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National Aeronautics and
Space Administration



Microhard MHX2420 Orbital Performance Evaluation Using RT Logic T400CS

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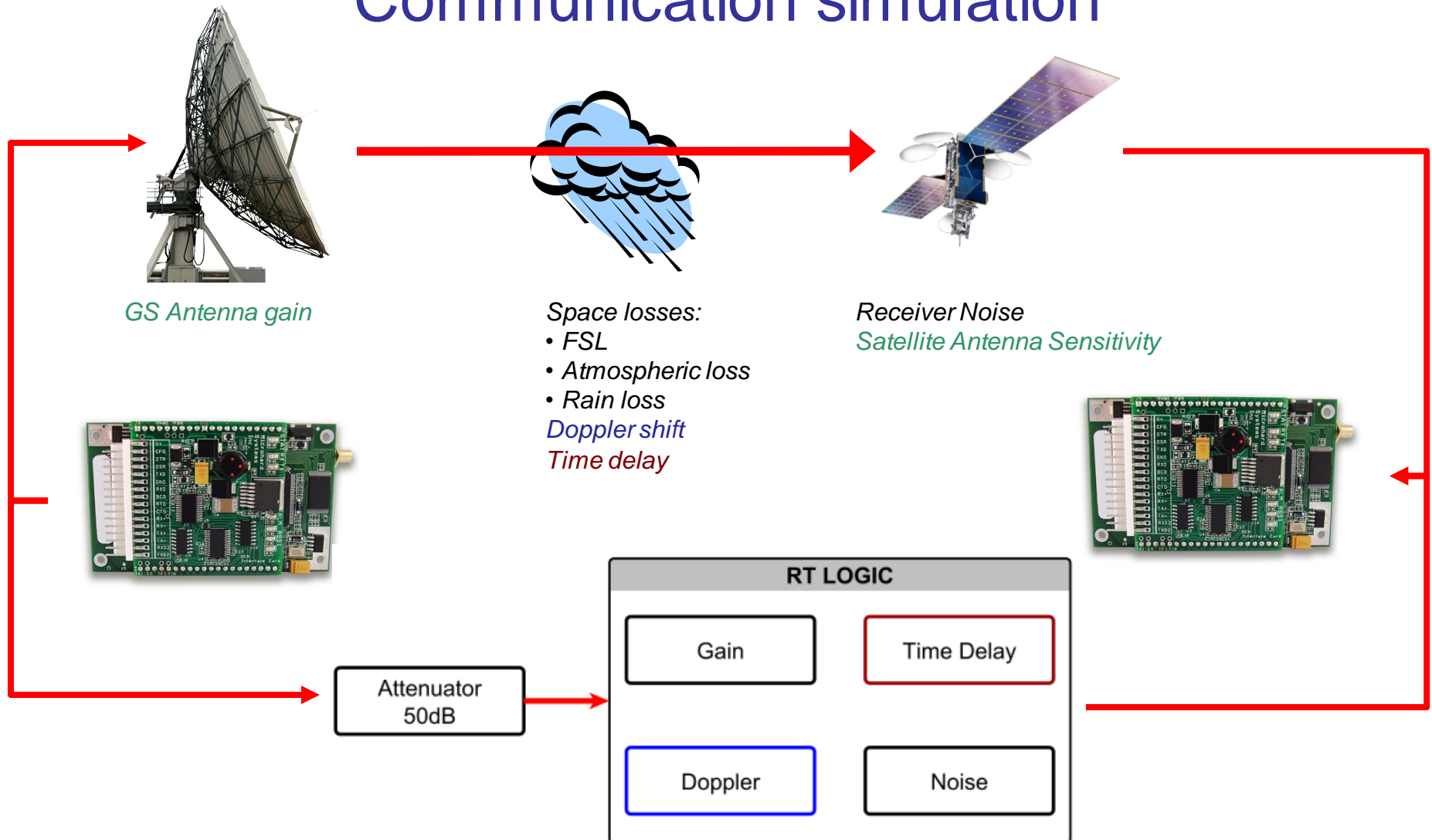


