

MEASURING LATENCY IN IRIDIUM SATELLITE CONSTELLATION DATA SERVICES



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Overview

- SATCOM has become essential
- Iridium satellite constellation has demonstrated its usefulness and flexibility
- Iridium provides voice and data services
 - Circuit-switched data service
 - Message-switched data service
- Network-centric application developers need to understand expectations of latency
- Need actual performance measurements

Tactical Component Network (TCN®)

- A technology transparently integrates sensor and communications suites with distributed network applications
- TCN has a Local Network
 - Time-critical, peer-to-peer applications
- TCN Global Network
 - Wide-area capability
 - Uses a hub-and-spoke architecture
 - Typically consisting of
 - Local area network (LAN)
 - Multiple processors
 - Cryptographic equipment
 - Various peripherals
- Employed during US Navy 7th Fleet exercises
 - TCN integrated sensor data from multiple ships in a Beyond Line Of Site (BLOS) operational environment
 - Each spoke connected a Tactical Component Network (TCN) node to the hub

TCN and Iridium

- The Iridium constellation is used as one type of spoke into the hub
- Currently, Global TCN uses circuit switching
- Message-based service is being investigated as an alternative data transmission method for applications not requiring continuous connectivity

Our Work

- Methods and experiments to measure performance
- We measured the actual latencies for these data services.
 - Circuit-switched data calls
 - Message-switched data calls
 - Mobile Originated (MO)
 - Mobile Terminated (MT)
 - Full Duplex

CSD and SBD

- Circuit-switched data (CSD) calls
 - Data transfer rate 300 Bytes/sec
 - Requires that satellite acquisition and call setup completed
- Message-switched calls
 - Short-burst data (SBD)
 - Data transfer rate 125 Bytes/sec
 - Requires only that satellite acquisition has completed
 - Low Probability of Intercept (LPI) / Low Probability of Detection (LPD) applications
 - Each call can transfer a maximum of
 - 1960 Bytes from a mobile system to a gateway
 - 1890 Bytes from gateway to a mobile system

CSD Experiments

- Used hub-and-spoke architecture of Global TCN
- Used custom blocking client-server application
- Interactive application
- Calls already established in CSD experiments, measured only actual transmission time
- Used combination of Iridium and land-line for spokes into hub

CSD Test Layout

Annapolis - Tempe, AZ 2008 miles

Iridium network ...

Altitude
50 miles



Altitude
50 miles

**Commercial
Gateway
(Tempe AZ)**

land line

Tempe, AZ - Laurel 1989 miles



**HUB
(Laurel, MD)**



YP

(Annapolis, MD)



