DTN for Interplanetary SmallSat Missions

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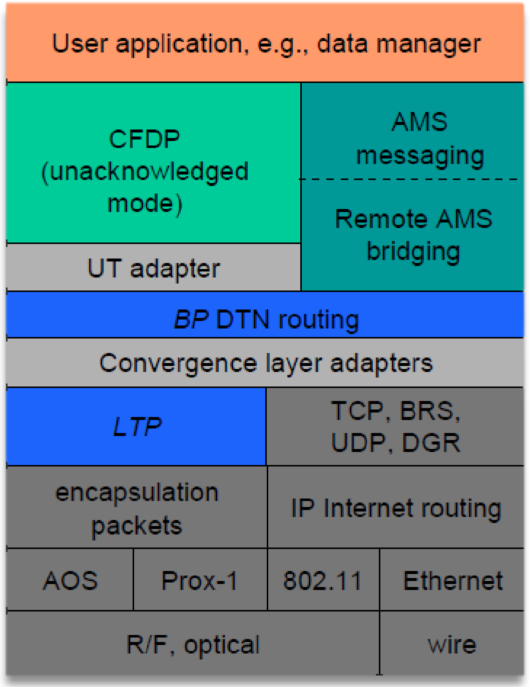
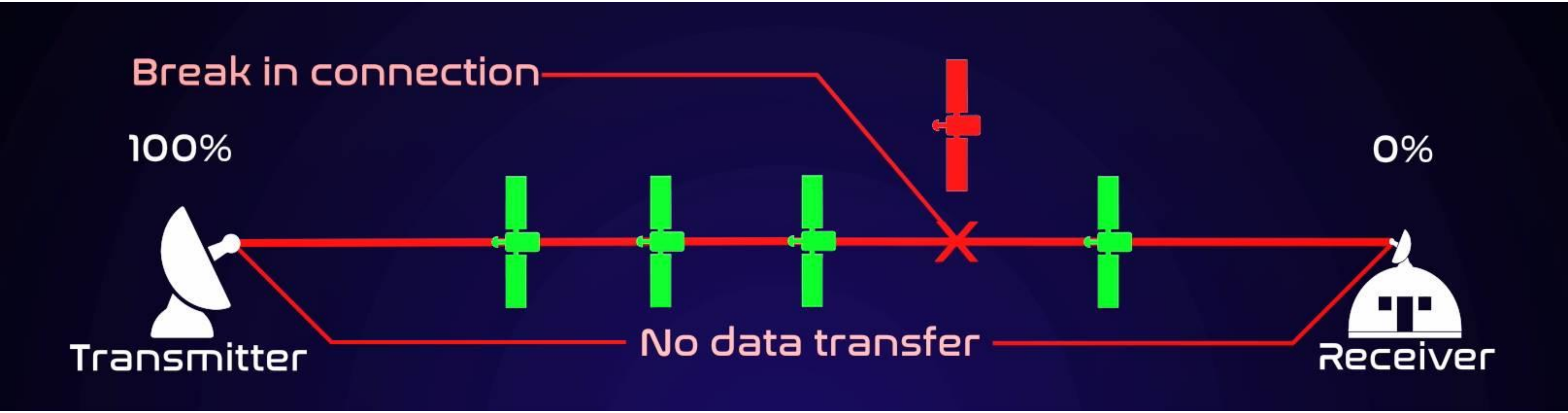
What is DTN?
Benefits to SmallSats
In Space Experiment
Ongoing Work

What is DTN?