Outline

- **Communication Simulation**
- **Experimental Setup**
 - Hardware Setup
 - RT Logic
 - Microhard MHX2420
 - Software Setup
 - Static, dynamic and STK tests
- **Microhard optimization**
 - Microhard and RT Logic settings
 - Microhard optimized settings
 - Test results
 - Future testing and Conclusion



Communication simulation





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Experimental Setup

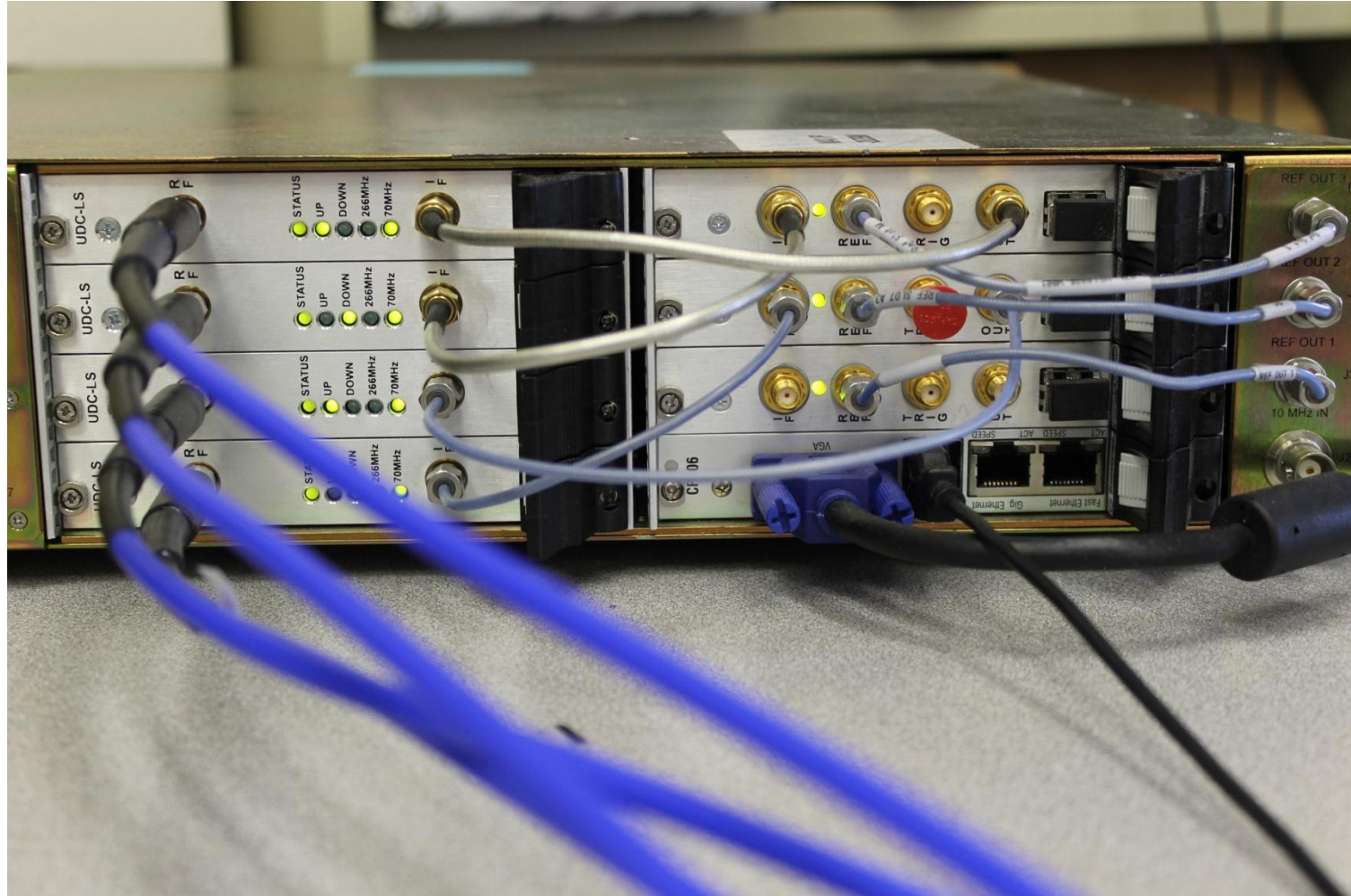




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RT Logic (Channel Simulation HW)