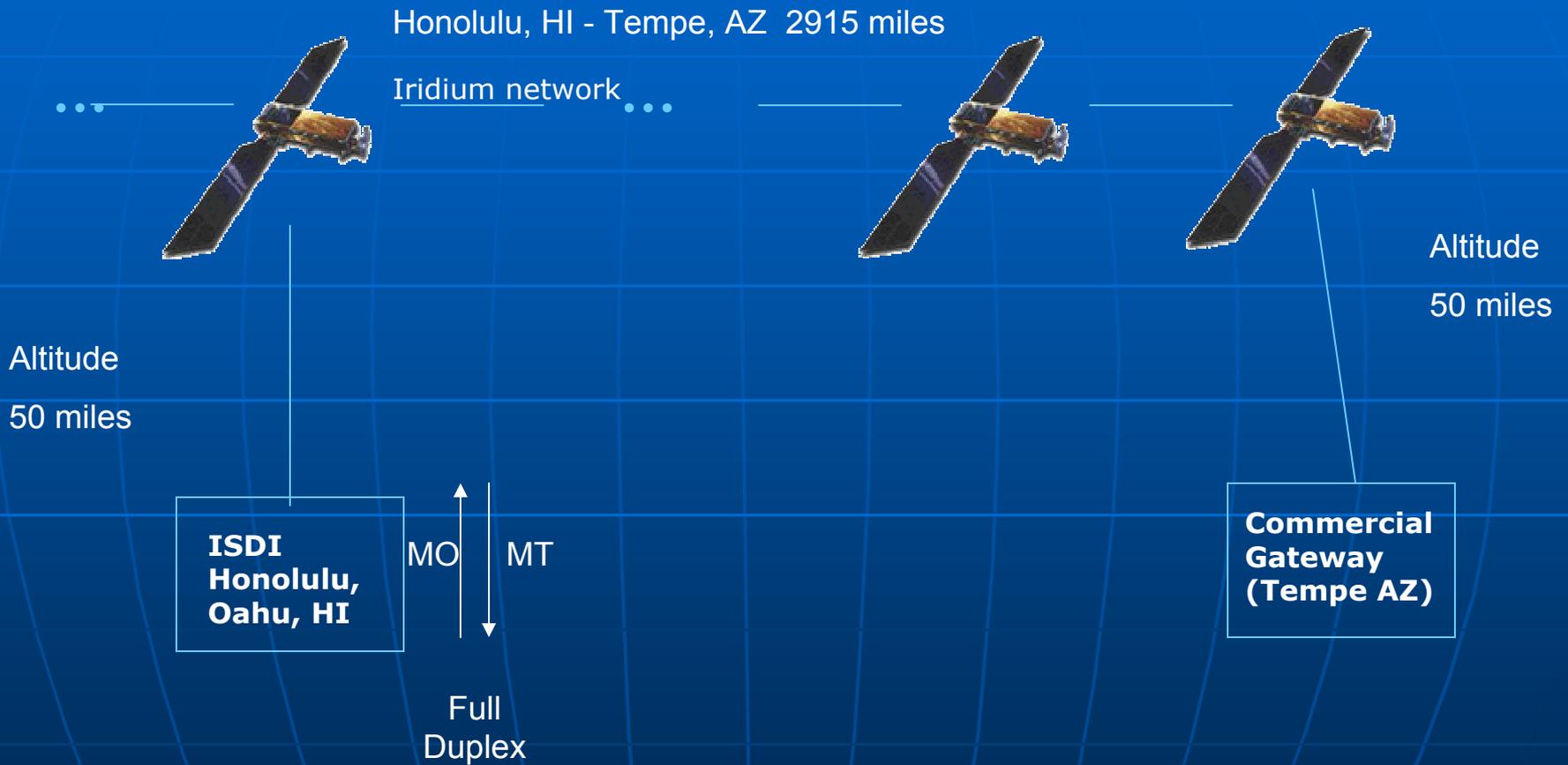
YP

Annapolis - Laurel 21 statute
miles (42 miles round trip)

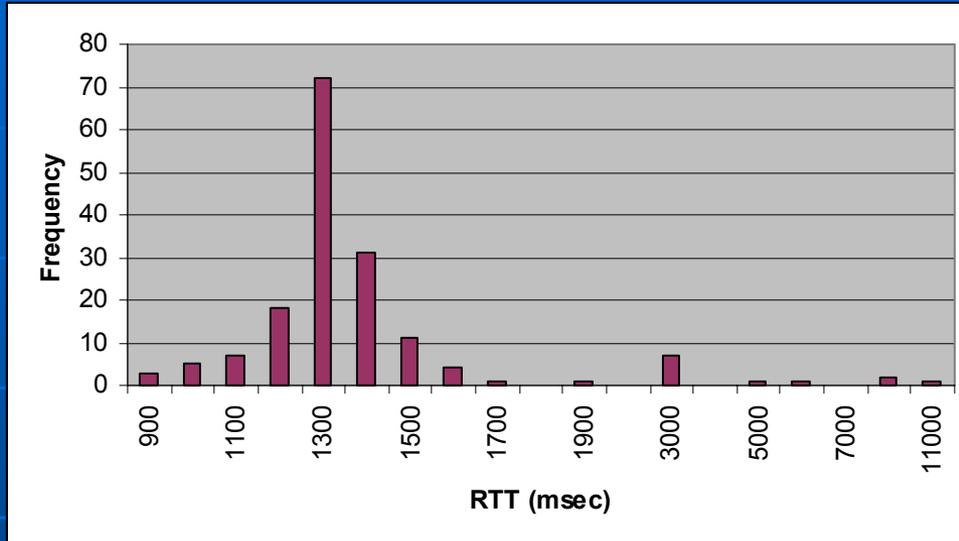
SBD Experiments

- Iridium 9522 L-Band Transceiver
- Used as modem
- Always used a mobile unit
- MO, MT, and Full-Duplex cases
- Measured at modem
- Automated application

