Telescience Resource Kit (TReK)

ACLS TIM

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Agenda

- General Information
- HOSC Payload Ethernet Gateway (HPEG)
- CCSDS File Delivery Protocol (CFDP)
- Delay Tolerant Networking (DTN)

Background

- TReK is one of the Huntsville Operations Support Center (HOSC) remote operations solutions. It can be used to monitor and control International Space Station payloads from anywhere in the world. It is comprised of a suite of software applications and libraries that provide generic data system capabilities and access to HOSC services.

- The TReK Software has been operational since 2000. A new cross-platform version of TReK is under development. The new software is being released in phases during the 2014-2016 timeframe.
  - The TReK Release 3.x series of software is the original TReK software that has been operational since 2000. This software runs on Windows. It contains capabilities to support traditional telemetry and commanding using CCSDS packets.
  - The TReK Release 4.x series of software is the new cross platform software. It runs on Windows and Linux. The new TReK software will support communication using standard IP protocols and traditional telemetry and commanding.
  - All the software listed above is compatible and can be installed and run together on Windows.

- The new TReK software contains a suite of software that can be used by payload developers on the ground and onboard (TReK Toolkit).
  - TReK Toolkit is a suite of lightweight libraries and utility applications for use onboard and on the ground.
  - TReK Desktop is the full suite of TReK software – most useful on the ground.
  - When TReK Desktop is released, the TReK installation program will provide the option to choose just the TReK Toolkit portion of the software or the full TReK Desktop suite.

- The ISS program is providing the TReK Toolkit software as a generic flight software capability offered as a standard service to payloads.

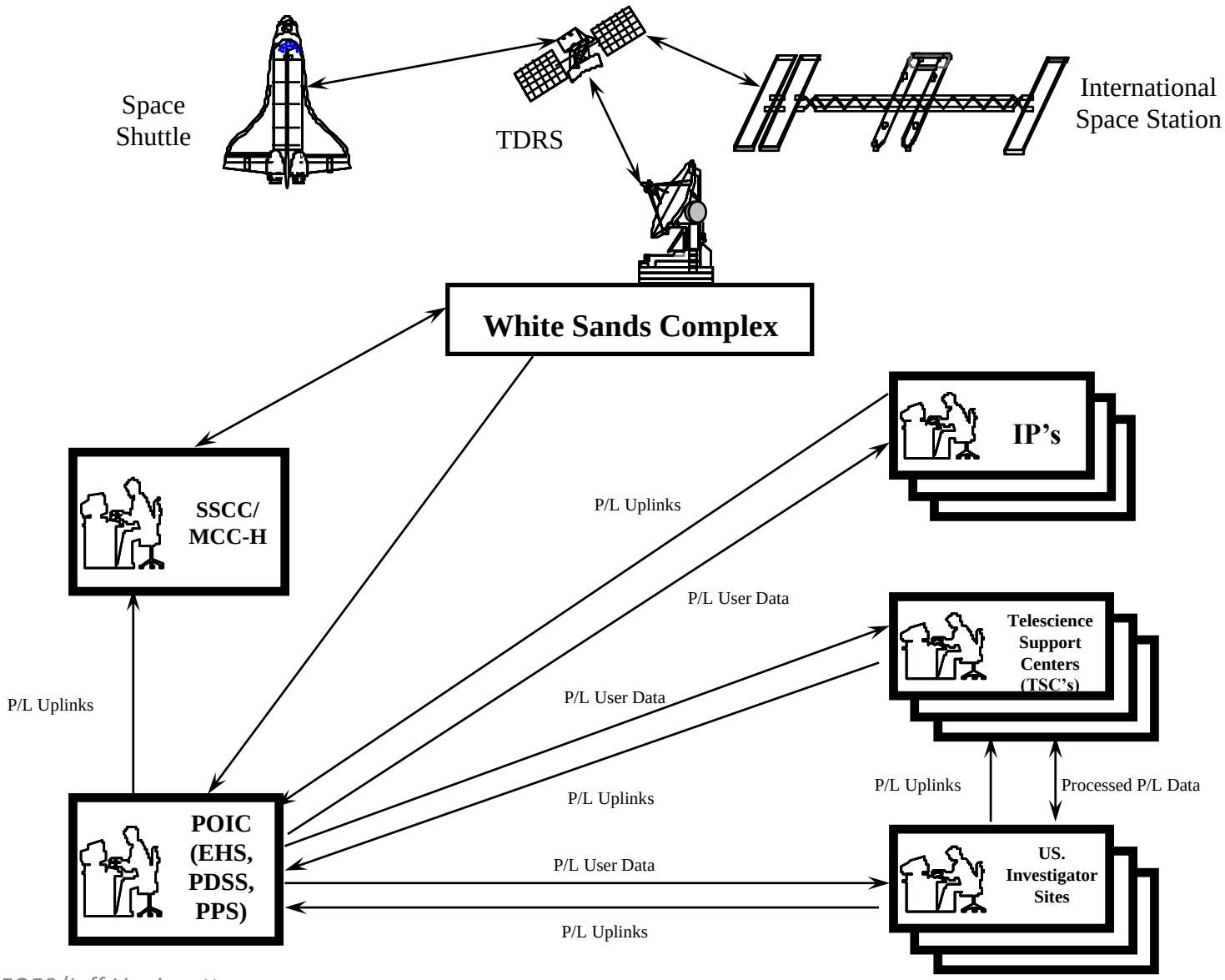
- TReK Software Verification was conducted during the April/May 2015 timeframe. Payload teams using the TReK software onboard can reference the TReK software verification.

Background

- TReK will be demonstrated on-orbit running on an ISS provided T61p laptop. Target Timeframe: September 2015 – 2016.
- The on-orbit demonstration will collect benchmark metrics, and will be used in the future to provide live demonstrations during ISS Payload Conferences.
- Benchmark metrics and demonstrations will address the protocols described in SSP 52050-0047 Ku Forward section 3.3.7.

TReK Release 3.x Overview

ISS Payload Telemetry and Command Flow

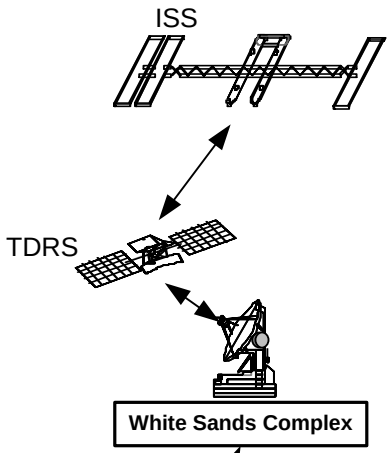


Telescience Resource Kit

- TReK 3.x is a suite of software applications that provide:
  - Local ground support system functions.
    - Telemetry Services
    - Command Services
    - Command Management Services
  - An interface with the Payload Operations Integration Center (POIC) to utilize POIC remote ground support system services.

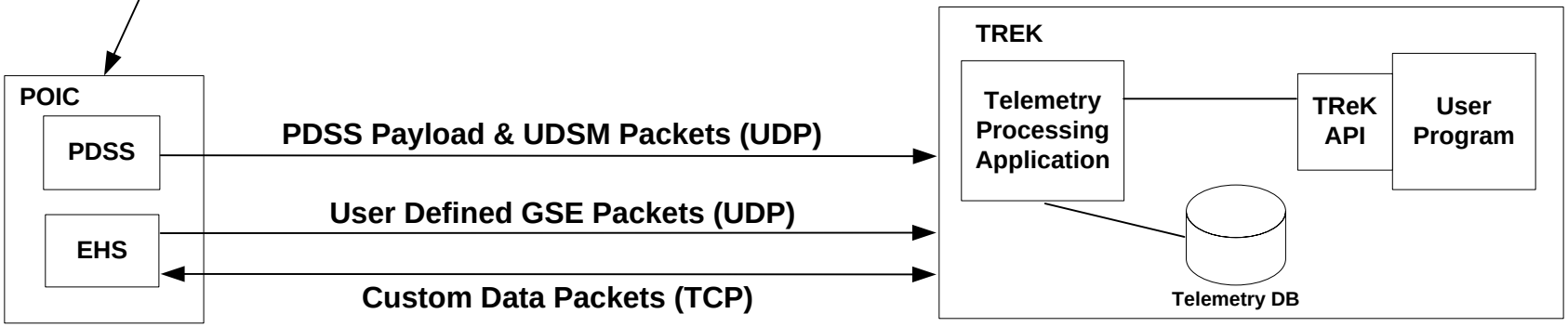
- TReK runs under Windows 7.
  - The TReK software is free.
  - Cost of PC and Commercial Software Products (3k – 5k).
    - Operating System, Microsoft Access, Word, Excel, Others

Telemetry Services

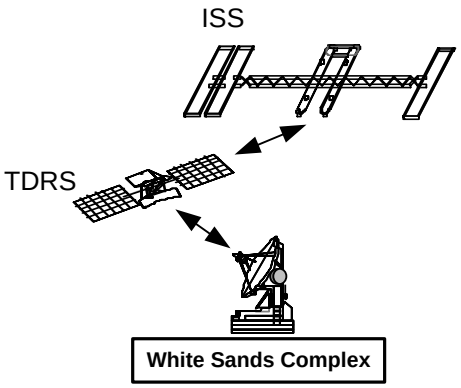


TReK Telemetry Capabilities:

* Receive, Process, Record, Forward, and Playback Telemetry Packets.
* Display, Record, and Monitor Telemetry Parameters
* Extract Telemetry Parameters from Recorded Data Files
* View Incoming Telemetry Packets (Hex/Text Format)
* View/Record Telemetry Processing Statistics
* Telemetry Application Programming Interface (API)
* Telemetry Database

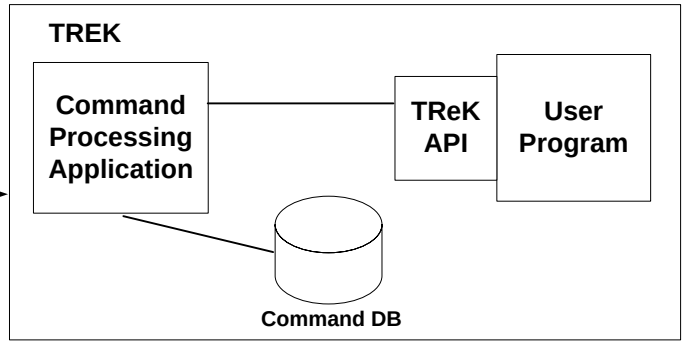


Command Services

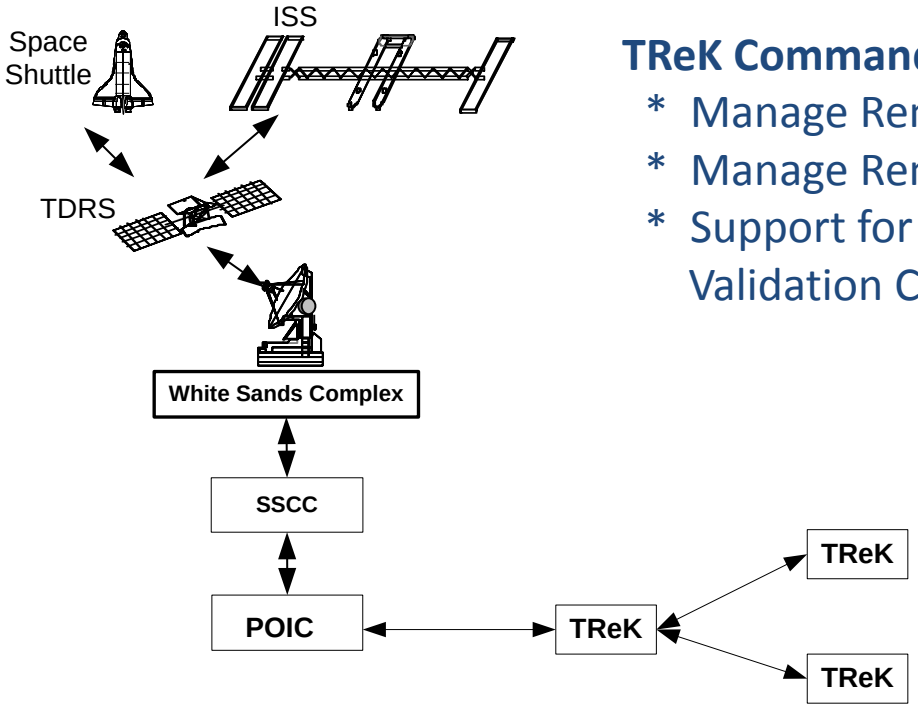


TReK Command Capabilities:

* Command System Status & Configuration Information
* Remotely Initiated Command (Cmd Built from POIC DB)
* Remotely Generated Command (Cmd Built at Remote Site)
* Command Updates
* Command Responses
* Command Session Recording/Viewing
* Command Track
* Command Statistics
* Command Application Programming Interface (API)
* Command Database



Command Management Services



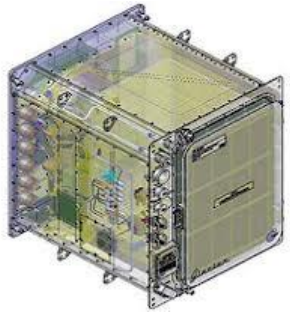
TReK Command Management Capabilities:

* Manage Remote User Logins
* Manage Remote User Commanding
* Support for User Provided Command Validation Checking

TReK Release 4.x Overview

TReK Capabilities Overview

ISS



TReK Capabilities On-Board

- Send/Receive data using standard IP protocols (Unicast, Multicast, TCP Listener, TCP Server, TCP Client).
- Create, populate, build, and decompose custom packets. Includes support for pre-defined and custom headers.
- Record data.
- Transfer files (send and receive) using CFDP.
- Configure and Manage (start, stop, monitor) ION DTN node.
- Support for the following EXPRESS messages (via Ethernet): Payload Health and Status, PEP Bundle Request, PEP Procedure Execution Request. Rack Time Request, Ancillary Data Config Control, Payload Telemetry Downlink Data.

Magic

Payload Ground Site

TReK Capabilities Ground

- Send/Receive data using standard IP protocols (Unicast, Multicast, TCP Listener, TCP Server, TCP Client).
- Create, populate, build, and decompose custom packets. Includes support for pre-defined and custom headers.
- Record and playback data.
- Transfer files (send and receive) using CFDP.
- Configure and Manage (start, stop, monitor) ION DTN node.
- Use HPEG application to log into POIC and start/stop HOSC Payload Ethernet Gateway (HPEG) session with payload. (HPEG session provides support for SSH, HTTPS, RDP, CFDP, etc.).
- Other capabilities provided via TReK Desktop (data display, data statistics, traditional telemetry & commanding (CCSDS), etc.)

Note: All capabilities are available on Windows and Linux.