Microhard MHX2420

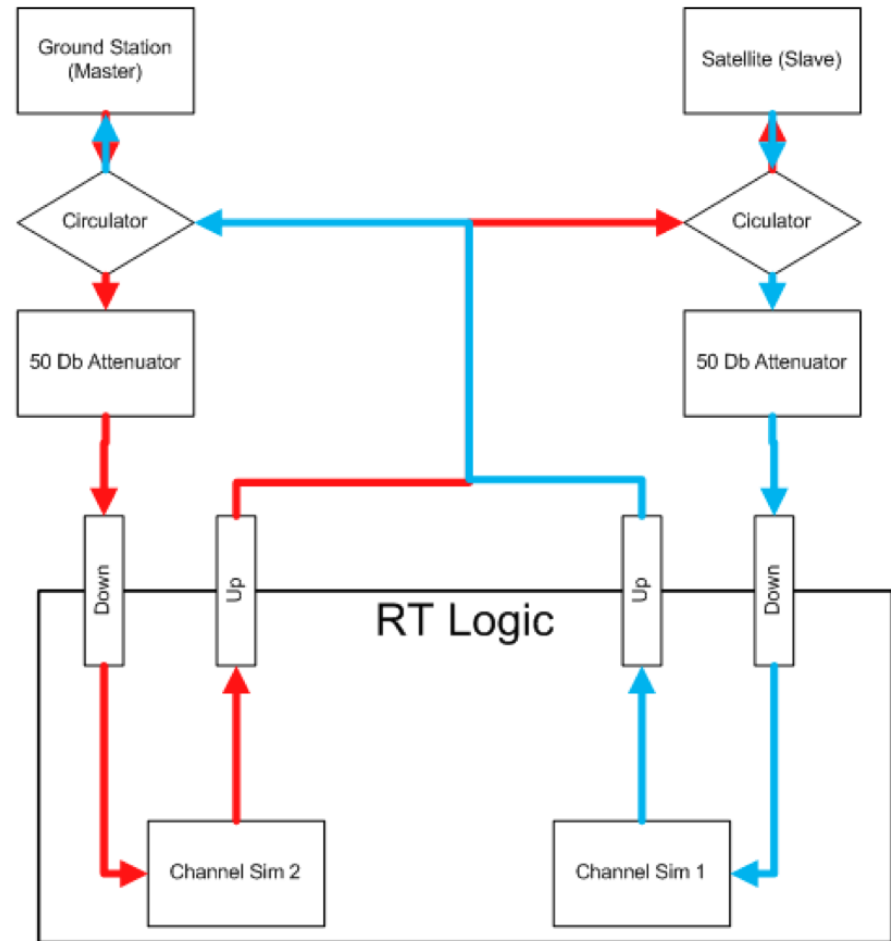
MHX2420		Specifications	
			
Frequency	2.4000 - 2.4835 GHz	Core Voltage	4.0VDC to 5.5VDC, 7VDC to 30VDC (see -HV option)
Spreading Method	Frequency Hopping	I/O Voltage (user selectable)	3.3VDC to 5.5VDC; RS232/485/422 levels (See -HV option)
Band Segments	Selectable via Freq. Restriction	Antenna Connector	MCX
Error Detection	32 bits of CRC, ARQ	Environmental	-40°F - +185°F (-40°C - +85°C) 5-95% humidity, noncondensing
Encryption	Optional (Canada & USA only. NOT AVAILABLE for export, see -AES option)	Weight	Approx. 2oz. (55 grams)
Range	30+ miles (50+ km) (dependant on link rate and line of sight)	Dimensions	Approx. 3.5" x 2.1" x .7" (89mm x 53.4mm x 17.8mm)
Output Power	100mW to 1W (30dBm)	Approvals	FCC Part 15.247 IC RSS210
Sensitivity	-108dBm @ 115.2kbps link rate (Also see option -SL)	Order Options	
System Gain	142dB (w/rubber duck antennas)	-HV	HV Option - High input voltage (12V to 30V) with RS232/485/422 Drivers
Serial Interface	RS232/RS485/RS422 TTL Driver Level (see -HV option)	-FT	Standard FAST Mode 115kbps - 230.4kbps
Serial Baud Rate	300bps to 230.4kbps	-FT1	Extended FAST mode 115kbps - 345.6kbps
Link Rate	19.2 kbps - 230.4kbps (See Order Options)	-SL	Extended sensitivity / SLOW Mode 19.2kbps - 230.4kbps
Operating Modes	Point-to-Point, Point-to-Multipoint, Store & Forward Repeater, Peer-to-Peer, TDMA, Multimaster	-C1D2	Class 1 Div 2 (for use in hazardous environments)
Signals Interface	RxD1, TxD1, RTS, CTS, DCD, DSR, DTR, RxD2, TxD2, RSSI LEDs, Tx/Rx LEDs, Reset, Config, Wake-up, RSmode	-AES	128-AES Encryption (Canada & USA only. NOT AVAILABLE for export)
Diagnostics	Battery Voltage, Temperature, RSSI, and remote diagnostics		
Rejection	Excellent strong signal interference & rejection characteristics		



