C-Band Testing
NAWCAD Patuxent River, MD

5/4/12

Presented to:
ITEA

Presented by:
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NAVAIR RANGES

Overview

- Airborne TM Goals
- Purpose of Test
- UH-60 TM System
- Flight Test Methodology
- Flight Test Data
- Answers to Questions
- Conclusions
- Path Forward

Igor Sikorsky Quote

“1 Test = 1000 Expert Opinions”

Airborne Telemetry System Goals

- Design a system for maximum flexibility
  - Single transmitter capable of (L/S/C) band
  - Form fit replacement for legacy aircraft TM transmitters
  - Multiband low-loss cable (L/S/C)
  - Multiband antennas (L/S/C)
- No aircraft modification (downtime) required to move between the L, S and C bands

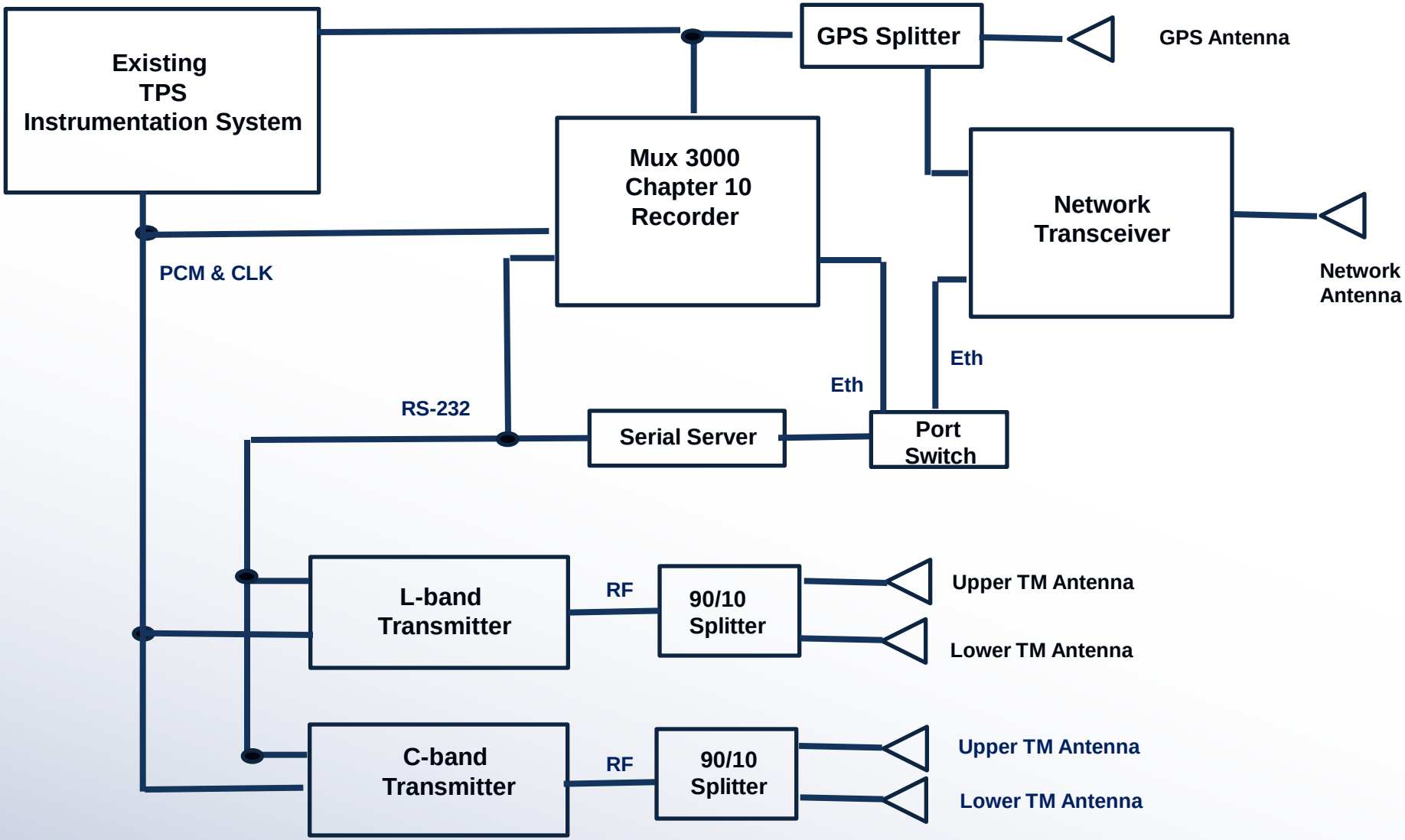
Purpose of Testing

- Answer the following questions:
  - How will C-band perform compared to L-band in a UH-60 at PAX?
  - How will C-band perform over the water?
  - How do multiband antennas perform compared to dedicated band specific antennas?