TReK Operational Software Releases through CY2015

Capability	Release	Date	Description	Contents
Ku-IP (Ku-Forward) Capabilities	4.0.0	10-2-2014	This release contains capabilities to access International Space Station payloads using standard network protocols and services. It is suitable for use on the ground and onboard ISS.	• CFDP Application • CFDP Console Application • CFDP Library • Device Services Library • Data Library • HPEG Application • TReK Help Application (Integrated Help)
DTN Capabilities	4.1.0	6-5-2015	This release provides support for Delay Tolerant Networking. It is suitable for use on the ground and onboard ISS.	Adds DTN Capabilities. This release includes all the capabilities from the previous release (4.0.0) with additions and updates for DTN. • All Previous Release Content (4.0.0): • IONconfig Application • IONizer Application • IONizer Library
EXPRESS Capabilities	4.2.0	10-23-2015	This release provides support for the EXPRESS Payload to ISS C&DH System Ethernet interface.	Adds EXPRESS Capabilities. This release includes all the capabilities from the previous release (4.1.0). • All Previous Release Content (4.1.0): • Support for EXPRESS interface.

TReK Schedule information is posted on the TReK Web Site here: http://trek.msfc.nasa.gov/trek_schedule.htm).

TReK 4.1.0 (TReK Toolkit) Content

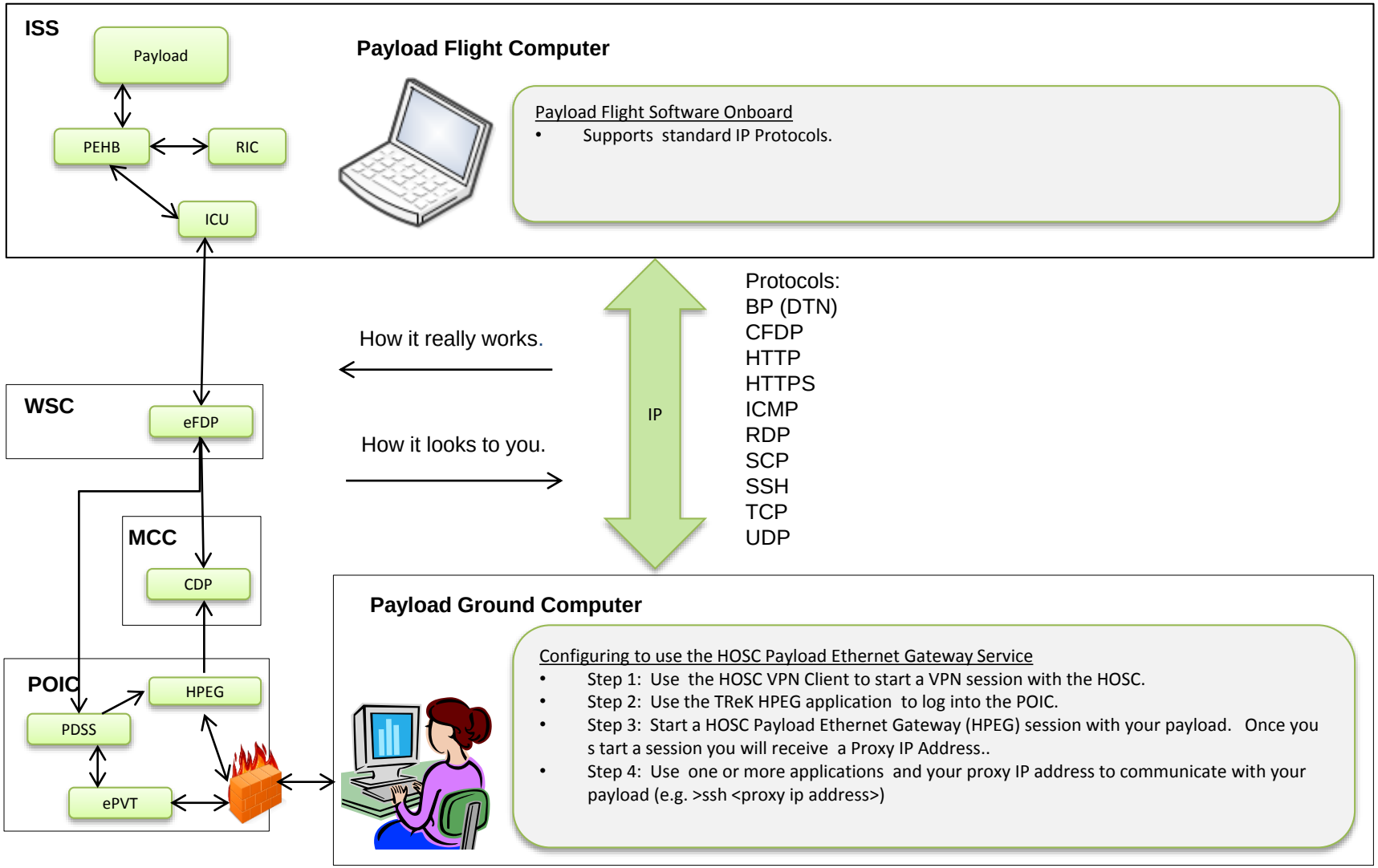
Software	Description
CFDP Application	Provides capabilities to perform file transfer functions using the CCSDS File Delivery Protocol (CFDP) . This application has a graphical user interface. You can choose to use Native CFDP (CFDP using UDP) or ION CFDP (CFDP over BP).
CFDP Console Application	Provides capabilities to perform file transfer functions using the CCSDS File Delivery Protocol (CFDP). This application is a console application targeted for use onboard ISS. It was provided to serve two purposes: (1) a CFDP console application for customers to use right out of the box, and (2) an example program showing customers how to use the CFDP Library to perform common CFDP functions. You can choose to use Native CFDP (CFDP using UDP) or ION CFDP (CFDP over BP).
CFDP Library	Provides an application programming interface to perform file transfer functions using the CCSDS File Delivery Protocol (CFDP). You can choose to use Native CFDP (CFDP using UDP) or ION CFDP (CFDP over BP).
Data Library	Provides an application programming interface to create, populate, build, and decompose packets. Includes support for pre-defined and custom headers and packets.
Device Services Library	Provides an application programming interface to perform functions such as creating sockets, sending data, receiving data, etc. Includes support for Bundle Protocol.
HPEG Application	Provides access to HOSC Payload Ethernet Gateway (HPEG) services. This application has a graphical user interface. It provides the capability to log into the HOSC and request HPEG services. This includes selecting a ground node ID (if applicable), starting and stopping services, and enabling and disabling the HPEG Idle Check. Includes support for DTN.

TReK 4.1.0 (TReK Toolkit) Content Continued

Software	Description
IONconfig Application	Provides the capability to generate ION configuration files and scripts. The scripts (Windows batch files and Linux shell scripts) can be used to start and stop ION. This application has a graphical user interface.
IONizer Application	Provides capabilities to start, stop, and monitor ION. This application has a graphical user interface.
IONizer Library	Provides an application programming interface to start, stop, and monitor ION.
TReK Help Application	Provides integrated help for all TReK applications and libraries.

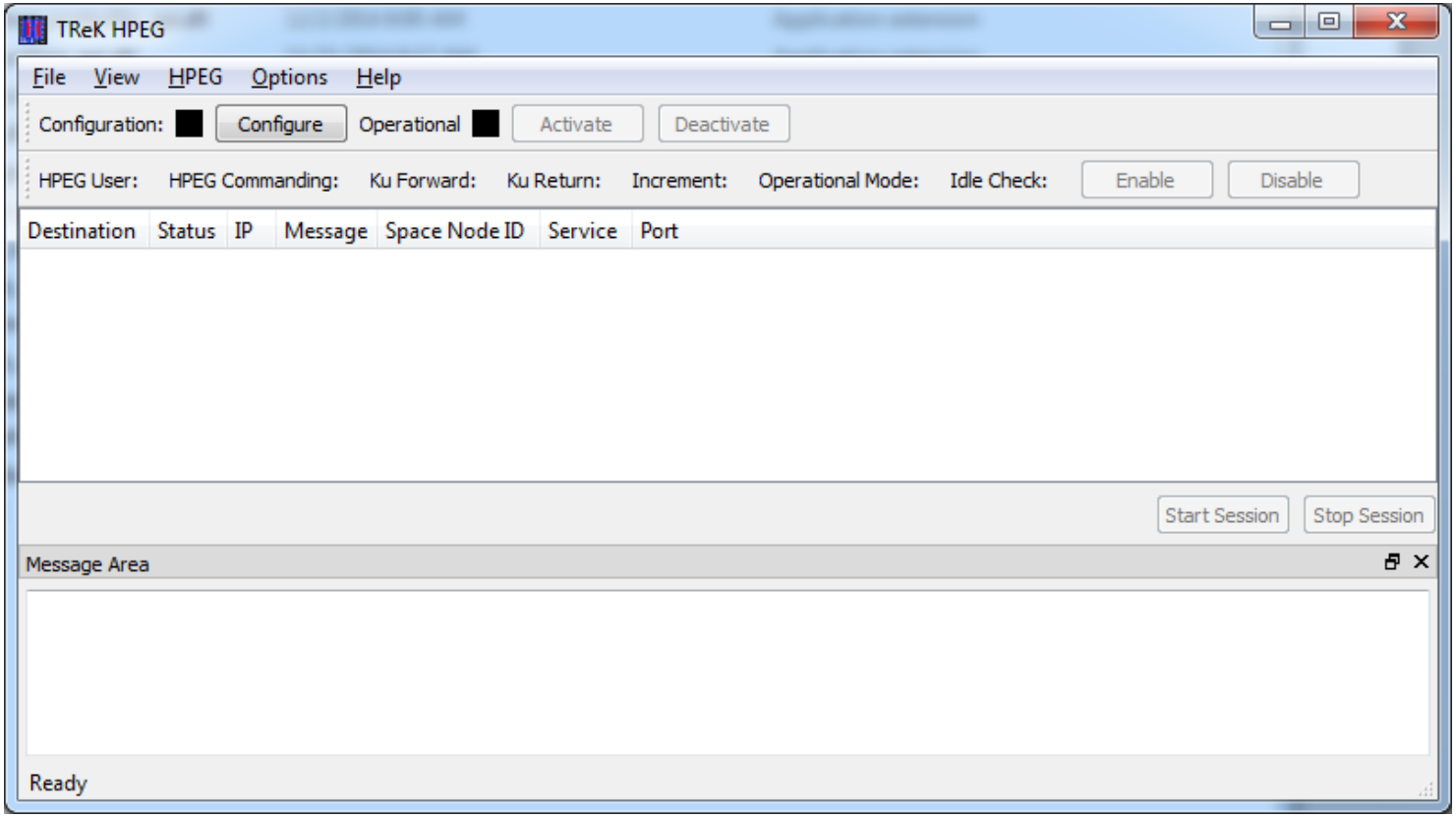
This is the second release of the TReK Toolkit. There will be additional releases that add more capabilities.

Configuring to use HPEG



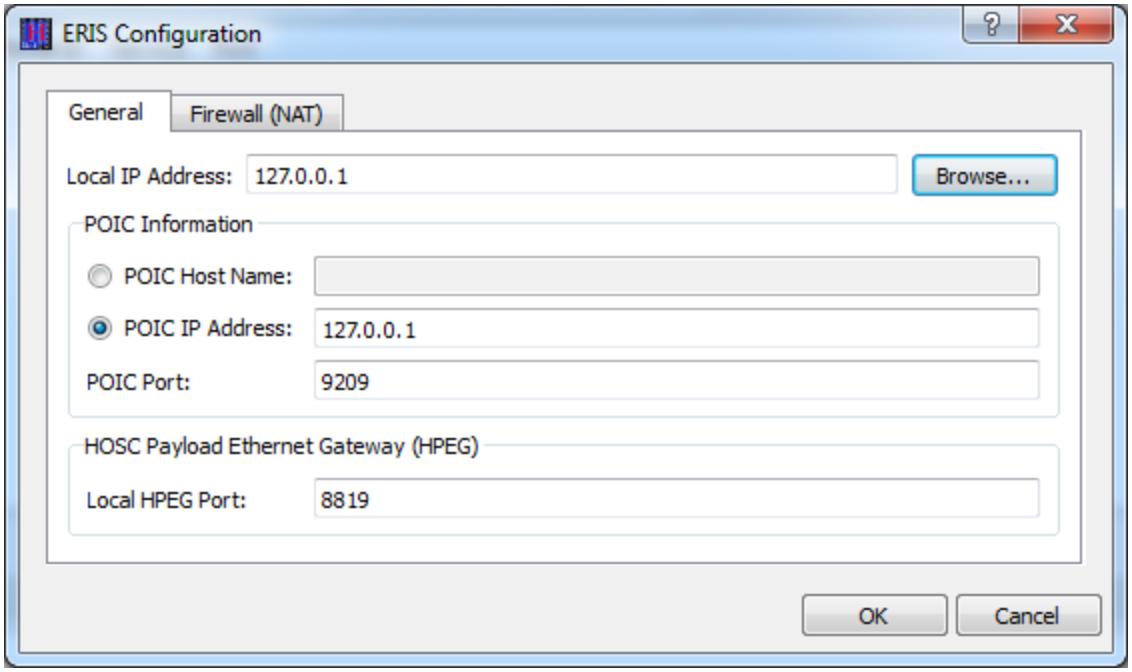
TReK HPEG Main Window

- This is the TReK HPEG application main window. This application is used to access the POIC's HOSC Payload Ethernet Gateway (HPEG) service and start an HPEG session with your payload.



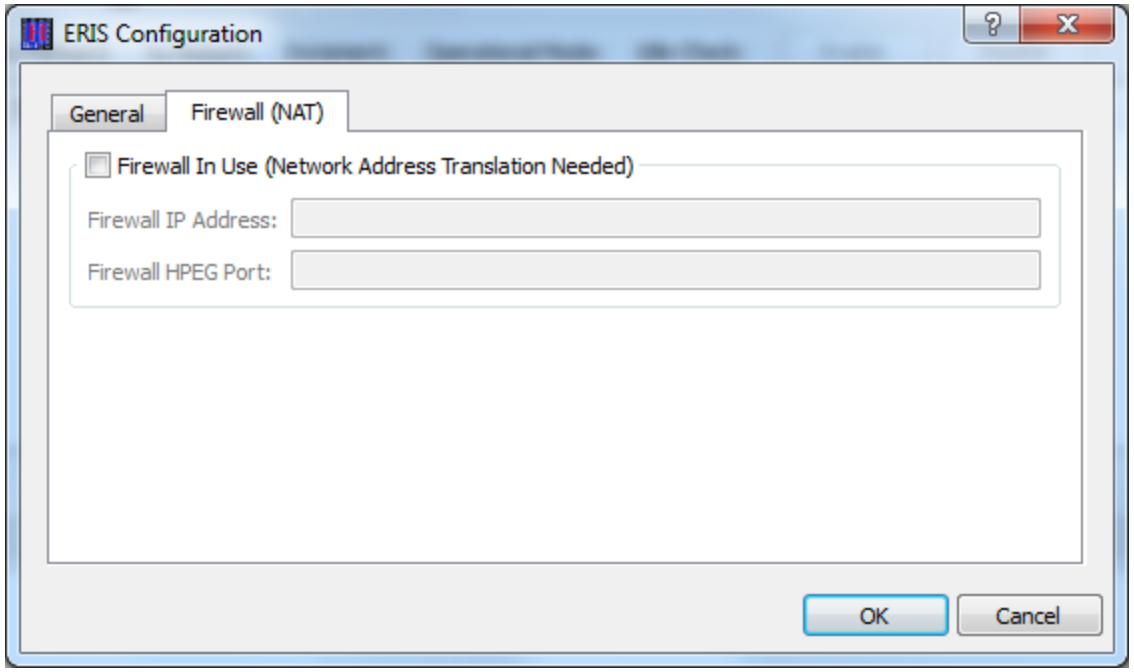
TReK HPEG Configure Dialog

- The Configure dialog provides the capability to enter configuration information needed to use the HPEG service.