http://www.microhardcorp.com/detail-images/detail_MHX920-2420_HV_bottom.jpg

Hardware Setup

1. Satellite sends file
2. Signal attenuated
3. Signal digitalized
4. RT Logic simulation
5. Output signal converted back to analog
6. File reaches the Ground Station





Software Setup

1. Initial Microhard settings: baseline settings for both radios from previous missions
2. 2 computers using Tera Term as configuration terminal and Zmodem as the file transfer protocol
3. File sent: 640kB JPEG picture

Ground Station Baseline Settings

Setting	Value	Setting	Value
Operating Mode	S101=0	Wireless Link Rate	S103=1
Serial Baud Rate	S102=1	Network Address	S104=5400
Output Power(dBm)	S108=25	Data Format	S110=1
Packet Retransmissions	S113=5	Average RSSI(dBm)	S123=-50
Character Timeout	S116=10	Destination Address	S140=1
Protocol Type	S217=0	Address Tag	S153=0
Sleep mode	S143=0	Sniff Search Sleep	S169=60
Wake time, sec	S145=10	Ch Access Mode	S244=0
Sync Mode	S150=0	M hop alloc timeout	S251=10
Hop Interval	S109=9	Packet Max Size	S112=255
Repeat Interval	S115=3	Roaming	S118=1
Network Type	S133=1	Serial Channel Mode	S142=0
Sniff timeout, hops	S237=10	Sleep time, sec	S144=60
LEDs brightness, %	S149=100	Fast Sync Timeout,hops	S151=100
FEC Mode	S158=0	Sniff Search Wake	S170=30
Sync timeout	S248=512		

Satellite Baseline Settings

Setting	Value	Setting	Value
Operating Mode	S101=2	Wireless Link Rate	S103=1
Serial Baud Rate	S102=1	Network Address	S104=5400
Output Power(dBm)	S108=2	Data Format	S110=1
Packet Retransmissions	S113=5	Average RSSI(dBm)	S123=-50
Character Timeout	S116=10	Destination Address	S140=1
Protocol Type	S217=0	Address Tag	S153=0
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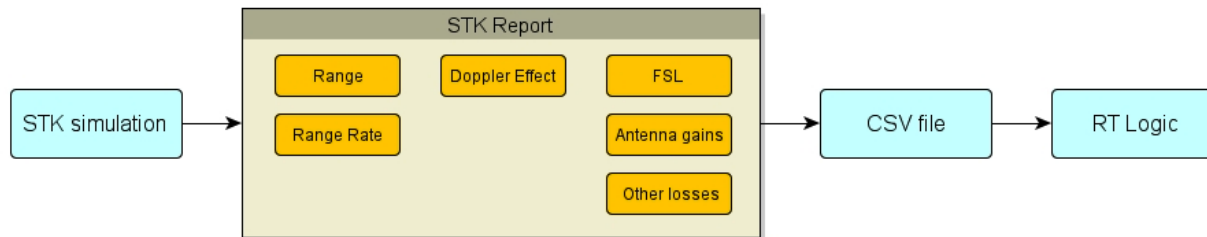
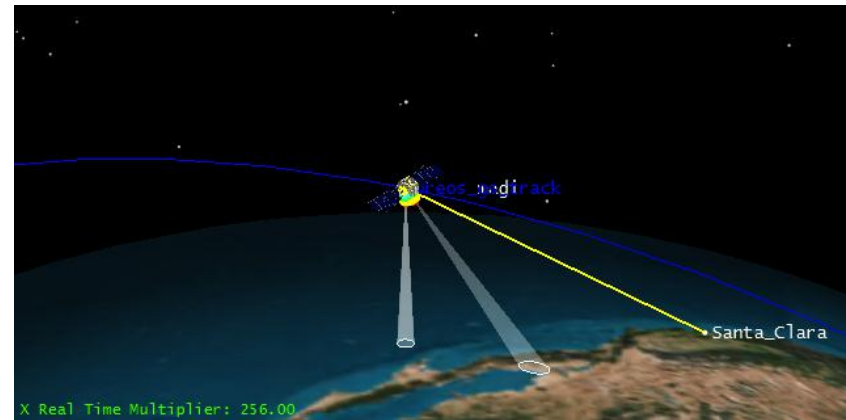
Static and dynamic test