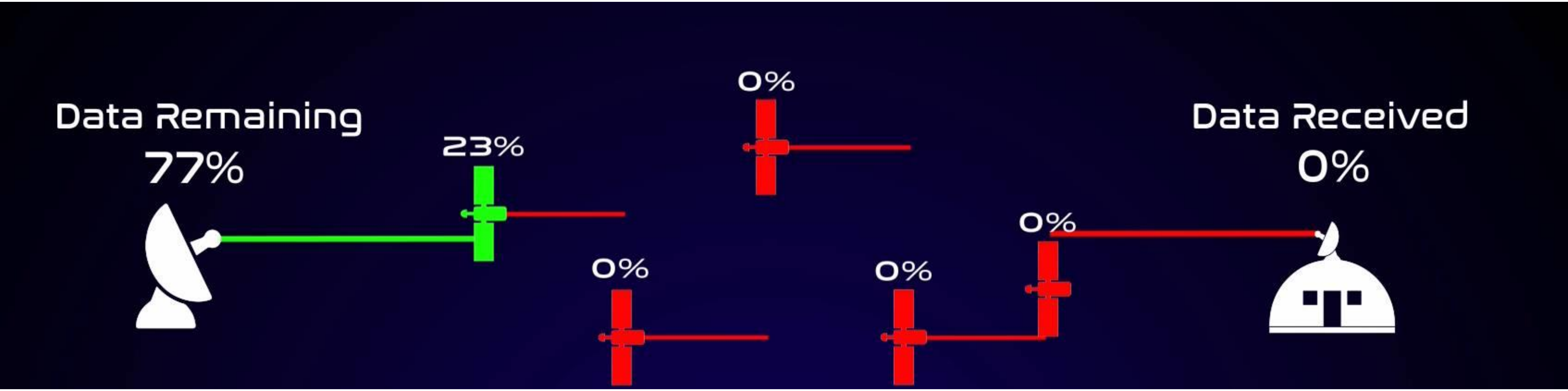
- Delay/Disruption-Tolerant Networking (DTN) can extend internet-like services to space
- The Internet was developed assuming: Rich network connection, Short network delays, Symmetric and Bidirectional data links, and Low Error Rates
- These assumptions don't hold up in space, where communications are subject to frequent disruptions, possibly long delays, unidirectional links, and high error rates.
  - DTN was developed to allow data transmissions to survive in this environment, **storing bundles** of data at nodes along the communication path until the next node is available
  - DTN provides assured delivery of data using an **automatic store-and-forward** mechanism, significantly simplifying operations and increasing bandwidth efficiency
- Reliability with DTN is achieved by **automated retransmission** between relay points within the network
- The DTN protocols are being standardized within international standards community, making it **interoperable and reusable**



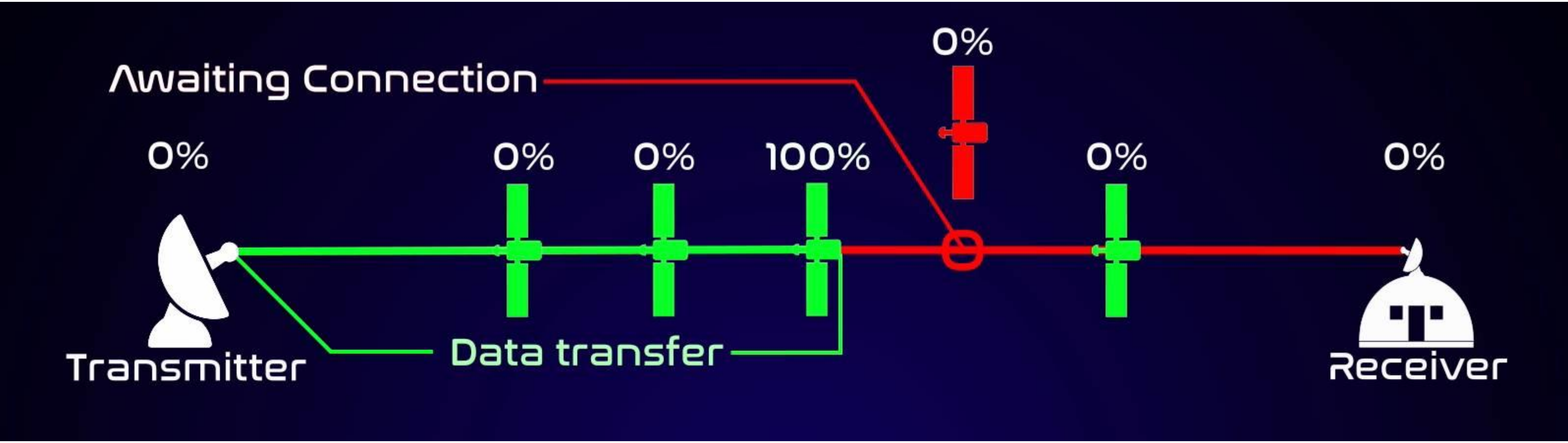
What is DTN?