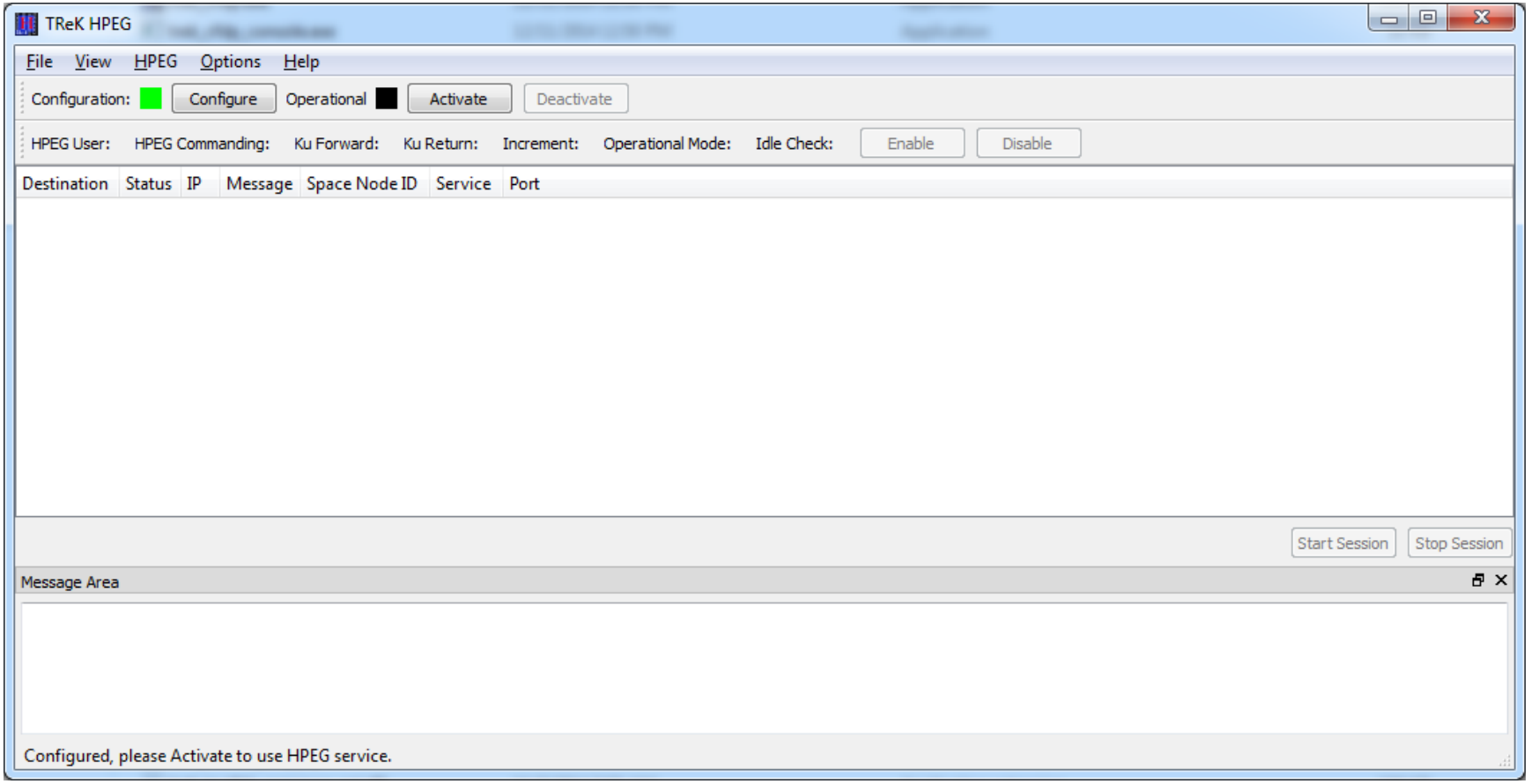
TReK HPEG Configure Dialog

- If you have a firewall and need to enter Network Address Translation information it can be entered on the Firewall tab.



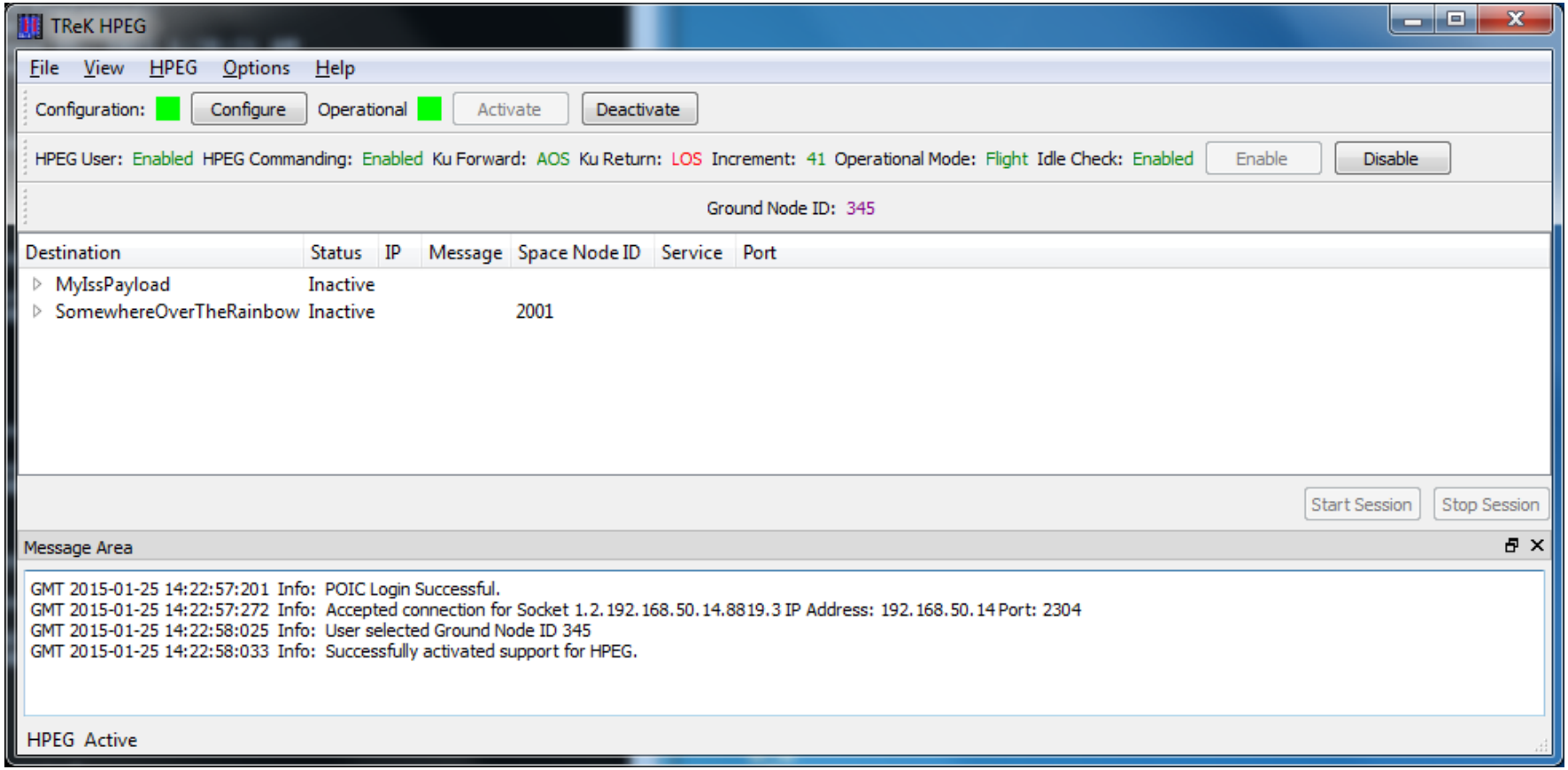
TReK HPEG Configured & Ready to Activate

- When you push the Activate button, a series of prompts will take you through the POIC login process (User ID, Password, Passcode, MOP, etc.). If you are registered to use CFDP or DTN this will include a prompt for Ground Node ID.



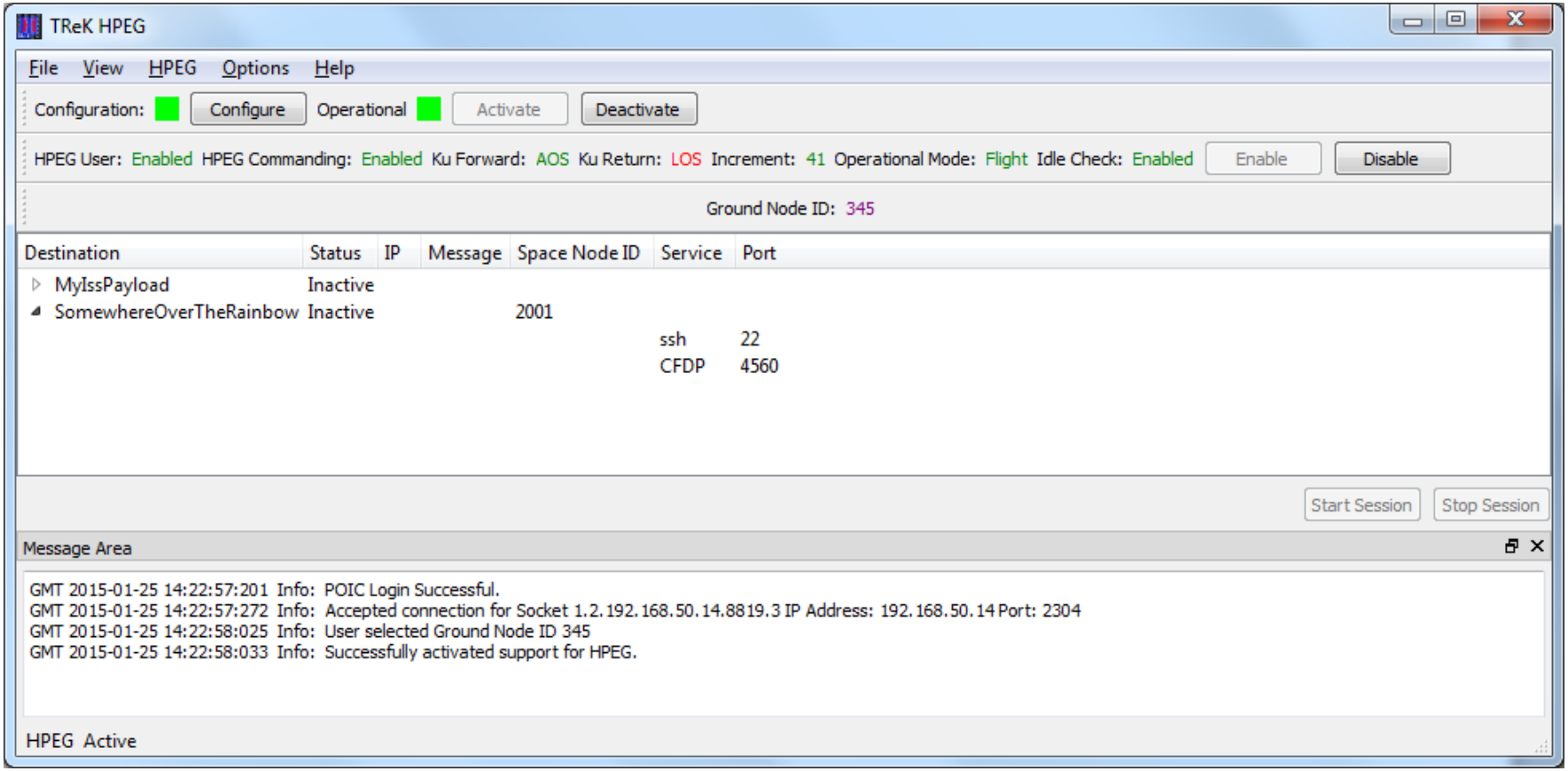
TReK HPEG Main Window

- This is the TReK HPEG application after a successful POIC login. This user has two payloads onboard: MyIssPayload and SomewhereOverTheRainbow.



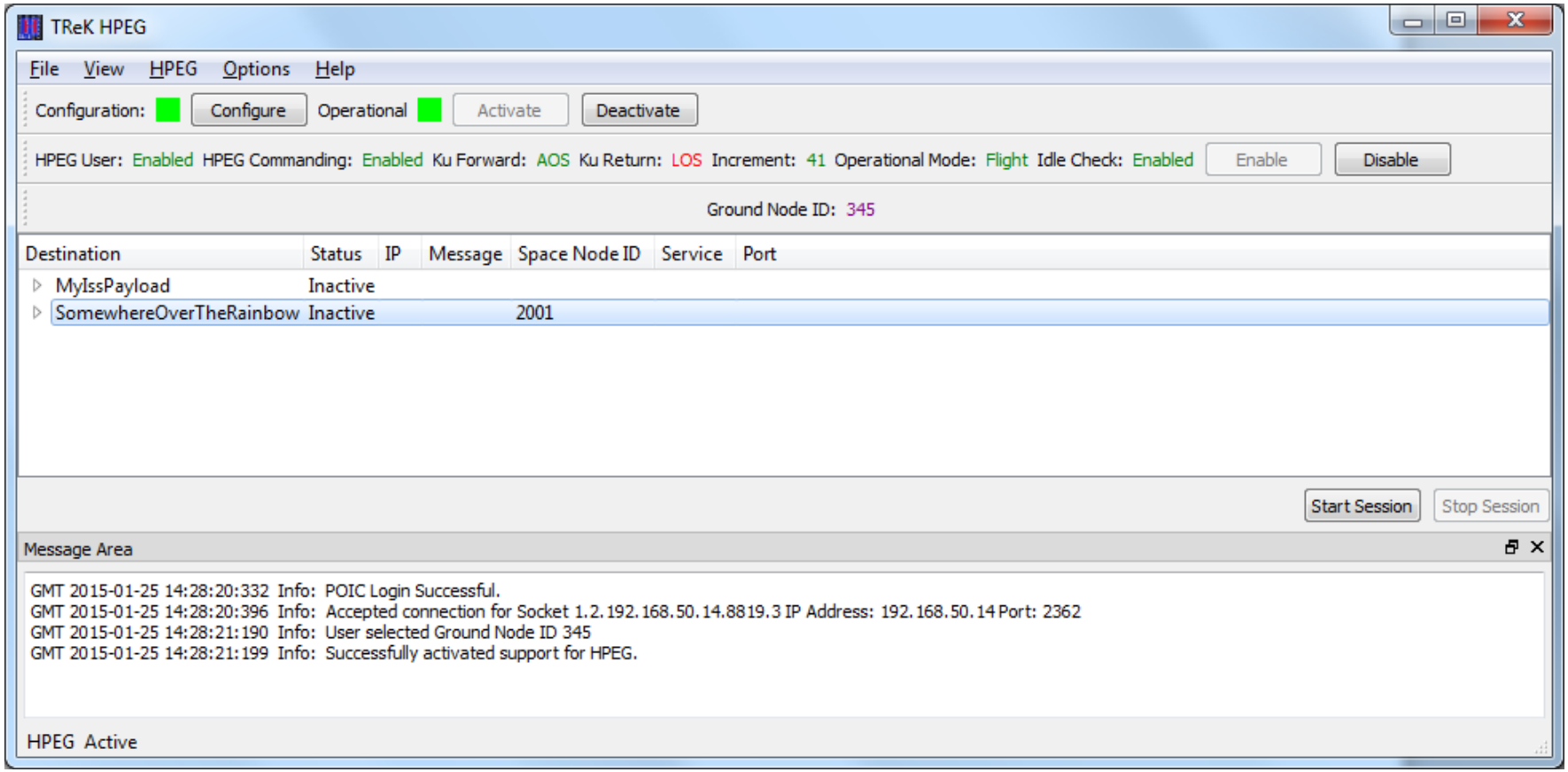
TReK HPEG Main Window

- In this picture, you can see the IP protocols that are available for use with the SomewhereOverTheRainbow payload.