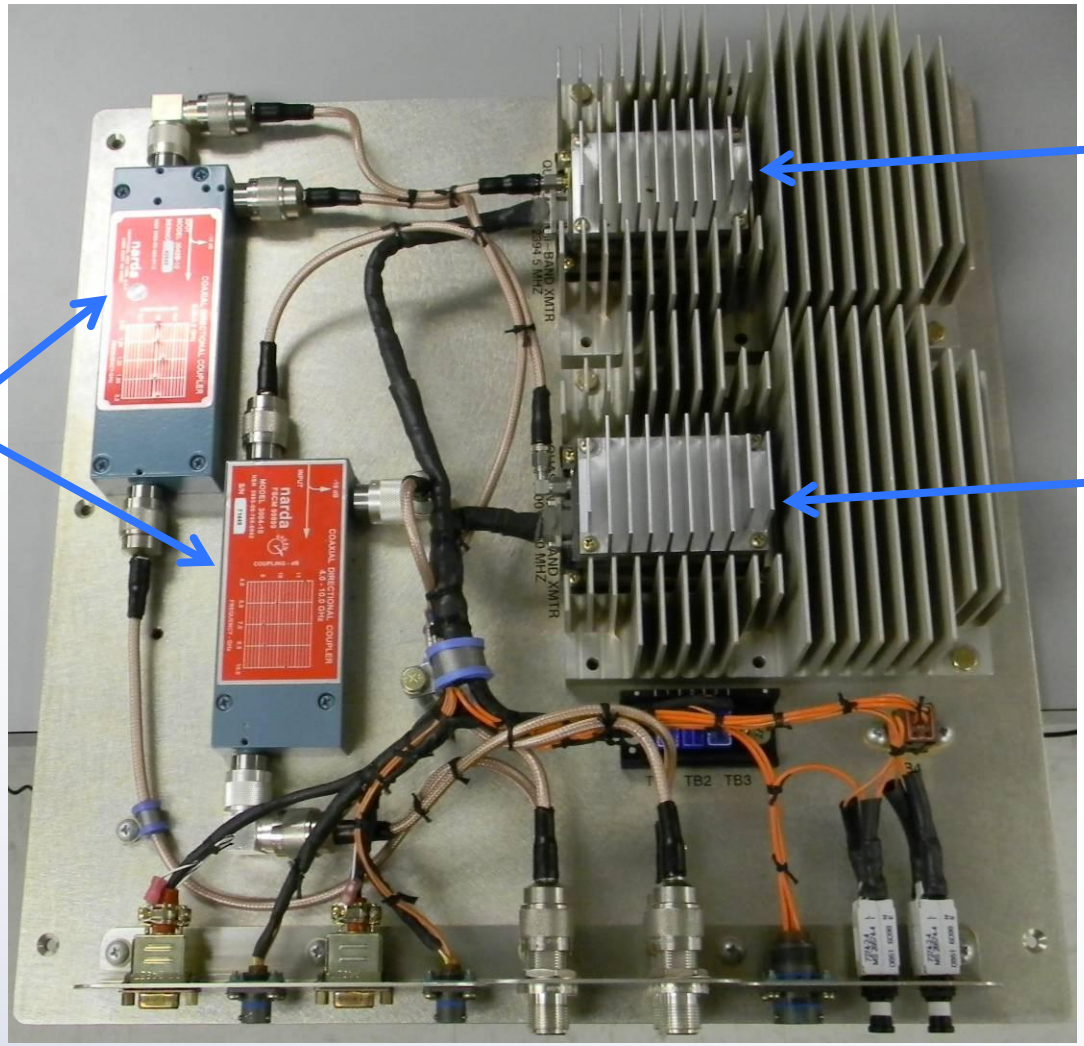
- Gather flight test data to convince reluctant Telemetry (TM) users to consider moving to the C-band

- Utilize network transceiver to adjust the center frequency on the C-band transmitter
  - Reduce the number of dedicated flights required to complete C- versus L-band testing