SBD Test Layout



CSD Performance



- Modes 1300 - 1400 msec
- Lowest RTT, 981 msec, was recorded during a dynamic test

	Static	Dynamic	Combined
Average RTT (msec)	1686.21	1811.89	1755.11
Standard Dev	1199.18	2059.99	1721.50
Max RTT (msec)	8832	16073	16073
Min RTT (msec)	1161	981	981
Mode (msec)	1362	1332	1332
Average Packet Size (Bytes)	11.48	16.14	13.82
Percent <= 1700 msec	89.33	93.41	91.57

SBD Results

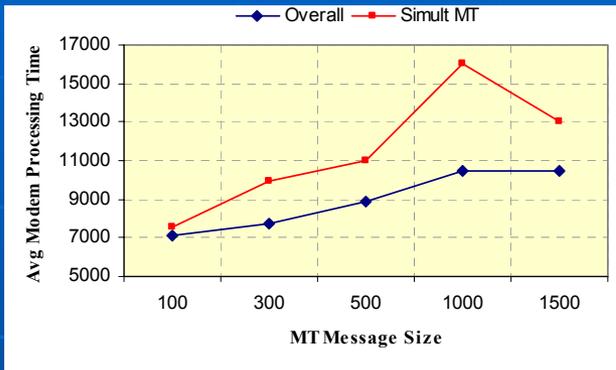


Fig. 4. MO Size 100 [Full Duplex Mode]

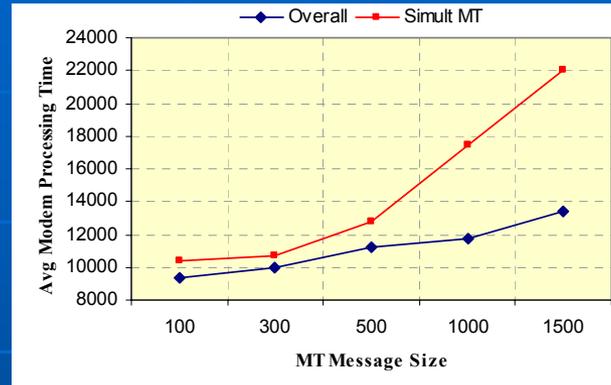


Fig. 5. MO Size 500 [Full Duplex Mode]