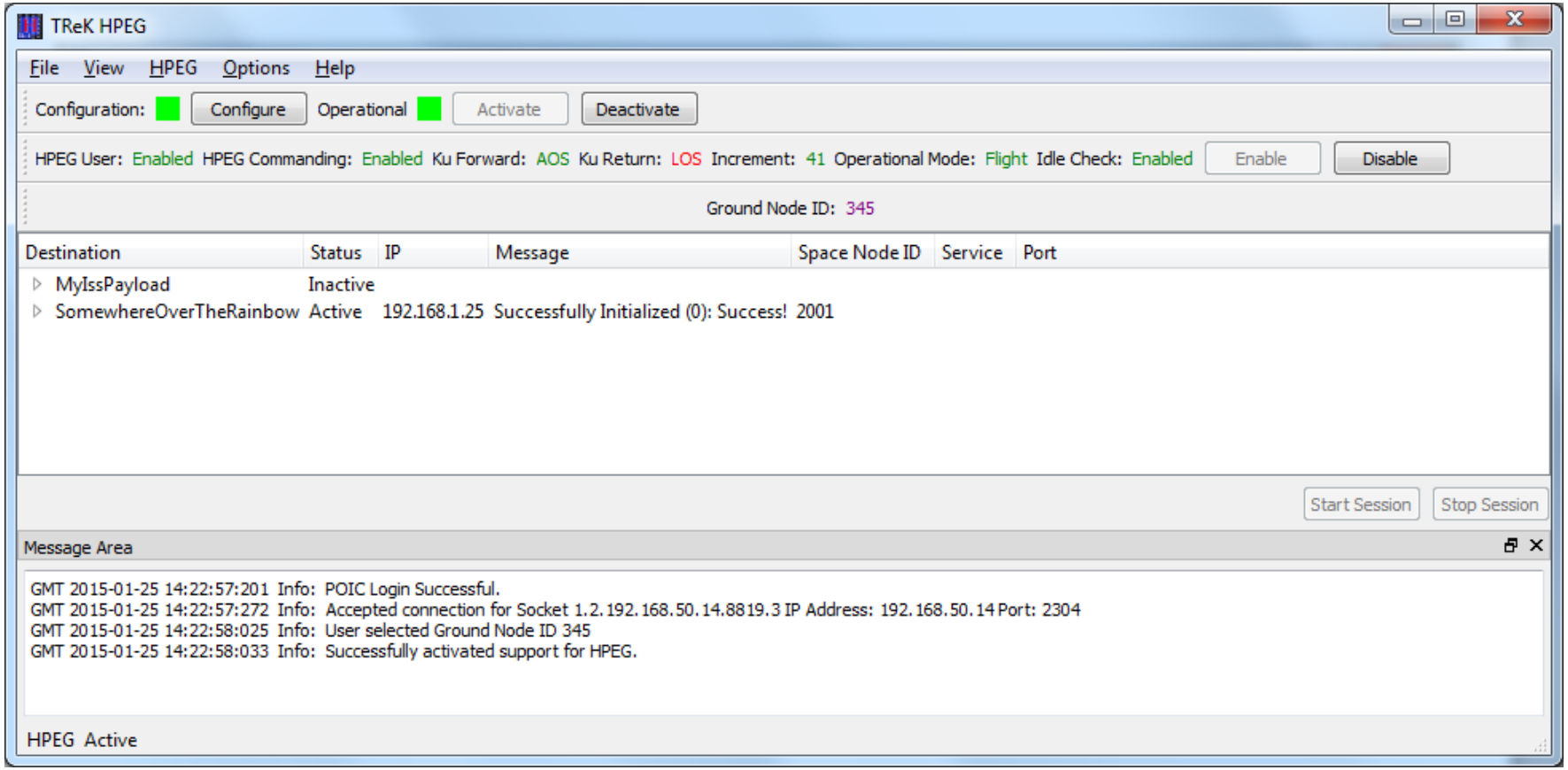
TReK HPEG Main Window

- In this picture, you can see the SomewhereOverTheRainbow destination is selected, and the Start Session button is available.



TReK HPEG Main Window

- This picture shows an active session with the SomewhereOverTheRainbow destination. You can see the Proxy IP address in the IP column.



CFDP

- The CFDP protocol provides reliable transfer of files from one computer to another, and has been designed to work well over space links. It can be used to perform space to ground, ground to space, space to space, and ground to ground file transfers.

- CFDP requires a sender and a receiver. The sender and receiver must be configured and running at the same time to perform a file transfer. Each party is referred to as an "Entity". The sender is an entity and the receiver is an entity. Each "Entity" must have a unique Entity ID. For example:

- If you choose to use the CFDP service, you will be given an Entity ID to use on your payload computer and an Entity ID to use on your ground computer. These are referred to as a Space Node ID and a Ground Node ID.

CFDP Options

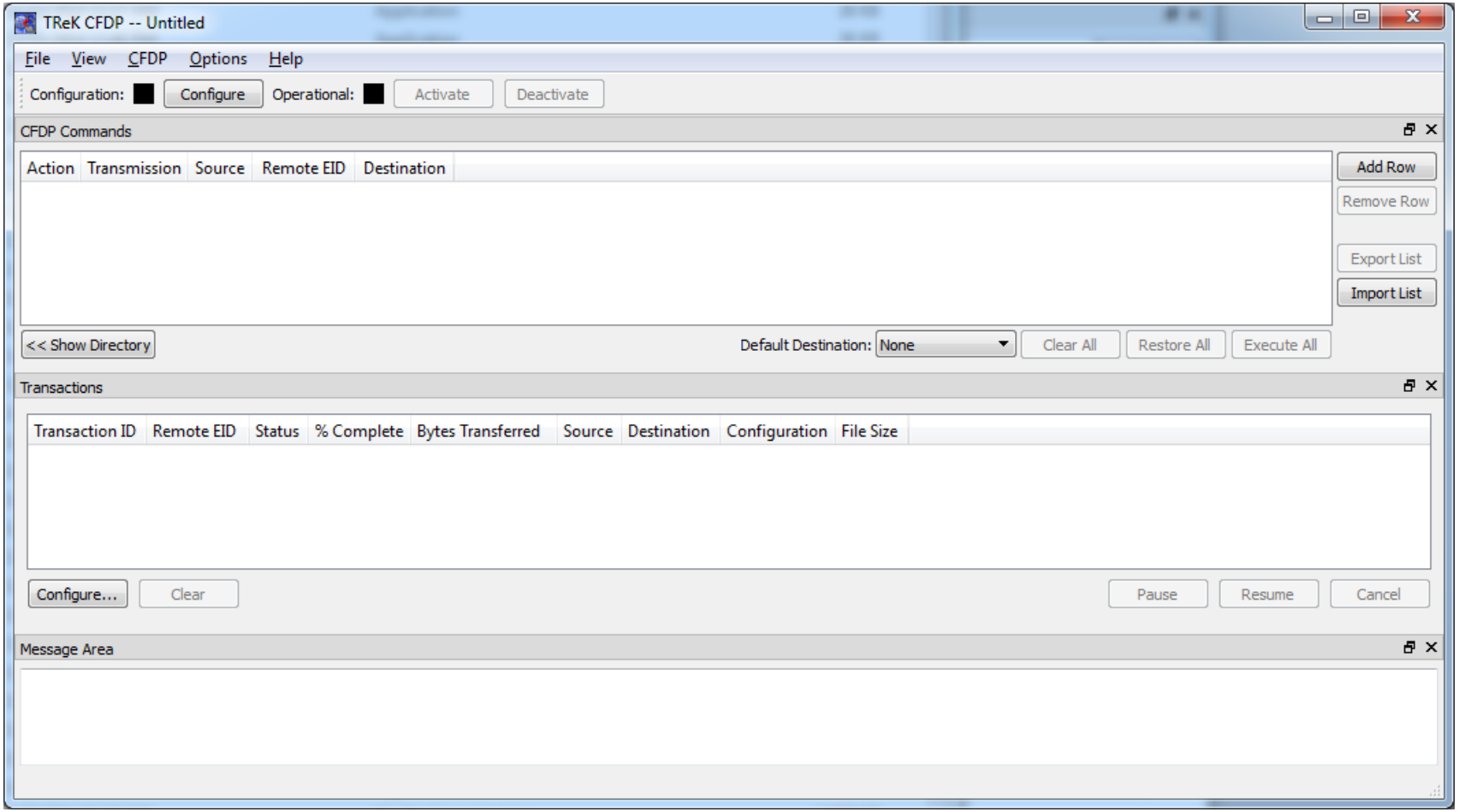
- The TReK CFDP software provides support for CFDP over User Datagram Protocol (UDP) and CFDP over Bundle Protocol (BP).
- The CFDP over UDP configuration option is referred to as Native CFDP.
- In the Native CFDP configuration, the software uses UDP sockets with the Goddard Space Flight Center (GSFC) CFDP library that performs the CFDP work.
- The CFDP over BP configuration option is referred to as ION CFDP.
- In the ION CDFP configuration, the software communicates with the Jet Propulsion Lab (JPL) Interplanetary Overlay Network (ION) Delay Tolerant Networking (DTN) software which performs all the CFDP work.

CFDP Directives Supported

- The TReK CFDP software currently supports multiple CFDP Directives based on how the software is configured.

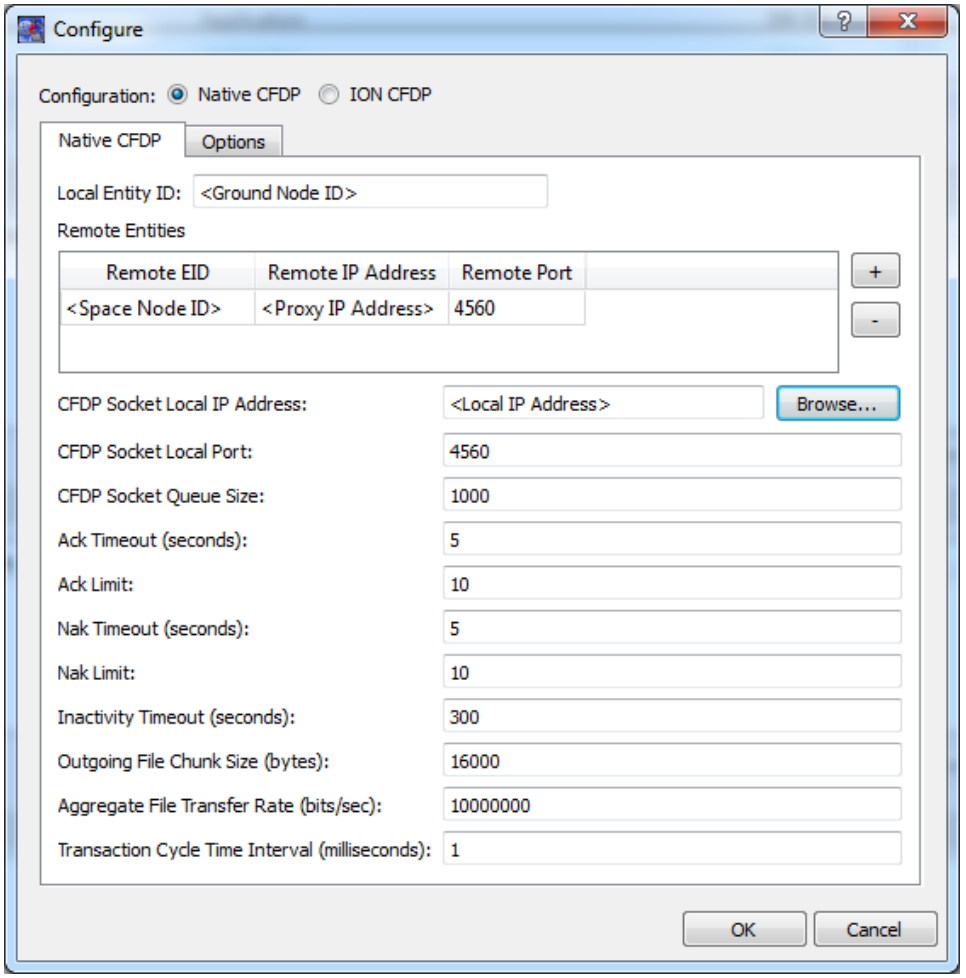
Directive	Description	Native	ION
append_file	append a file at the remote entity to another file at the remote entity.		✓
create_dir	create a directory at the remote entity.		✓
create_file	create an empty file at the remote entity.		✓
delete_file	delete a file at the remote entity.		✓
deny_dir	delete a directory at the remote entity. (like *remove_dir*, but does not fail if the directory does not exist)		✓
deny_file	delete a file at the remote entity. (like *delete_file*, but does not fail if the file does not exist)		✓
get	copy one file from the remote entity to the local entity.	✓	✓
message	send a text string to the remote entity.		✓
put	copy one file from the local entity to the remote entity.	✓	✓
remove_dir	delete a directory at the remote entity.		✓
rename_file	rename a file at the remote entity.		✓
replace_file	replace a file at the remote entity with another file at the remote entity.		✓