Static test

- Objective: gain insight of the effects of both the Microhard and the RT Logic settings on the quality and data throughput of the link
- Static gain, time delay, receiver noise and Doppler effects

Dynamic test

- Objective: simulate an entire orbital pass for a given satellite
- Possibility of attitude simulation
- Dynamic gain, time delay, receiver noise and Doppler effects
- Start and stop communication conditions



STK test

- STK Plug-in

T400CS Target	Name	Range (km)	Range Rate...	Path Delay (ms)	Azimuth °	Elevation °	Total Loss (dB)	Comm Link	Doppler (Hz)	Gain (dB)	Delay (ms)	AWGN (dBm/Hz)	Recv Noise (dBm/Hz)	Prepro
<input checked="" type="checkbox"/> /T400/DG4000ChannelSim1	T400CS-Oreos_gs_track_downlink	1,497.663	-4.742	4.996	-41.0	31.7	-163.6	None	0	-63.6	0.003	-168.0	-168.0	0.0
<input checked="" type="checkbox"/> /T400/DG4000ChannelSim2	T400CS-Oreos_mag_downlink	1,497.663	-4.742	4.996	16.9	57.4	-163.6	None	38,200	-8.6	4.996	-138.0	-150.0	0.0
<input checked="" type="checkbox"/> /T400/DG4000ChannelSim2	T400CS-Oreos_nadir_downlink	1,497.663	-4.742	4.996	-41.0	31.7	-163.6	None	38,279	-7.2	4.996	-150.0	-150.0	0.0



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Microhard optimization



http://www.microhardcorp.com/detail-images/detail_MHX920-2420_HV_bottom.jpg



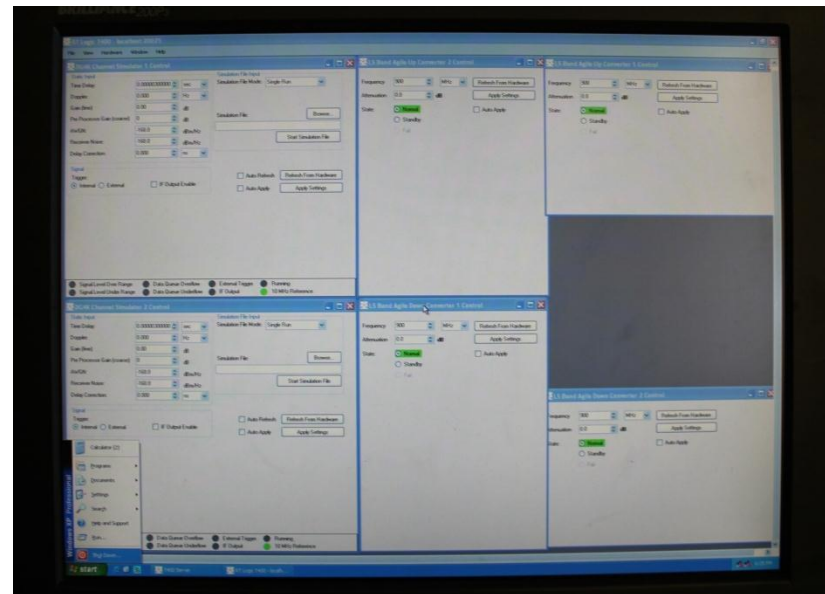
Microhard and RT Logic Settings

Microhard adjusted settings:

- Serial baud rate
- Wireless link rate
- FEC
- Hop interval
- Maximum packet size

RT Logic adjusted settings:

- Receiver noise
- Doppler shift
- Gain
- Time delay
- AWGN





Microhard optimized settings

Setting	Past mission values*	Optimized value
Serial Baud rate	115200bps	115200bps
Wireless link rate	115200bps	115200bps
Hop Interval	20ms	150ms
Maximum packet size	255bytes	255bytes
FEC	None	Reed-Solomon

* Based on past missions O/OREOS, GeneSat and NPS

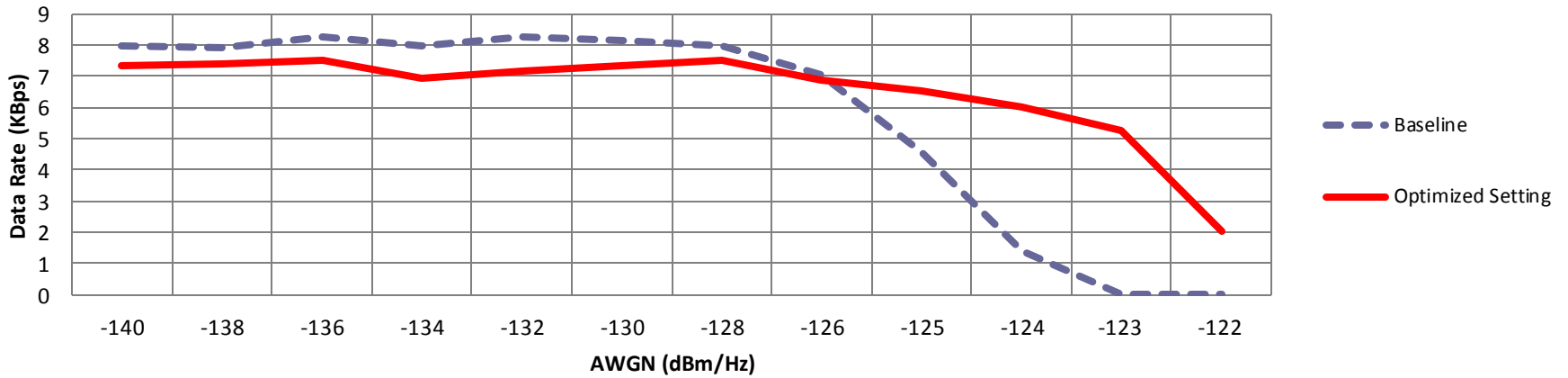
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Sniff timeout, hops	S237=10	Sleep time, sec	S144=60
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Sync Mode	S150=0	M hop alloc timeout	S251=10
Hop Interval	S109=19	Packet Max Size	S112=255
Repeat Interval	S115=3	Roaming	S118=1
Network Type	S133=1	Serial Channel Mode	S142=0
Sniff timeout, hops	S237=10	Sleep time, sec	S144=60
LEDs brightness, %	S149=100	Fast Sync Timeout,hops	S151=100
FEC Mode	S158=0	Sniff Search Wake	S170=30
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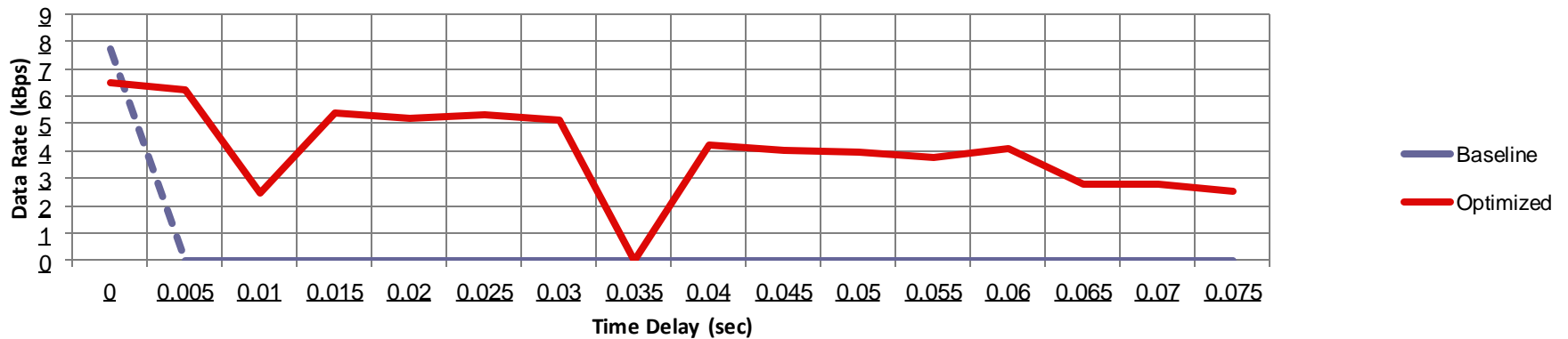