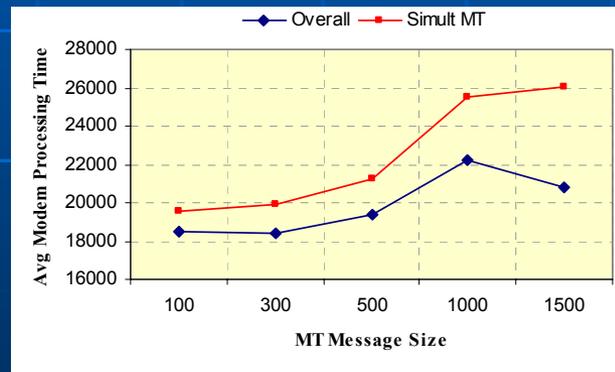
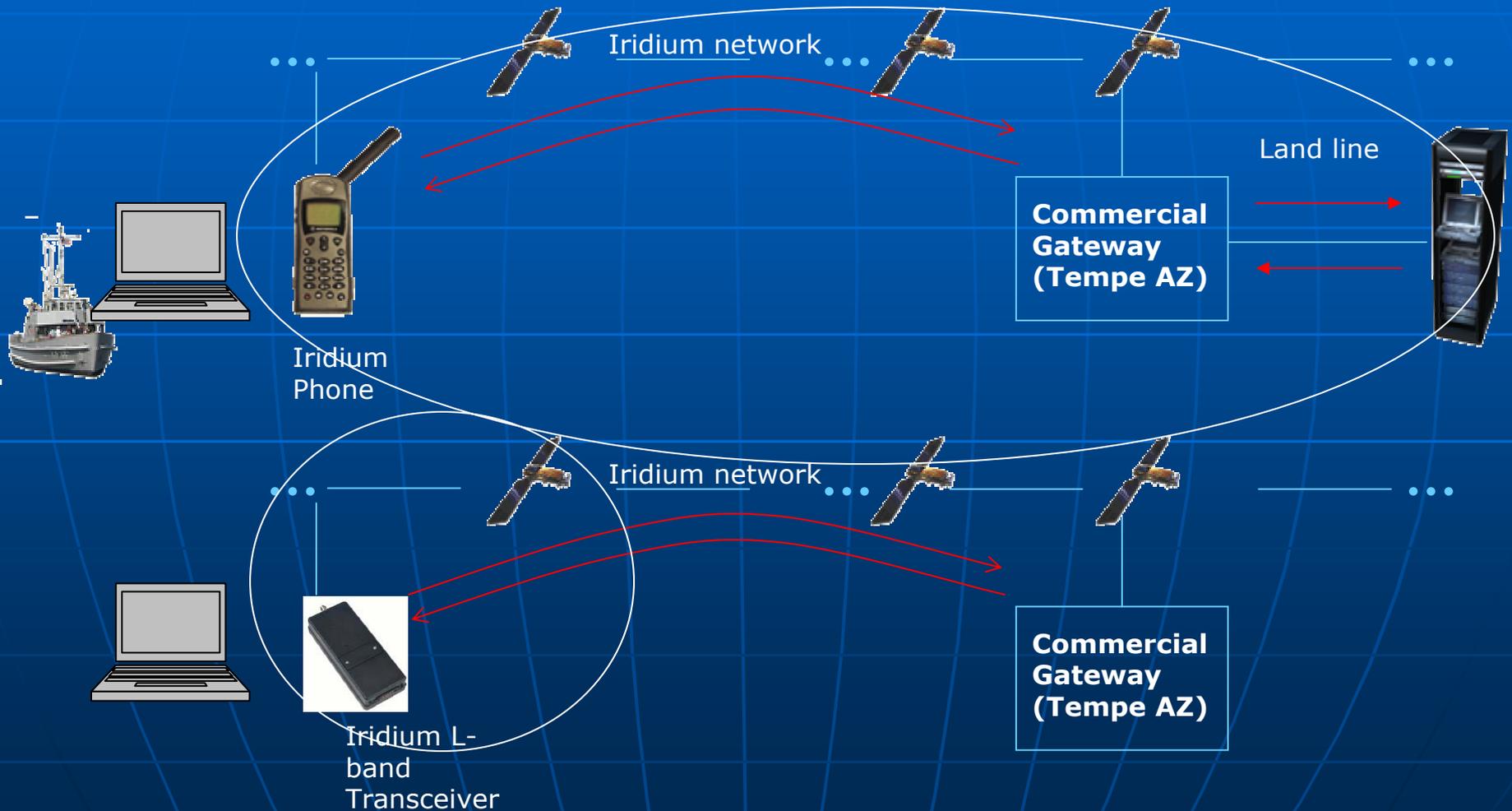


Fig. 6. MO Size = 1500 [Full Duplex Mode]

Comparing Test Layouts



Analysis

- Differences in the experiments:
 - Services data rates (CSD 300 Bytes/sec vs. SBD 125 Bytes/sec)
 - Distance from the gateway
 - Simultaneous incoming and outgoing transmissions
 - Packet size used for the experiments
- The combined data in CSD experiments had an average RTT of 1755 msec
- Amount of processing time added before transmission for the smallest MO (100 Bytes) 7.1 sec, in Full Duplex is 7.5 sec