TReK CFDP Main Window



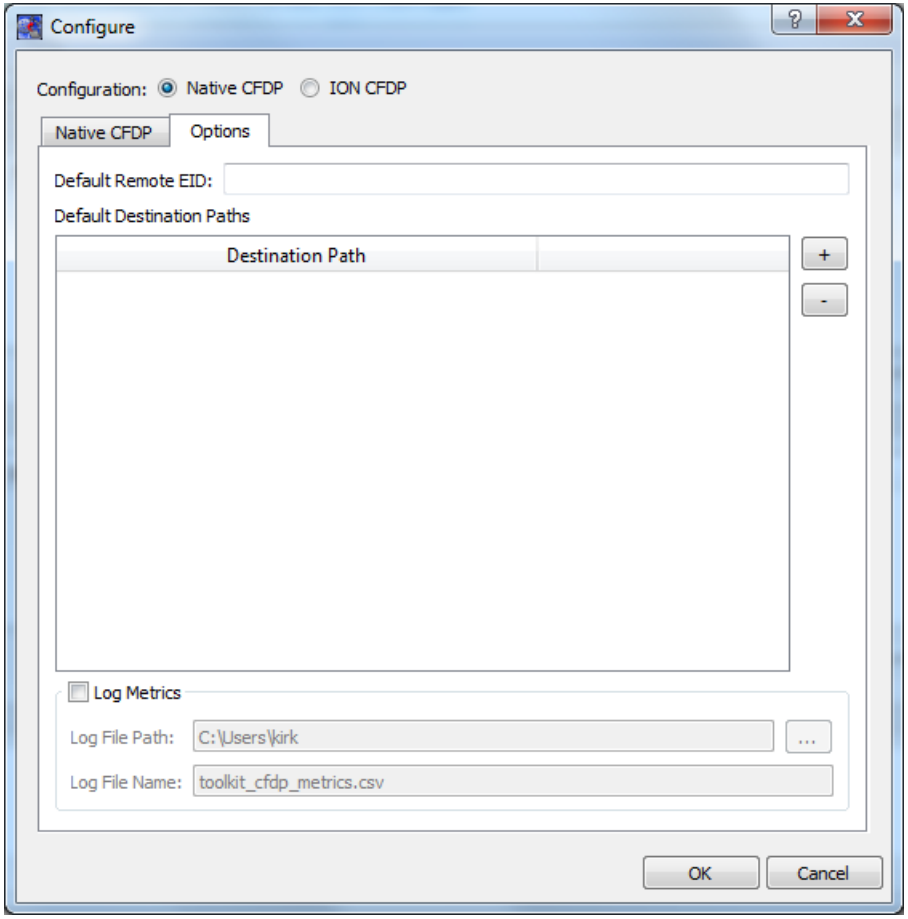
CFDP Configure Dialog

- Ground Configuration

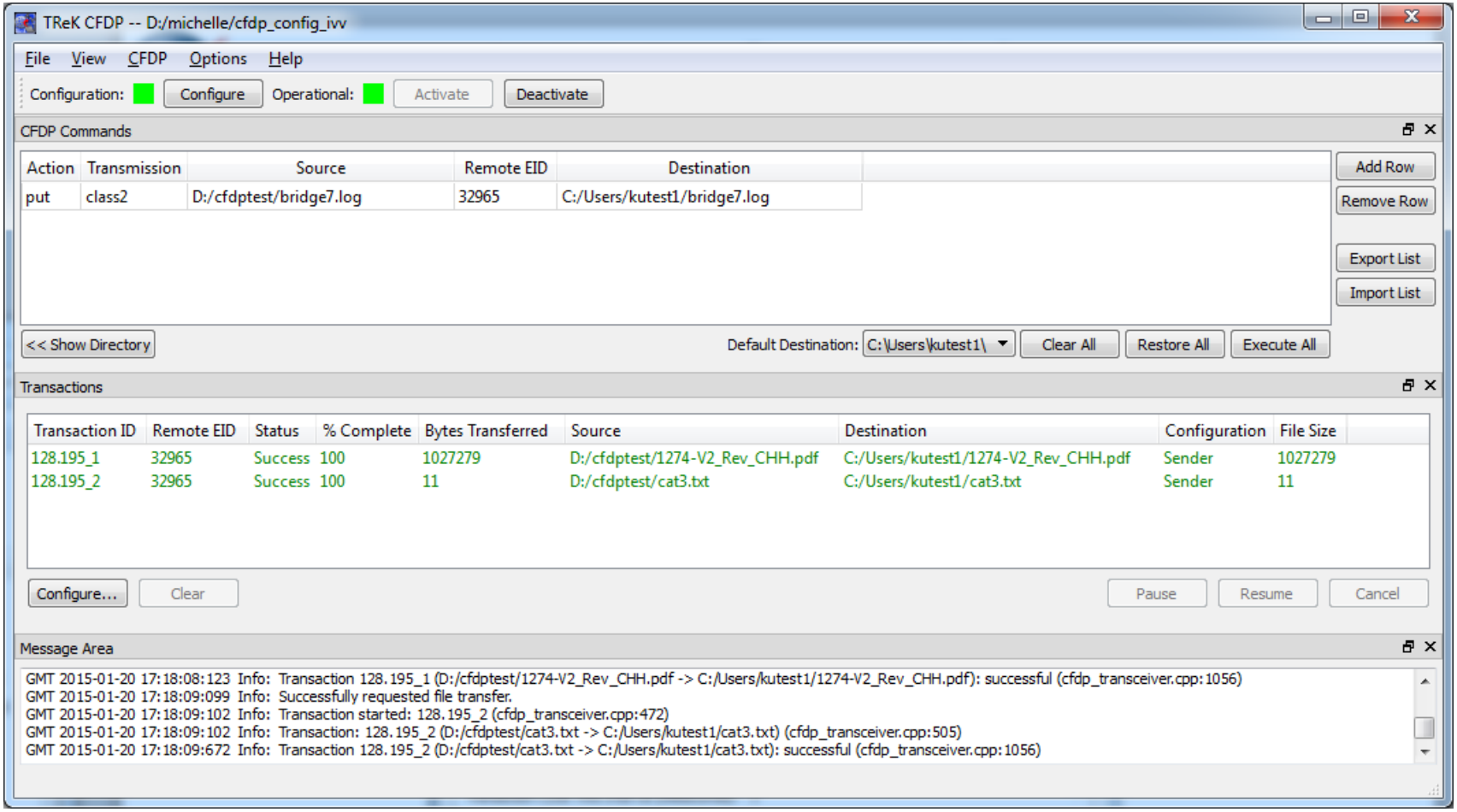


CFDP Configure Dialog

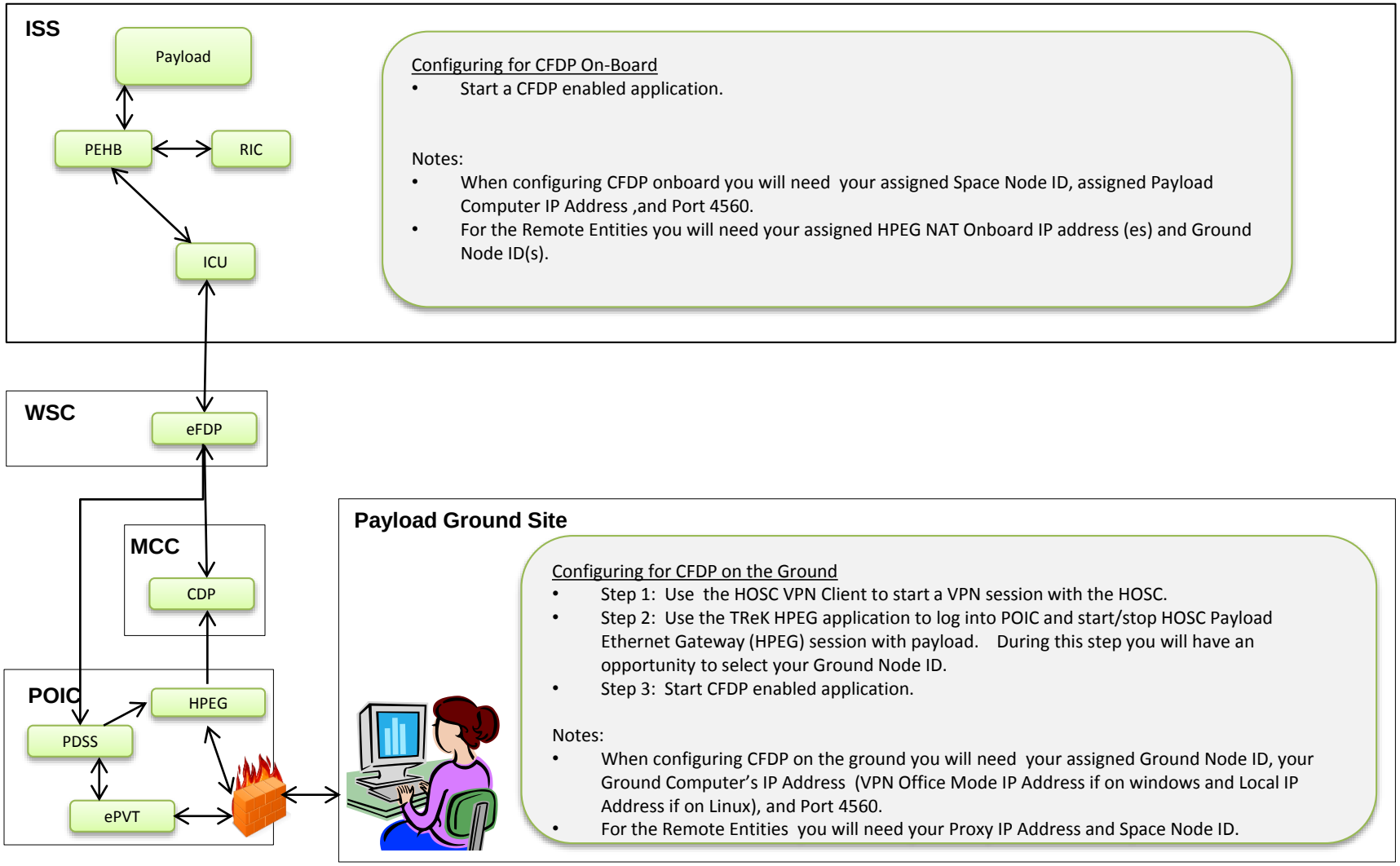
- If you fill in the Default Remote EID and a Default Destination Path, this provides a way for the software to fill in these values when you use drag and drop.



CFDP Main Window



Configuring to use Native CFDP



Configuring for CFDP On-Board

- Start a CFDP enabled application.

Notes:

- When configuring CFDP onboard you will need your assigned Space Node ID, assigned Payload Computer IP Address ,and Port 4560.
- For the Remote Entities you will need your assigned HPEG NAT Onboard IP address (es) and Ground Node ID(s).

Configuring for CFDP on the Ground

- Step 1: Use the HOSC VPN Client to start a VPN session with the HOSC.
- Step 2: Use the TReK HPEG application to log into POIC and start/stop HOSC Payload Ethernet Gateway (HPEG) session with payload. During this step you will have an opportunity to select your Ground Node ID.
- Step 3: Start CFDP enabled application.

Notes:

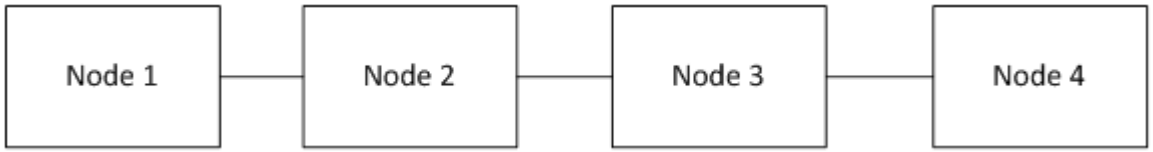
- When configuring CFDP on the ground you will need your assigned Ground Node ID, your Ground Computer's IP Address (VPN Office Mode IP Address if on windows and Local IP Address if on Linux), and Port 4560.
- For the Remote Entities you will need your Proxy IP Address and Space Node ID.

Delay Tolerant Network (DTN)

- A Delay Tolerant Network provides capabilities to communicate over networks where connectivity is not continuous or there is a long delay in communications.
- Delay or disruption in any path can cause problems in the transfer of data.
- The flight and payload computers of space systems must often build specialized code to store the data during periods of disruption and send it when a transmission link becomes available.
- If data is identified as lost on the receiving end, a means of requesting the retransmission of lost data must be provided.
- DTN can address these issues and alleviate the need for this type of work.

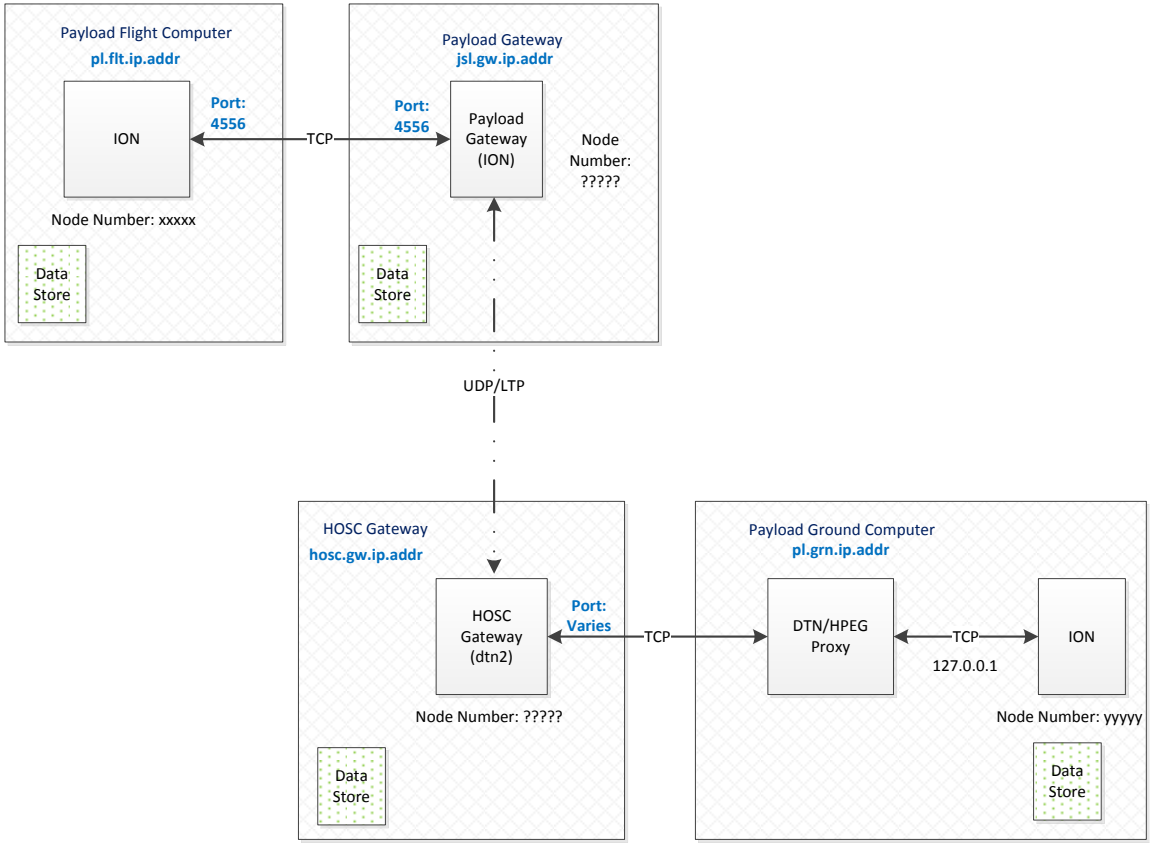
DTN Example

- A delay tolerant network is composed of multiple computers or nodes.
- Data sent between nodes are called bundles.
- Each node has the knowledge of other nodes with which it may directly communicate and when those communication links are available.



- Node 1 only knows how to communicate with Node 2.
- Node 1 knows when the communication link is available for Node 2.
- If Node 1 needs to send data (bundles) to either Node 3 or Node 4, then it must send the bundle through a gateway. In this case the gateway is Node 2. Any DTN node that routes data from one DTN node to another DTN node is considered a gateway.
- Node 1 does not need to know when the communication links are available from Node 2 to Node 3 or Node 3 to Node 4. It only knows that by sending the bundles to Node 2 the bundles will get to the other nodes.
- DTN can be used as a store and forward network since end-to-end communication is not always possible. A node can send bundles to another node that will store the bundles until it is possible to forward it to the next node.

