable bandwidth. DTN also improves link reliability by having multiple network paths and assets for potential communication hops.
- **Security:** The DTN Streamlined Bundle Security Protocol (SBSP) allows for integrity checks, authentication and encryption, even on links where not previously used.
- **Quality-of-Service:** The DTN protocol suite allows for many priority levels to be set for different data types, ensuring that the most important data is received ahead of less important data.

To NASA unfunded & planned missions:

Missions operated using an internet and automated mission communications can result in more data from spacecraft and reduced operations costs.

To other government agencies:

DTN can be used by other agencies to enable reliable, automated and internetworked communication in disrupted environments, potentially resulting in more data return and reduced operations costs. Other agencies may also be able to leverage NASA assets as part of the Solar System Internet.

To the commercial space industry:

DTN is being standardized by the Consultative Committee for Space Data Systems (CCSDS) and the Internet Engineering Task Force (IETF) and all of the DTN protocols will be open international standards, supported by open-source software that is freely available to Industry for incorporation into their products.

To the nation:

DTN can provide benefit in any environment where communication links are frequently disrupted, highly delayed or prone to errors. In such environments, found in both terrestrial



Management Team

Program Director:

- Jason Crusan

Program Executive:

- Richard Mcginnis

Project Manager:

- Brenda Lyons

Technology Areas

Primary Technology Area:

Communications, Navigation, and
Orbital Debris Tracking and
Characterization Systems (TA 5)

└ Internetworking (TA 5.3)

└ Internetworking (TA 5.3)

└ Ground and Launch Systems (TA 13)

└ Environmental Protection and
Green Technologies (TA 13.2)

└ Corrosion Prevention,
Detection, and
Mitigation (TA 13.2.1)

└ Self-Healing Launch
Structures (TA
13.2.1.3)

Continued on following page.

Disruption Tolerant Networking Project

Advanced Exploration Systems Program | Human Exploration And Operations
Mission Directorate (HEOMD)



and space applications, DTN enables reliable, automated and internetworked communication and is more efficient than traditional techniques, allowing for better bandwidth utilization when bandwidth can be very costly and/or limited.

DTN will also enable the Solar System Internet architecture to be realized and used to support future exploration and other applications. In addition, DTN standardization will ease leveraging international and industry partnerships to achieve future mission objectives.

DETAILED DESCRIPTION

Disruption Tolerant Networking (DTN) is a protocol suite that extends the terrestrial Internet capabilities into highly stressed data communication environments where the conventional Internet does not work well. These environments are typically subject to frequent disruptions, unidirectional links, possibly long delays, and high error rates.

The DTN protocol suite can run over the existing Internet Protocol (IP) suite or it can operate by itself as a full Internetworking protocol. DTN provides assured delivery of data using an automatic store-and-forward mechanism. The DTN suite also contains network management, security, routing, and quality-of-service mechanisms.

DTN is being standardized by the Consultative Committee for Space Data Systems (CCSDS) and the Internet Engineering Task Force (IETF) and all of the DTN protocols will be open international standards, supported by open-source software. Several DTN implementations exist and are publically available, including NASA's Interplanetary Overlay Network (ION) implementation (<http://sourceforge.net/projects/ion-dtn/>).

Technology Areas (cont.)

Secondary Technology Area:

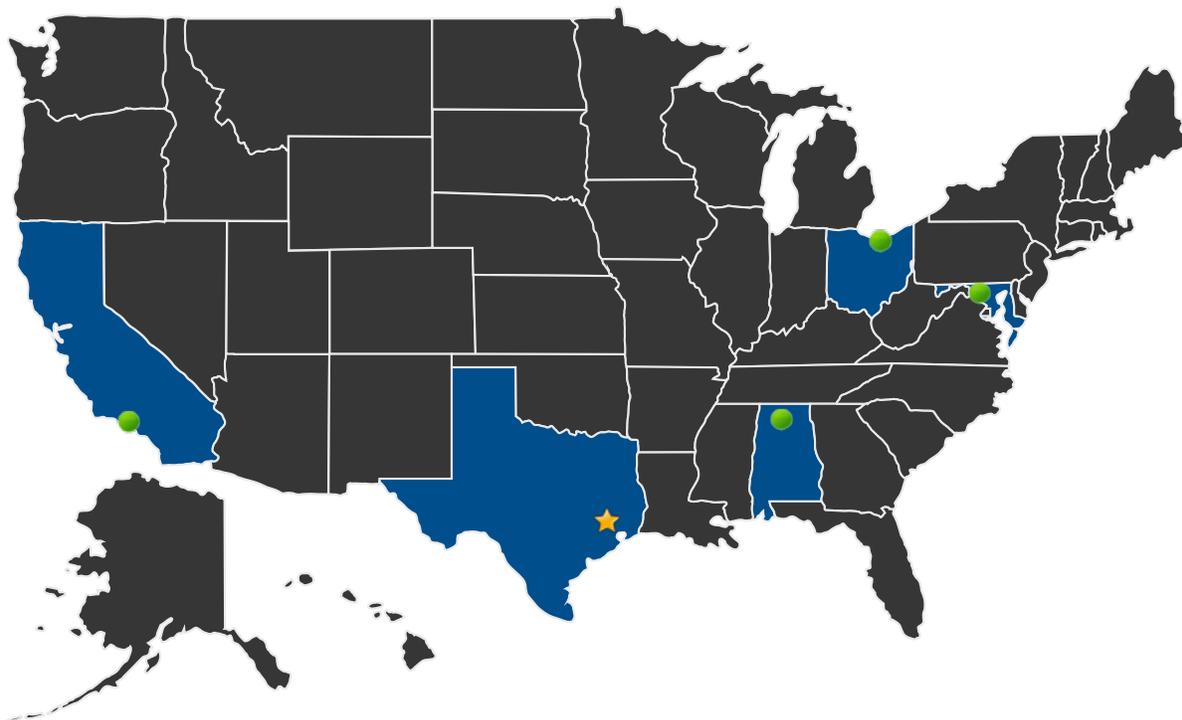
Communications, Navigation, and
Orbital Debris Tracking and
Characterization Systems (TA 5)

Disruption Tolerant Networking Project

Advanced Exploration Systems Program | Human Exploration And Operations
Mission Directorate (HEOMD)



U.S. WORK LOCATIONS AND KEY PARTNERS



■ U.S. States With Work ★ **Lead Center:**
Johnson Space Center

● **Supporting Centers:**

- Glenn Research Center
- Goddard Space Flight Center
- Jet Propulsion Laboratory
- Marshall Space Flight Center

Other Organizations Performing Work:

- JHU APL

Disruption Tolerant Networking Project

Advanced Exploration Systems Program | Human Exploration And Operations
Mission Directorate (HEOMD)

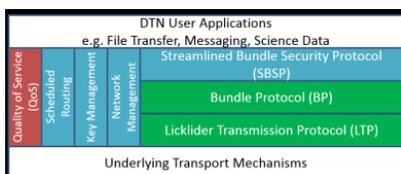


PROJECT LIBRARY

Publications

- Infusion Story - DTN and International Space Station
 - (<http://techport.nasa.gov:80/file/26174>)

IMAGE GALLERY



DTN Protocol Suite



Solar System Internet Concept

DETAILS FOR TECHNOLOGY 1

Technology Title

Disruption Tolerant Networking (DTN)

Technology Description

This technology is categorized as software memory for manned spaceflight

There are two parts to this project supported by two HEOMD organizations: standardization of DTN protocols and technology development, technology demonstration, and infusion into programs. The standardization of the DTN protocols is funded and managed by Space Communications and Navigation (SCaN). The technology development, demonstrations, and infusion into humans space flight programs is managed by Advanced Exploration Systems (AES).

Currently, protocols to move data have been developed and demonstrated in the lab. These are being infused into operational systems, starting with the International Space Station.

The future development services are: security, network management, routing, quality of service, key management, and deployment services (e.g., timing). As these are developed by AES, they will be demonstrated by AES and moved into HEOMD programs.

In addition, there are international agreements to use DTN. AES will manage the US part of

Disruption Tolerant Networking Project

Advanced Exploration Systems Program | Human Exploration And Operations
Mission Directorate (HEOMD)



international human space flight tests and usage; SCan will manage the international standardization effort in the Consultive Committee for Space Data Systems (CCSDS).

Capabilities Provided

The DTN protocol suite extends the terrestrial Internet capabilities into highly stressed data communication environments where the conventional Internet does not work well. These environments are typically subject to frequent disruptions, unidirectional links, possibly long delays and high error rates.

Potential Applications

DTN can be used in communication systems, including radio frequency and optical systems that operate in disrupted environments, to enable reliable internetworking. Potential applications include: human spaceflight, space science missions, and emergency/disaster response.

Performance Metrics

Metric	Unit	Quantity
complies with CCSDS standard(s)	yes/no	yes