Test results

AWGN Test



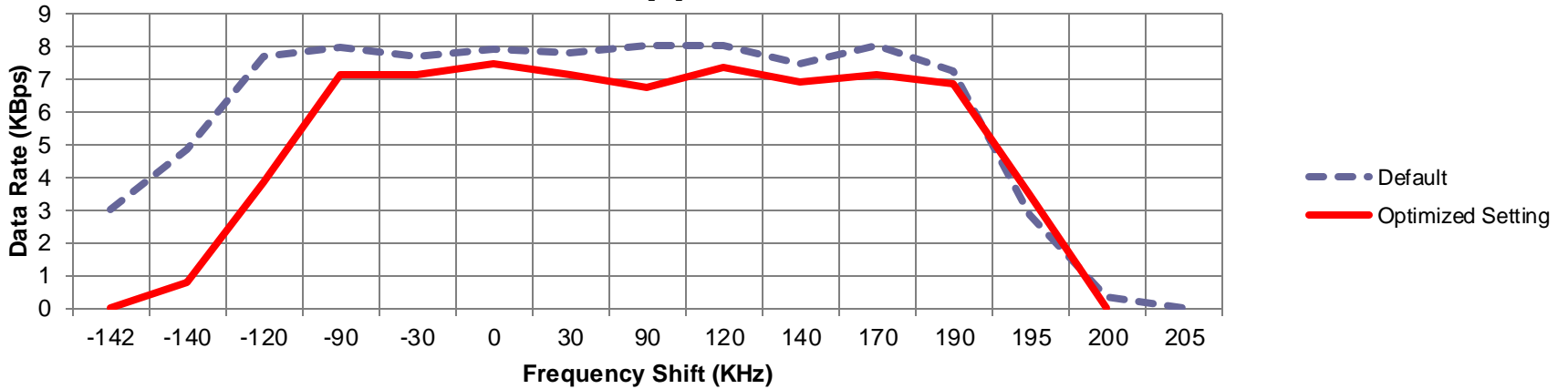
Time Delay Test



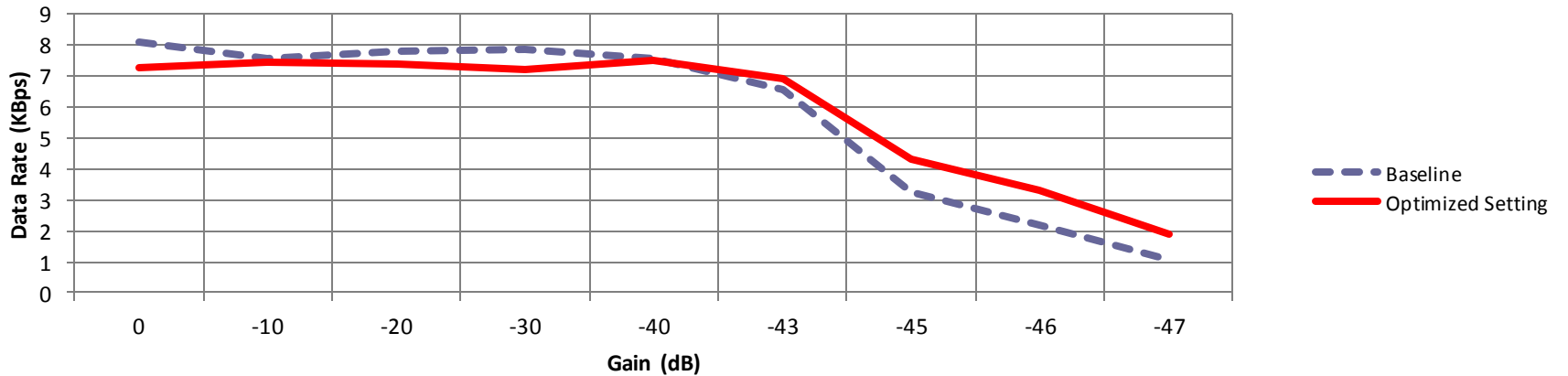


Test results

Doppler Effect Test



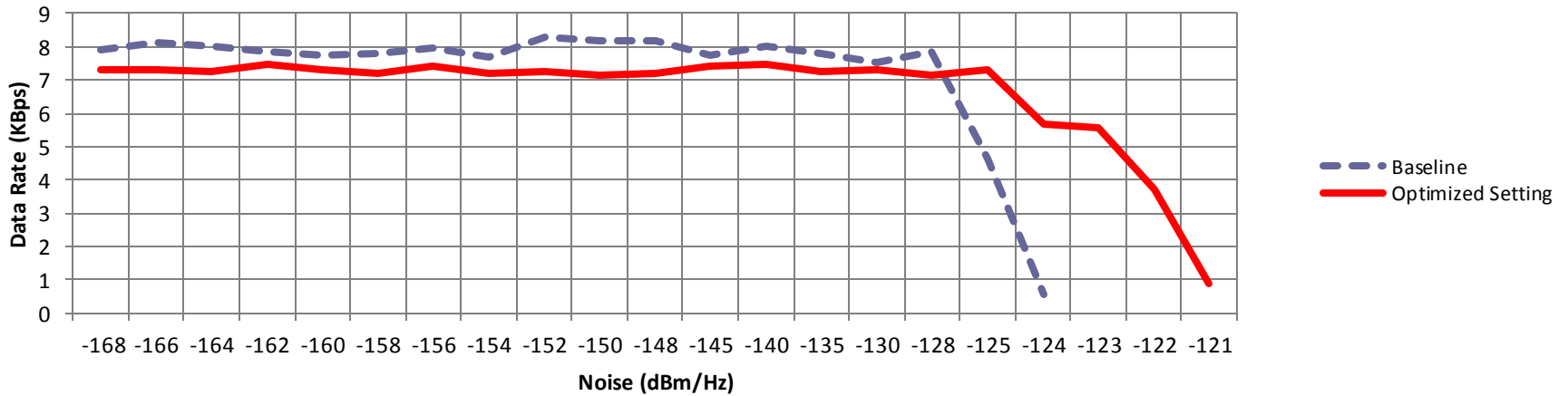
Gain Test





Test results

Receiver Noise Test





Conclusions

- **RT Logic allows simulation of Ground Station – satellite communications**
 - Static tests have been successful
 - Dynamic tests have been performed for simple passes
 - Future dynamic tests are needed to simulate real orbit communications
 - **Satellite attitude changes antenna gain**
 - **Atmospheric and rain losses need to be added**
 - STK Plug-in will be the next step to improve the dynamic tests
 - **Possibility of running longer simulations**
 - **Simulation of different losses available in the STK Plug-in**
- **Microhard optimization**
 - Effect of Microhard settings on the data throughput have been understood
 - Optimized settings improve data throughput for LEO communications
 - **Longer hop intervals make transfer of larger packets more efficient (more time between hops in frequency)**
 - **Use of FEC (Reed-Solomon) reduces the number of retransmissions for long-range or noisy communications**



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Thank You

Big thank you to RT Logic for lending equipment and providing support



Questions?

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