ISS DTN Configuration

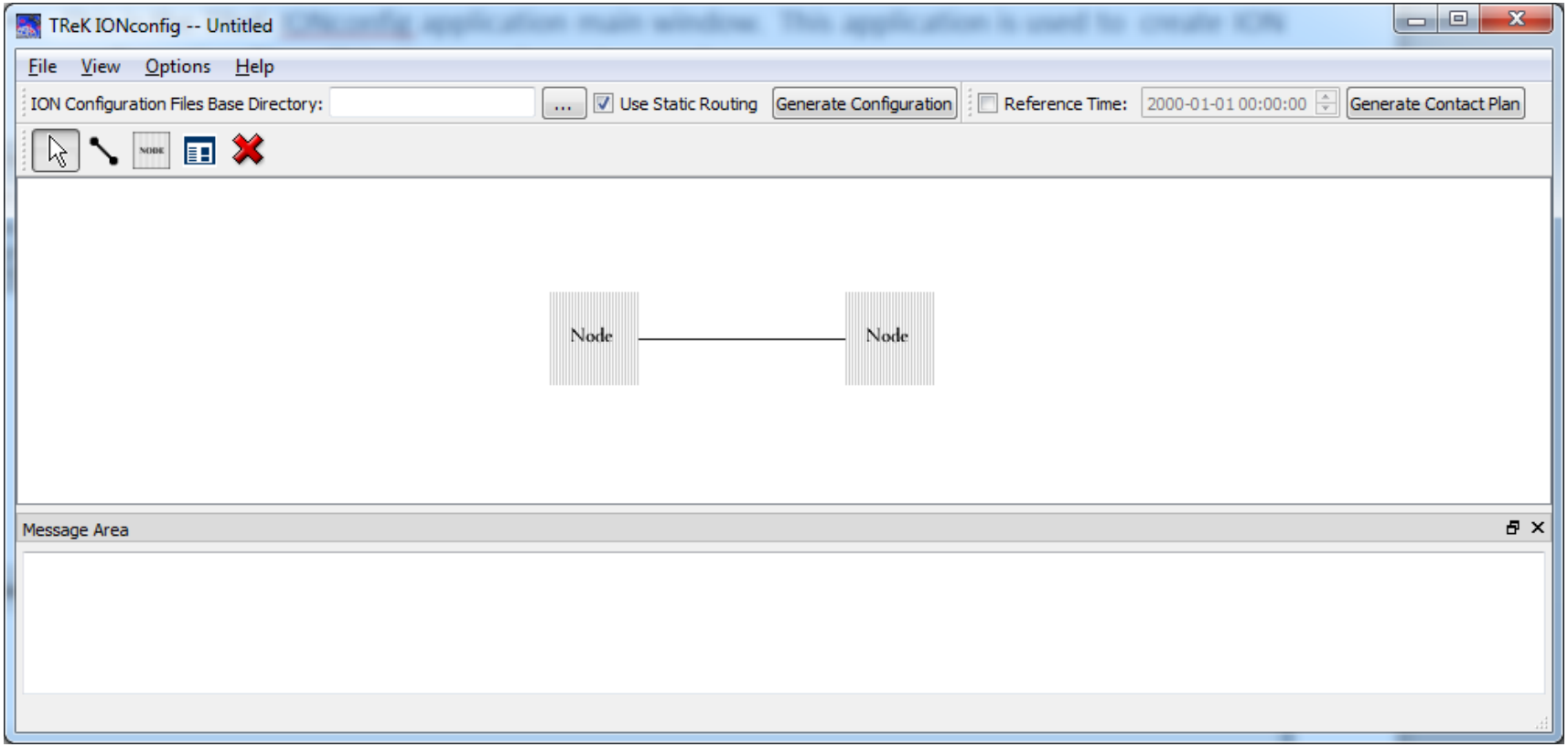


Example Steps for a Payload Using DTN (ION)

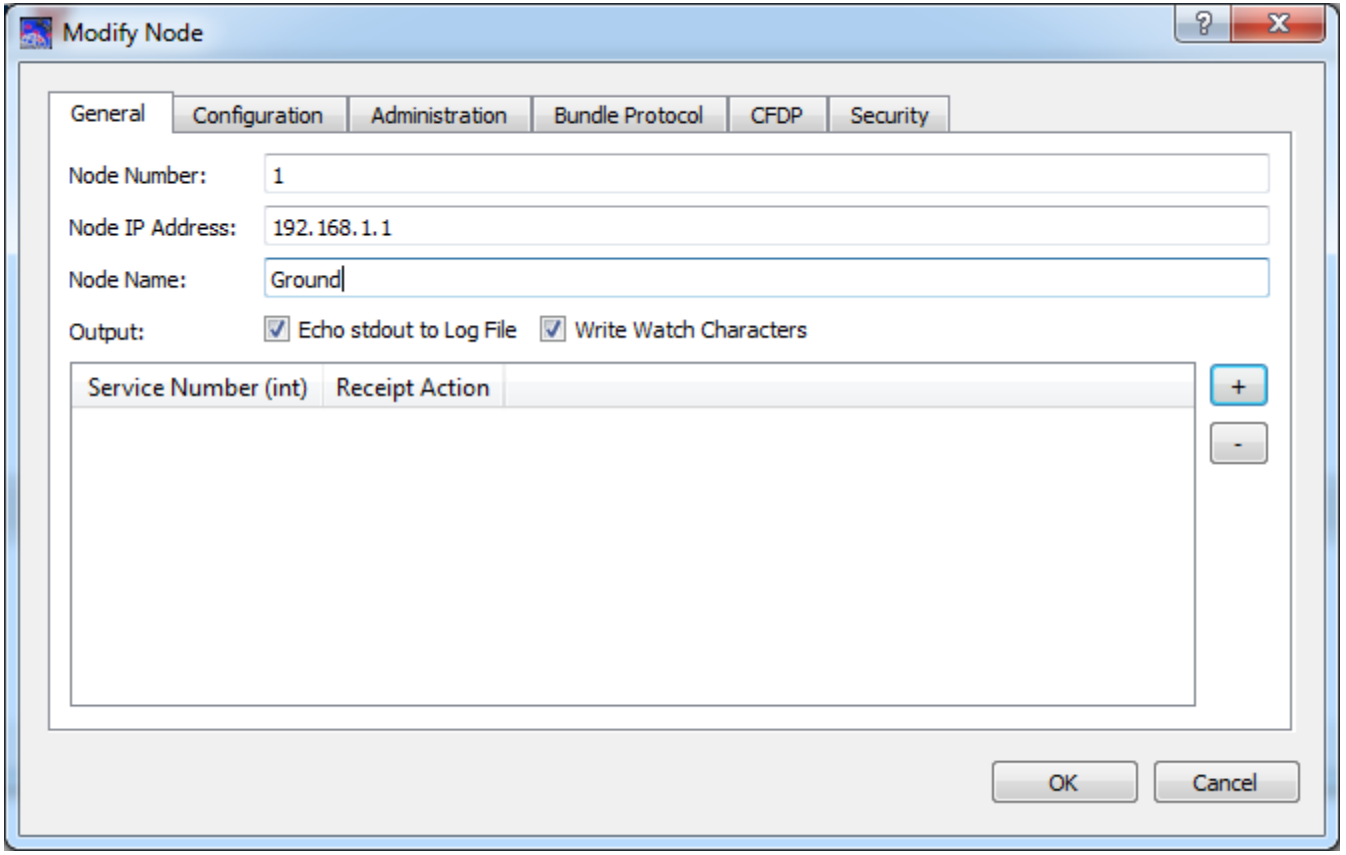
- Step 1: Generate ION Configuration Files (TReK IONconfig)
- Step 2: Run the ION Software (TReK IONizer, IONizer API, startion.bat/startion.sh)
- Step 3: Run one or more DTN Enabled Application (e.g. TReK CFDP over BP, other DTN applications).

TReK IONconfig Application

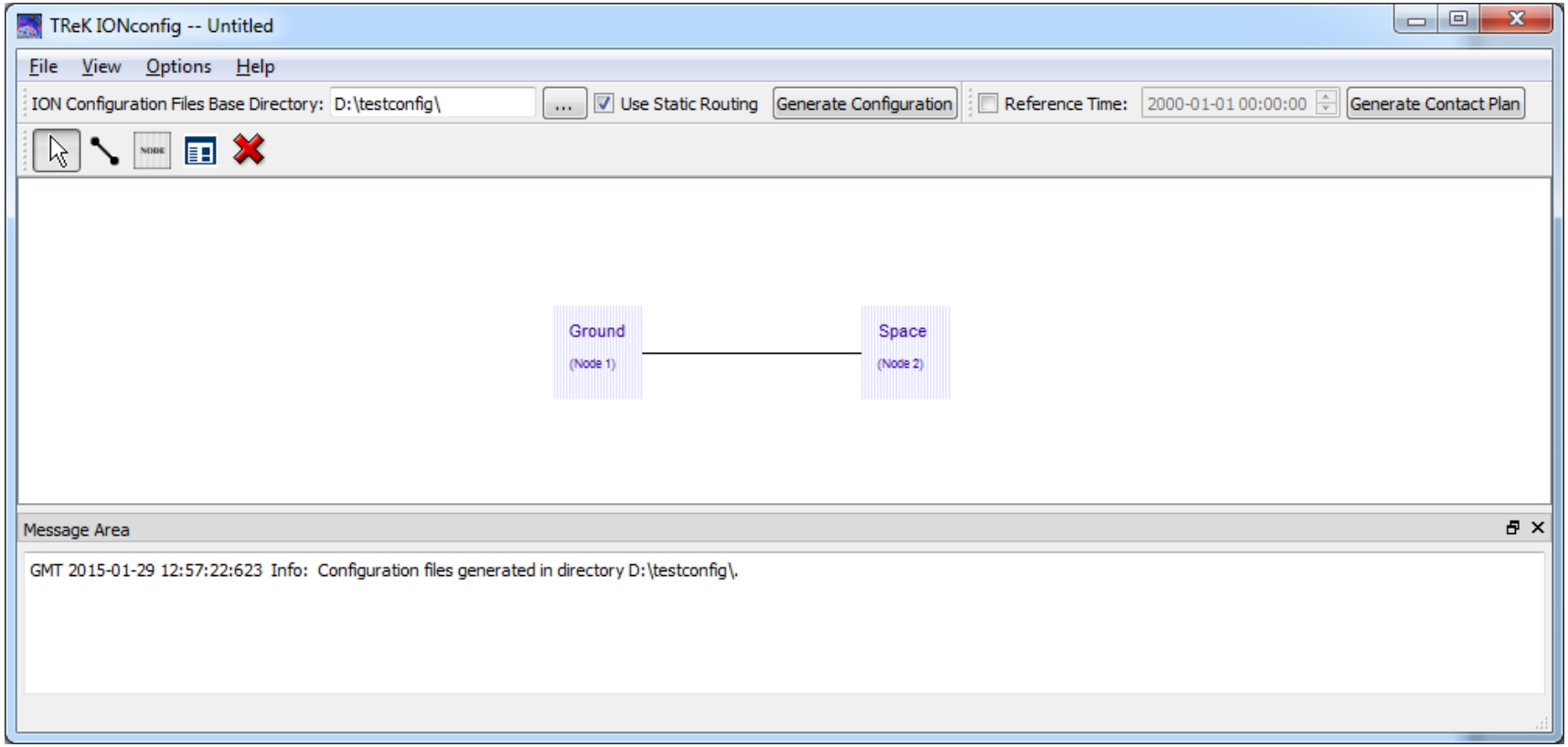
- This is the TReK IONconfig application main window. This application is used to create ION configuration files. This diagram shows two nodes.

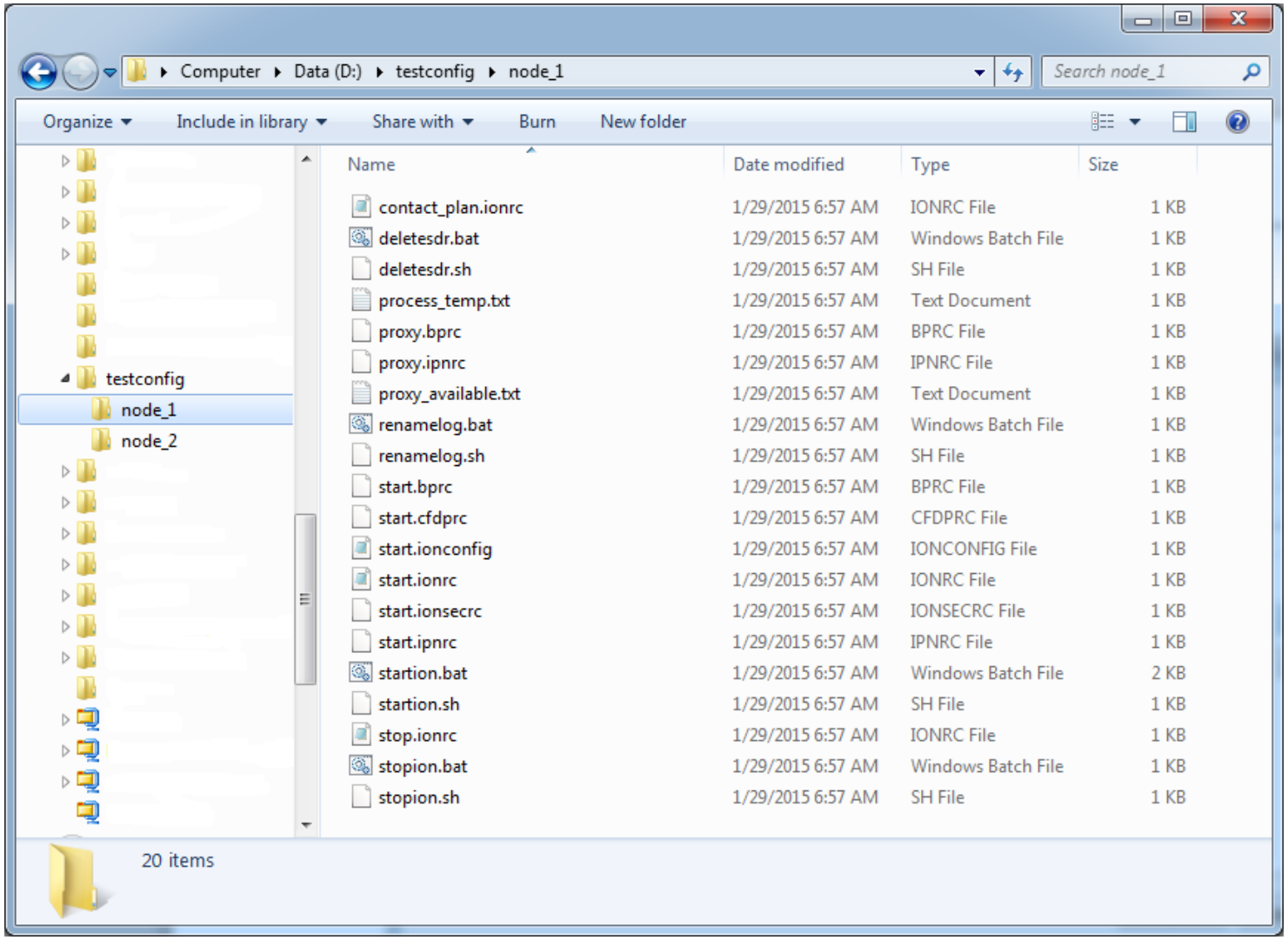


IONconfig Modify Node Dialog



TReK IONconfig Application




Computer ▸ Data (D:) ▸ testconfig ▸ node_1
Search node_1
Organize
Include in library
Share with
Burn
New folder
testconfig
node_1
node_2
Name
Date modified
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Size
contact_plan.ionrc 1/29/2015 6:57 AM IONRC File 1 KB
deletesdr.bat 1/29/2015 6:57 AM Windows Batch File 1 KB
deletesdr.sh 1/29/2015 6:57 AM SH File 1 KB
process_temp.txt 1/29/2015 6:57 AM Text Document 1 KB
proxy.bprc 1/29/2015 6:57 AM BPRC File 1 KB
proxy.ipnrc 1/29/2015 6:57 AM IPNRC File 1 KB
proxy_available.txt 1/29/2015 6:57 AM Text Document 1 KB
renamelog.bat 1/29/2015 6:57 AM Windows Batch File 1 KB
renamelog.sh 1/29/2015 6:57 AM SH File 1 KB
start.bprc 1/29/2015 6:57 AM BPRC File 1 KB
start.cfdprc 1/29/2015 6:57 AM CFDPRC File 1 KB
start.ionconfig 1/29/2015 6:57 AM IONCONFIG File 1 KB
start.ionrc 1/29/2015 6:57 AM IONRC File 1 KB
start.ionsecrc 1/29/2015 6:57 AM IONSECRC File 1 KB
start.ipnrc 1/29/2015 6:57 AM IPNRC File 1 KB
startion.bat 1/29/2015 6:57 AM Windows Batch File 2 KB
startion.sh 1/29/2015 6:57 AM SH File 1 KB
stop.ionrc 1/29/2015 6:57 AM IONRC File 1 KB
stopion.bat 1/29/2015 6:57 AM Windows Batch File 1 KB
stopion.sh 1/29/2015 6:57 AM SH File 1 KB
20 items