Break in connection
100%
0%
No data transfer
Transmitter
Receiver

What is DTN?



What is DTN?



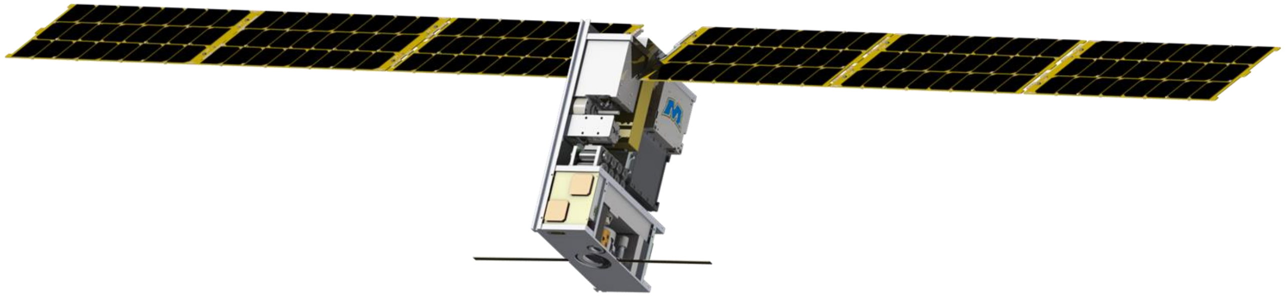
0%
Awaiting Connection
0%
0%
0%
100%
0%
0%
Transmitter
Data transfer
Receiver

Benefits to SmallSats

- BP allows applications to produce and send data without any knowledge or management of the link schedule
- BP will accept streaming data as well as file data and multiplex them into the outbound flow, with a multi-level priority scheme available that means neither the instrument nor the flight software has to manage multiplexing and data prioritization
- With current coding techniques and a good understanding of the link propagation there can be virtually zero errors, but coding cannot make up for weather, pointing errors, or other phenomena so missing frames must be recovered manually in an unplanned session or automatically and in real time with LTP
- Routing might not be necessary from spacecraft to ground, but BP routing can assist in terrestrial delivery especially if the MOC and PI are not co-located

In Space Experiment

- 180 day coast time offers the opportunity to demonstrate DTN on a CubeSat without interfering with the primary mission
- Morehead has control of a ground station capable of communicating with Lunar IceCube and a DTN node located on site
- Lunar IceCube will use different data rates for different ground stations
  - DSN Station: 128 kbps
  - MSU Station : varies between 32 & 64 kbps depending on distance to ground station



Benefits of Experiment

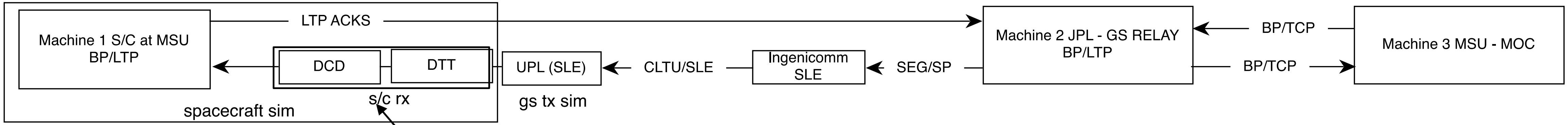
- Performing CFDP operations would serve to show Morehead's ground station is capable of supporting Lunar IceCube's required CFDP operations via DTN
- Comparing data volume would serve to show how DTN streamlines mission operations and reduces the load on spacecraft operators
- Assigning priorities to telemetry would show how DTN helps deliver critical information to spacecraft operators faster