CONCLUSIONS

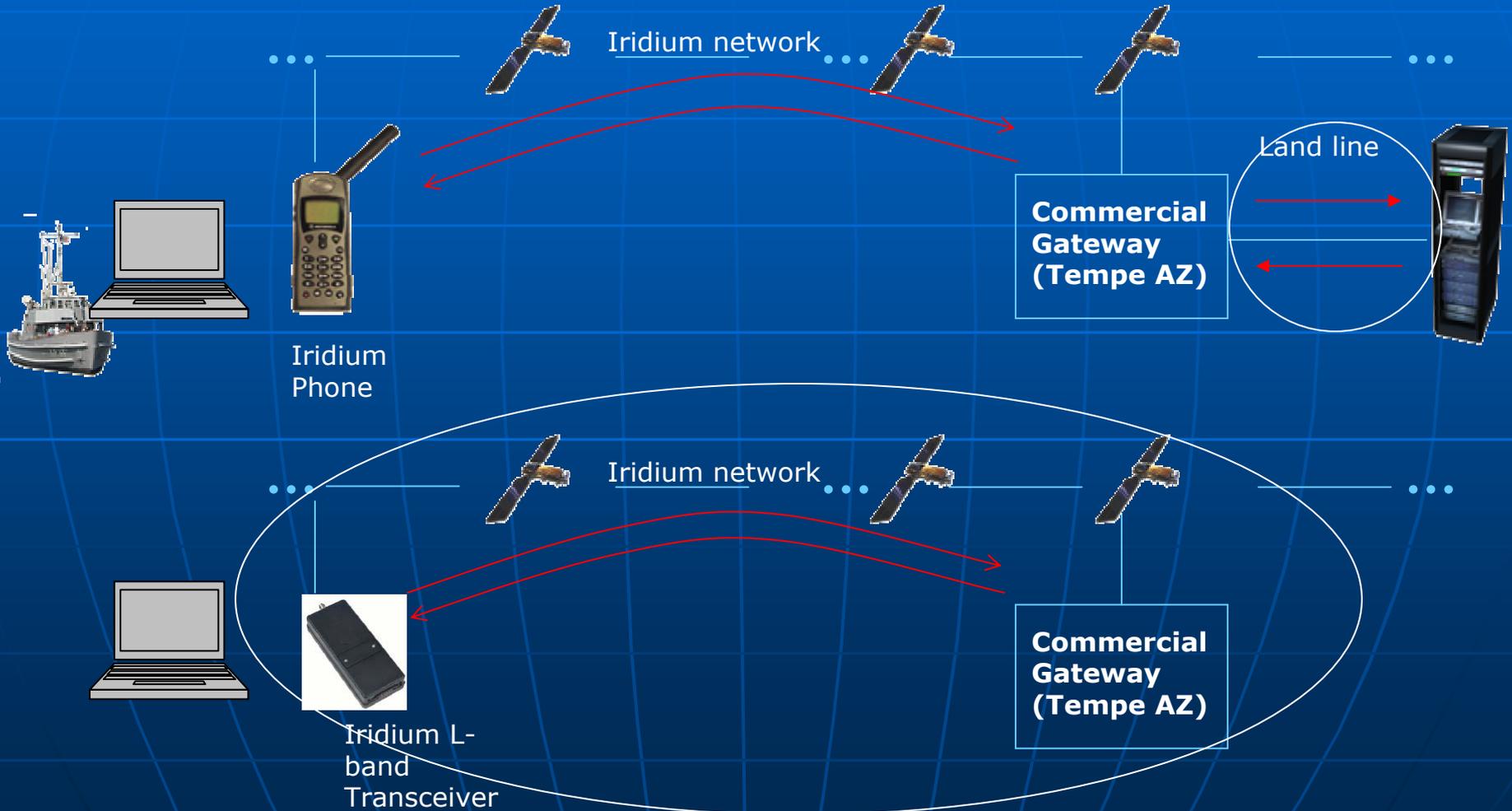
- SBD and CSD each suited to different applications
- SBD
 - Avoids the time penalty of establishing a call
 - Cost of maintaining a call
 - Saves power and transmission signature
 - Preferable for applications that need to intermittently exchange smaller packets of data
 - Example: automated client-server application
- Time-critical applications or large data transfers
 - Analyze whether the latencies incurred in SBD can be tolerated
 - Example: TCN data provider has continuous sensor data
Data user there may only be a requirement for periodic updates
- Insights about MO, MT and Full-Duplex modes in the paper

Hub-and-spoke approach allows a mix of both the CSD and SBD applications depending on the needs of the end-user

Conclusions

- Developing hub applications requires insight into the performance of the spokes
- Experimental measurements of performance is necessary
- Consider geographic areas
- Understanding performance, and parameterize clients to add to robustness of hub applications

Future Work



Future Work

- Additional data communication tests
- For CSD
 - Use a hub closer to the ground station
 - Use comparable message sizes
- For SBD
 - Investigate military version