Files Generated By IONconfig for a Node

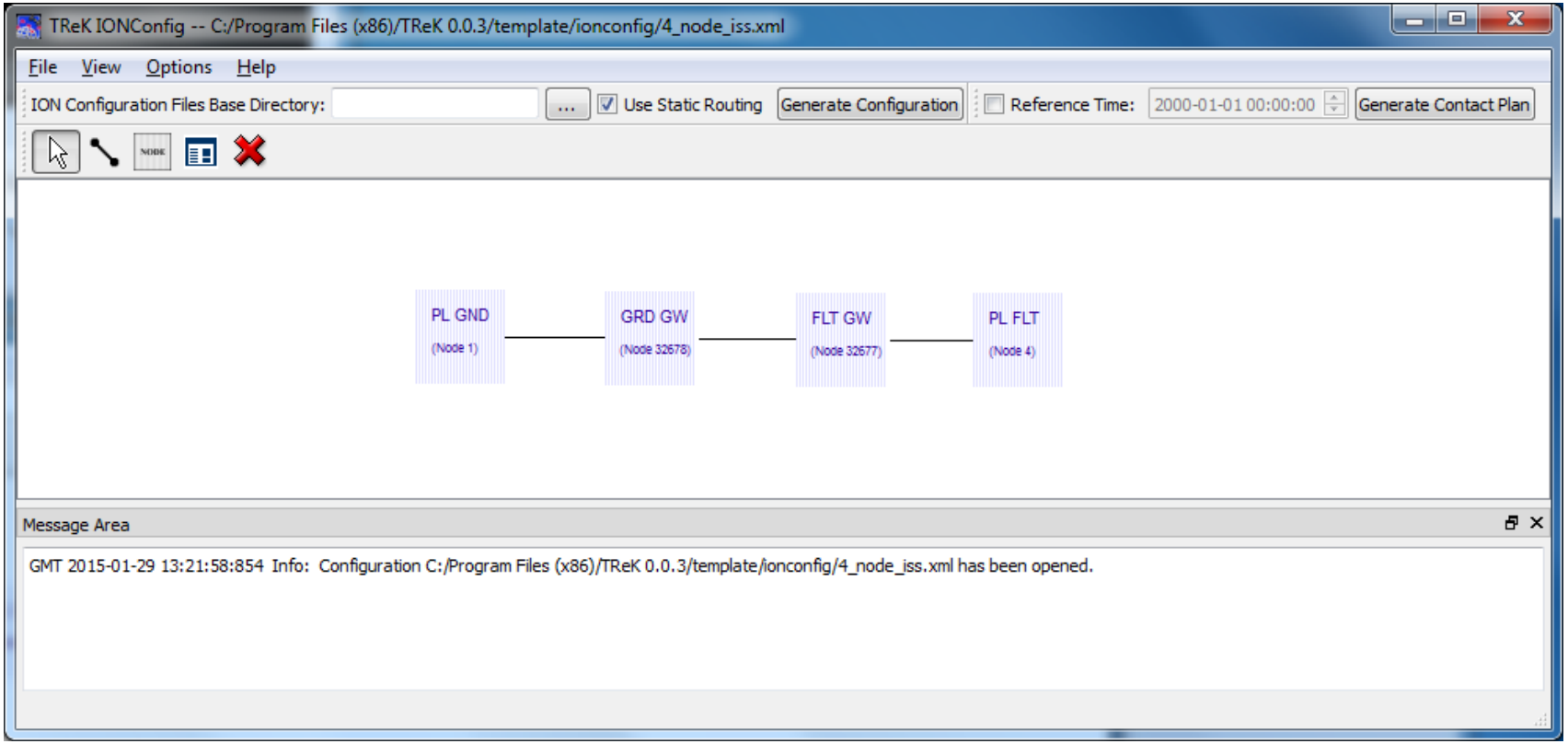
ION Configuration File	Description
contact_plan.ionrc	Contact plan for the entire network. This plan is only used for nodes with LTP. The ground and payload nodes will use static routing.
proxy.bprc	For nodes where a proxy is used, this file replaces the start.bprc file.
proxy.ipnrc	For nodes where a proxy is used, this file replaces the start.ipnrc file.
start.bprc	Configuration information for the Bundle Protocol. The only changes expected for some payloads is the addition of unique service numbers for DTN enabled applications (NOTE: CFDP and echo service numbers are automatically generated as needed).
start.cfdprc	Configuration information for the CFDP protocol. The defaults provided should be sufficient.
start.ionconfig	Configuration information for the SDR. The location and size of the SDR should be changed from the defaults.
start.ionrc	Configuration information for ION. The provided defaults should be sufficient.
start.ionsecrc	Configuration information for ION security. Only starts the security service to prevent unnecessary message logging.
start.ipnrc	Configuration information for routing bundles. All of the information in this file is generated automatically including static routing of bundles as needed.
stop.ionrc	Configuration file needed to properly shut down ION without errors.

Files Generated By IONconfig for a Node

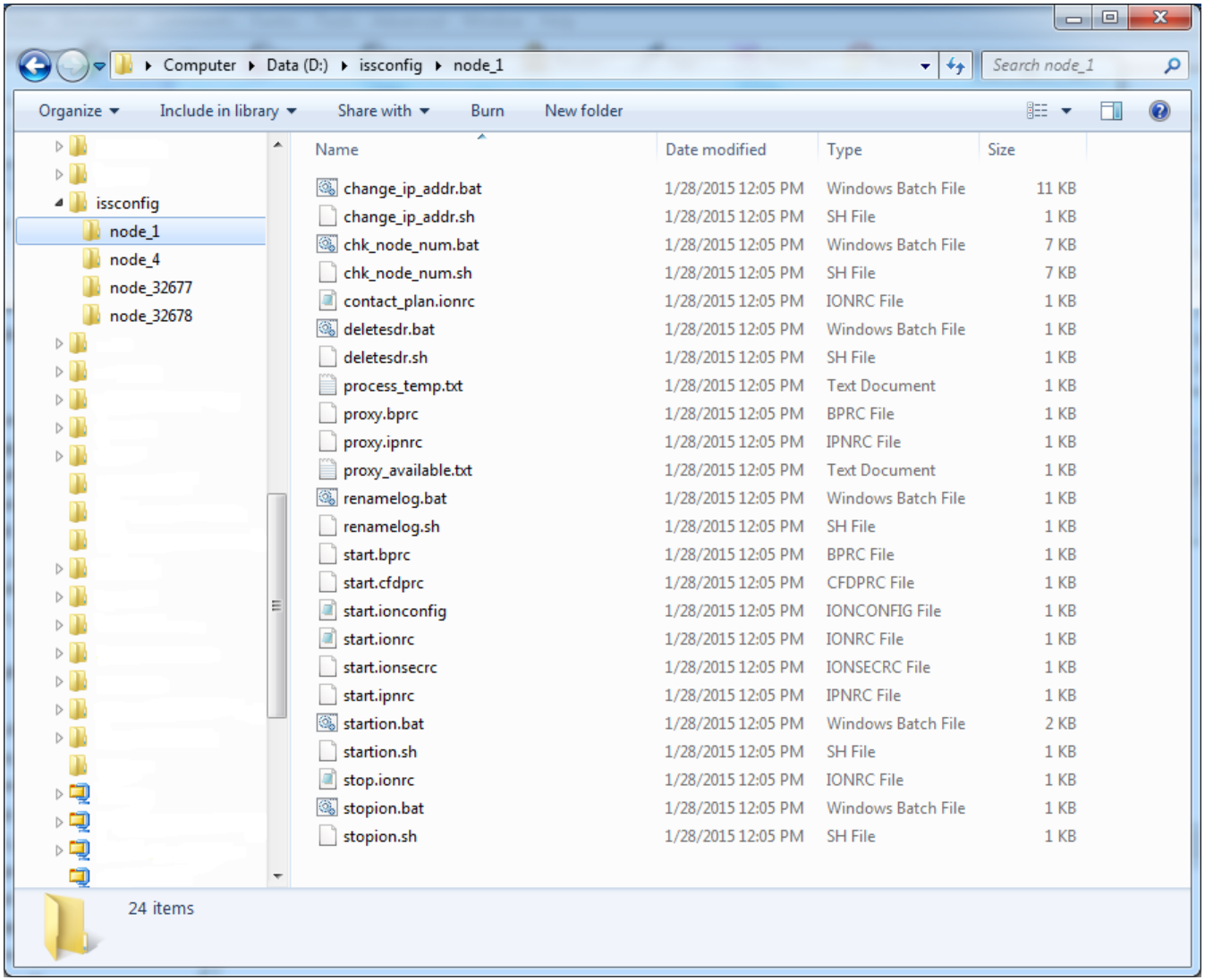
Other Files	Description
change_ip_addr.bat/change_ip_addr.sh	These scripts are used to change IP addresses when reconnecting to the HPEG system.
chk_node_num.bat/chk_node_num.sh	For nodes connecting to the HOSC DTN node, these scripts ensure that the node numbers used in the configuration are compatible with the node numbers identified by the HOSC interface.
deletesdr.bat/deletesdr.sh	Operating specific script to delete the SDR for a node. This script should only be executed when the SDR is corrupted.
process_temp.txt	A text file containing a list of all of the expected processes based on the ION configuration information. TReK will use this list to monitor for missing processes.
proxy_available.txt	A text file containing either YES or NO to indicate a proxy is available for this configuration.
renamelog.bat/renamelog.sh	Operating specific script to rename the ION log file. The file is renamed to include a timestamp and a new ion.log file is generated.
startion.bat/startion.sh	Operating specific script to start the ION processes. This script is used by the TReK IONizer application and can also be run from the command line.
stopion.bat/stopion.sh	Operating specific script to stop the ION processes.

TReK IONconfig Application

- This diagram shows the ISS DTN configuration. You can use this configuration to produce the ION configuration files you need for your onboard node and your ground node. TReK provides a template file for this configuration.