Ongoing Work

- A few demonstrations have been done or are in the process of being done to reduce risk for the in flight experiment
- Demonstration was performed in August with L-IC's previous Mission Operations Software, AMPCS
  - While no longer using AMPCS, the demo serve to show DTN working with L-IC's mission architecture
  - L-IC's new mission ops software operates on similar principles to AMPCS, so integration should be straight forward
- Another demonstration is planned for July with Morehead's ground station
  - An intermediate demo is planned for May to verify that DTN can interface with the backend equipment
  - The final demo will involve L-IC's radio SDU serving as a "captive" spacecraft to represent L-IC

Ongoing Work

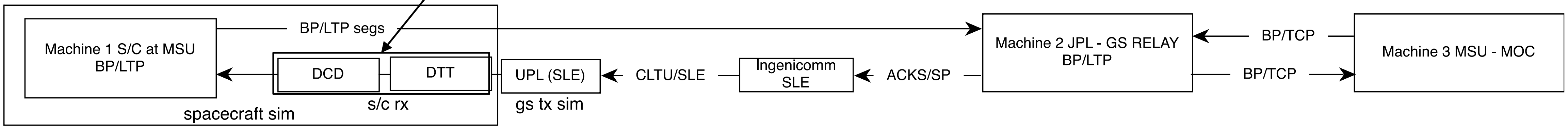
UPLINK FILE TO SPACECRAFT



SP
BP
LTP
ACKs: TCP down to Machine 2 socket
SEGS: TCP up from DCD socket

Spacecraft RX Sim

DOWNLINK FILE TO MOC



SP
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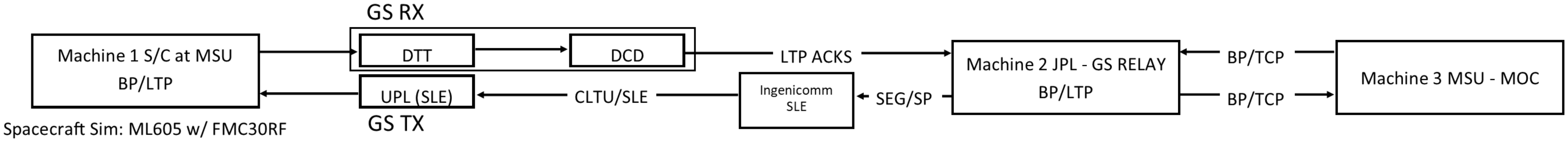
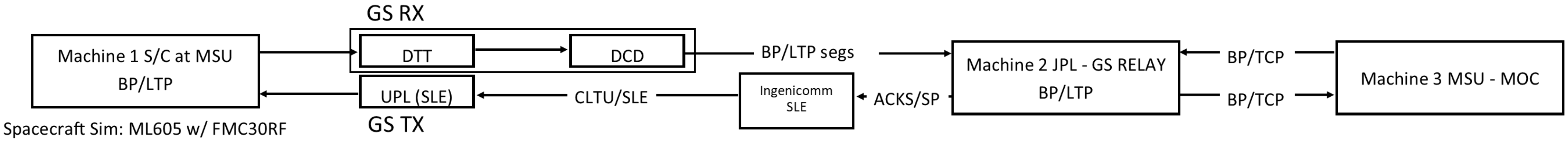
Ongoing Work

Uplink File to Spacecraft



Downlink File to MOC



DTN Implementations

- Interplanetary Overlay Network (ION):
  - http://sourceforge.net/projects/ion-dtn
  - NASA's primary DTN implementation (developed by JPL)
  - Includes implementations of BP and LTP as well as implementations of CFDP, BSS and AMS
  - Supported by multiple Operating Systems
- DTN2:
  - http://sourceforge.net/projects/dtn/
  - Includes an implementation of BP and BSP
  - Used at the MSFC HOSC
- Goddard has developed BP app for cFS

Questions?