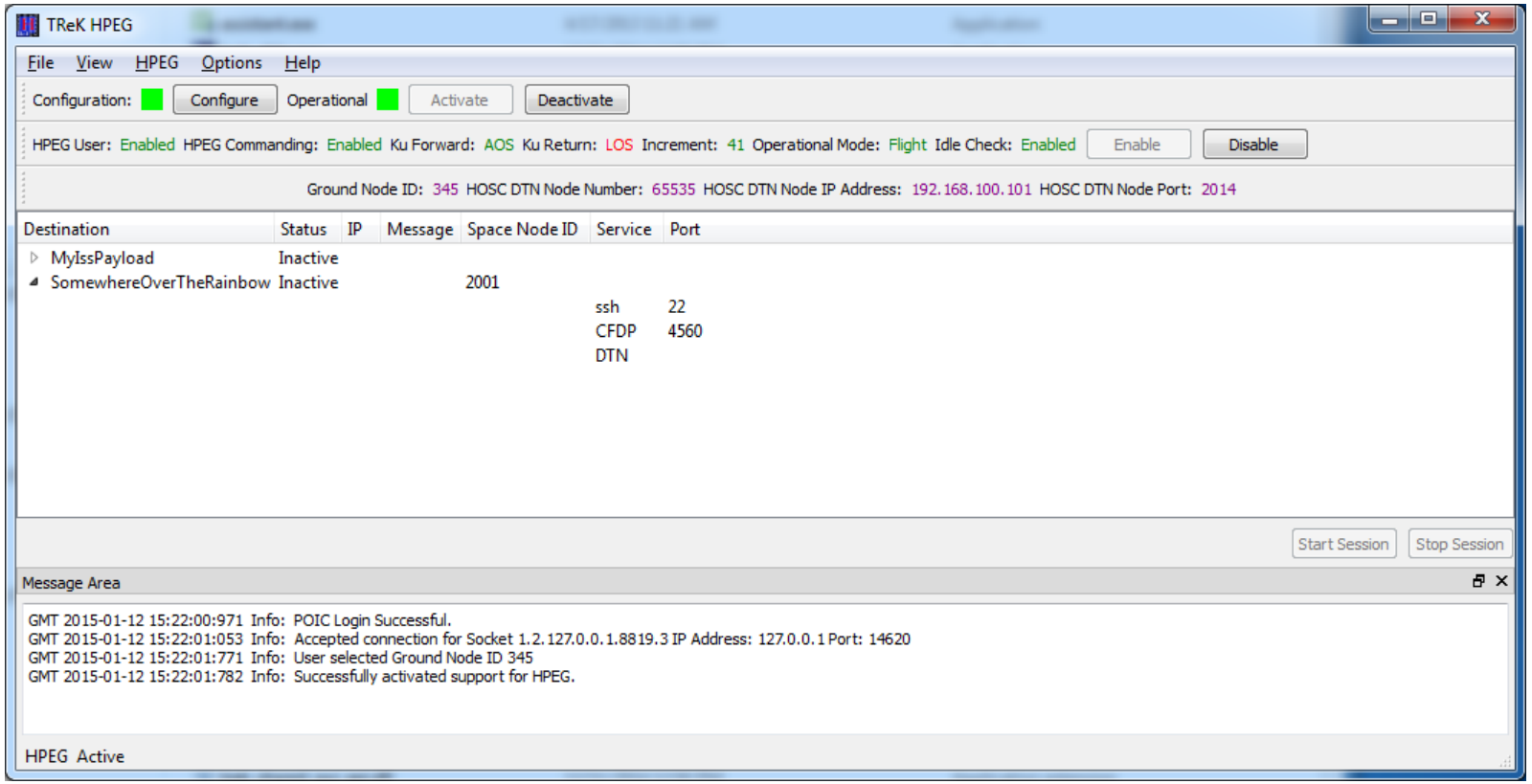


Files Generated By IONconfig for a Node

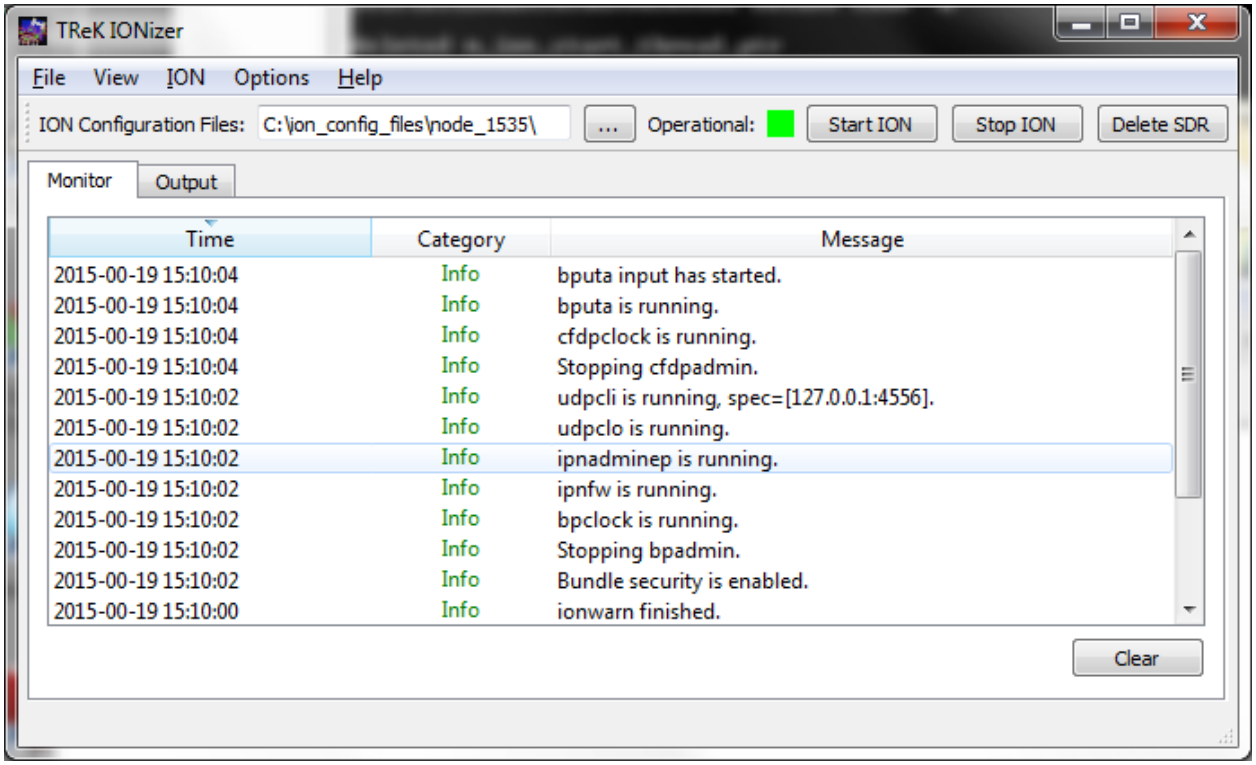


TReK HPEG

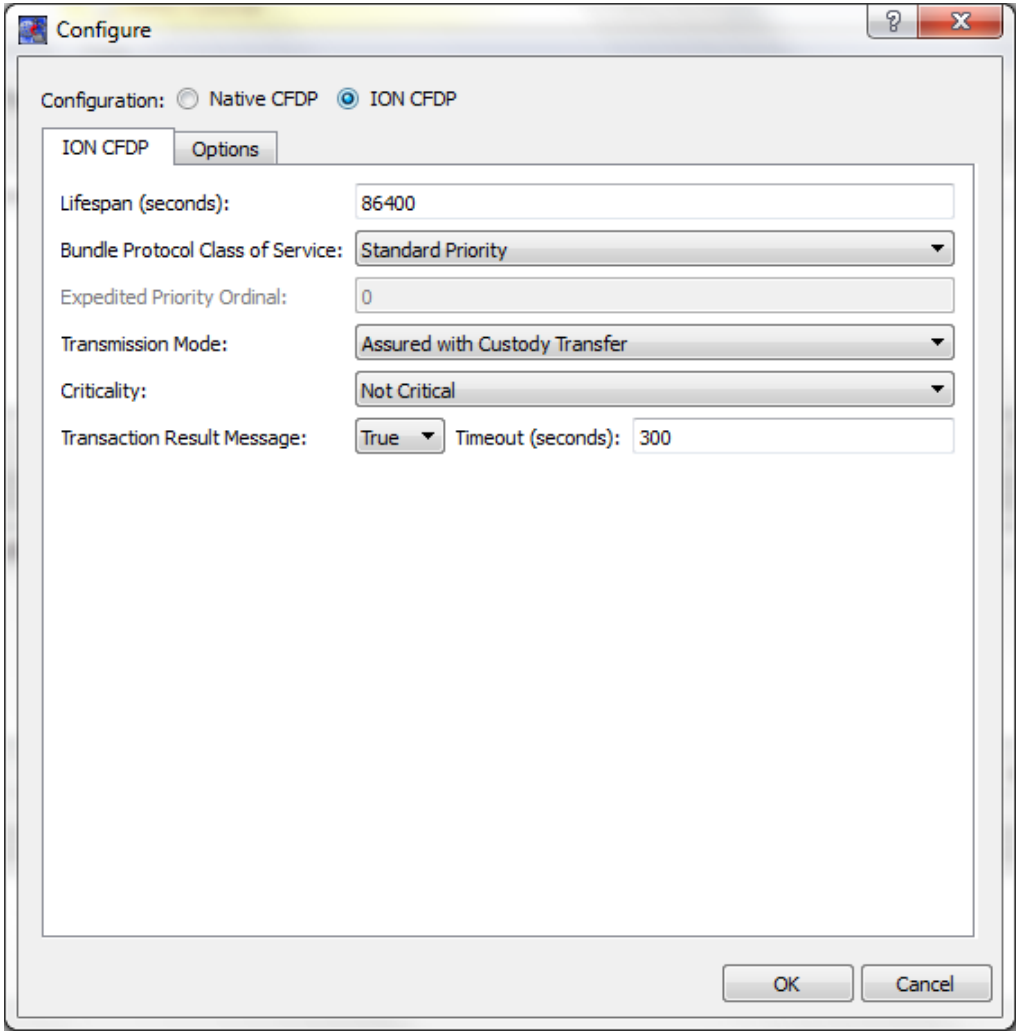
- This is the TReK HPEG application after a successful POIC login. HOSC DTN information is displayed in the toolbar. The SomewhereOverTheRainbow destination lists DTN as one of the services supported.



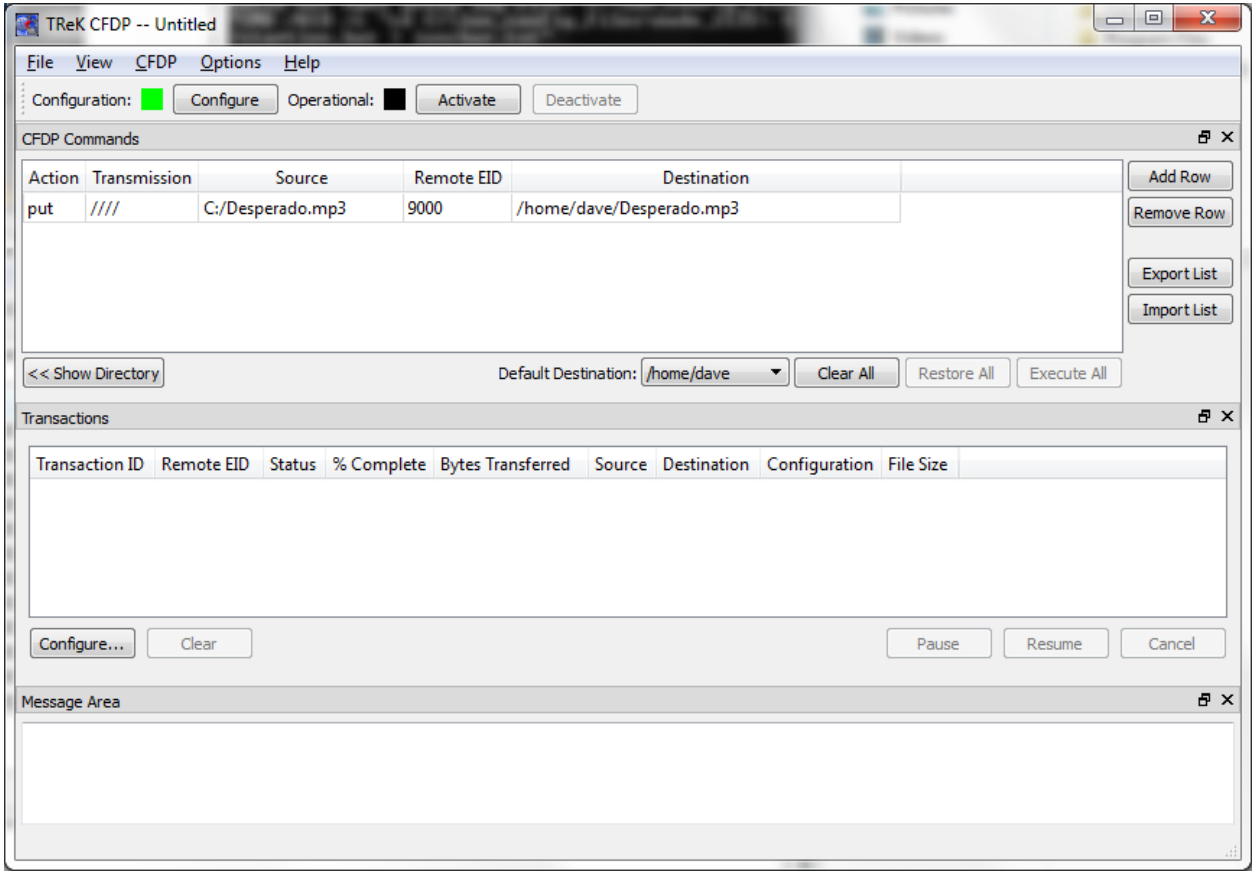
TReK IONizer



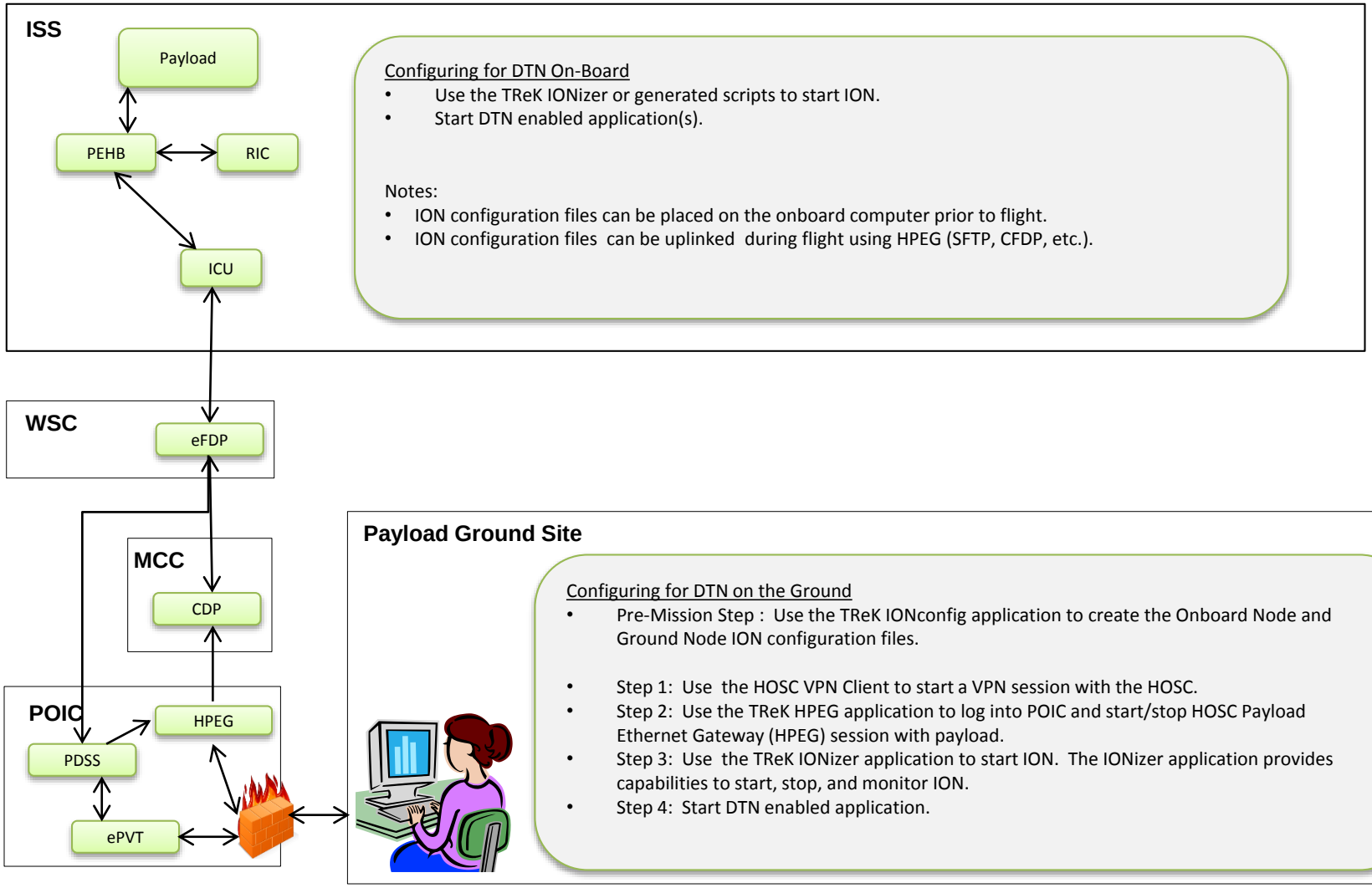
TReK CFDP Configured with ION CFDP



TReK CFDP


TReK CFDP -- Untitled
File View CFDP Options Help
Configuration: Configure Operational: Activate Deactivate
CFDP Commands
Action Transmission Source Remote EID Destination
put //// C:/Desperado.mp3 9000 /home/dave/Desperado.mp3
Add Row
Remove Row
Export List
Import List
<< Show Directory
Default Destination: /home/dave
Clear All
Restore All
Execute All
Transactions
Transaction ID Remote EID Status % Complete Bytes Transferred Source Destination Configuration File Size
Configure...
Clear
Pause
Resume
Cancel
Message Area

Configuring to use DTN



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