UH-60 Block Diagram



Transmitters

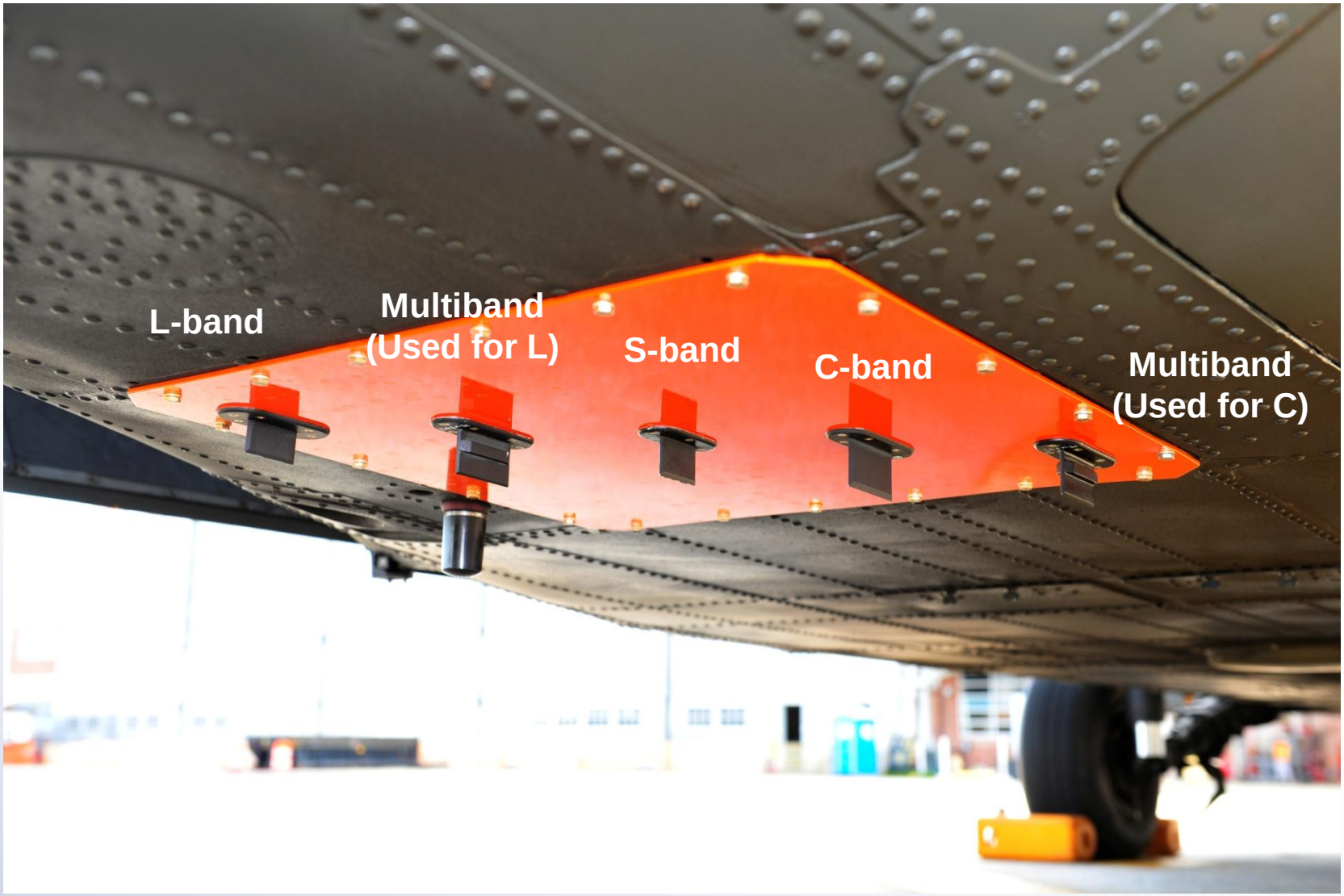


C-band Xmtr

L/S-band Xmtr

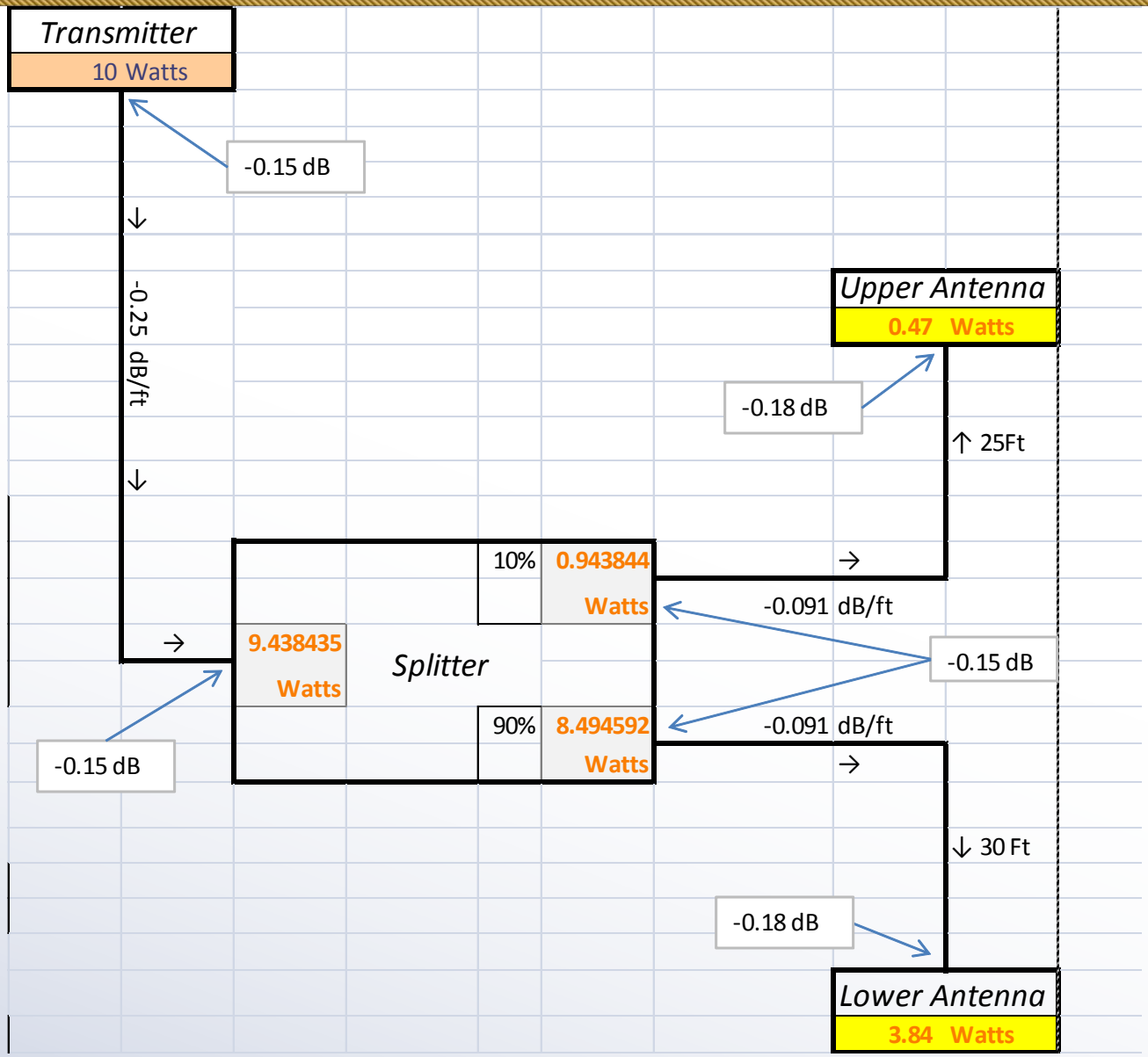
90/10 Splitters

Configurable Lower Antennas



Aircraft Link Analysis

C-band
4930.5 MHz



UH-60 Flight Test Methodology

- Three (3) aircraft antenna configurations
- Repeat all test points in each configuration
  - Test three (3) C-band frequencies with dedicated C-band antenna
- Utilize network transceiver to change C-band transmitter center frequency

Configuration # 1 **Flights 7/26, 7/28, 8/8, 8/10**	**Dedicated L-band Antenna** Freq: 1449.5Mhz All Test Points	**Dedicated C-band Antenna** Freq: 4490 Mhz (All Test Points) Freq: 4710 mhz (All Test Points) Freq: 4930 Mhz (All Test Points)	**Network Transceiver** Freq: 2381.5 Mhz
Configuration # 2 **Flight 8/11**	**Multiband Antenna** Freq: 1470.5 Mhz	**Dedicated C-band Antenna** Freq: 4710 mhz (All Test Points)	**Network Transceiver** Freq: 2381.5 Mhz
Configuration # 3 **Flight 8/12**	**Multiband Antenna** Freq: 1470.5Mhz	**Multiband Antenna** Freq: 4710 mhz (All Test Points)	**Network Transceiver** Freq: 2381.5 Mhz

UH-60 Flight Test Points

Hover 360 Degree Pedal Turn

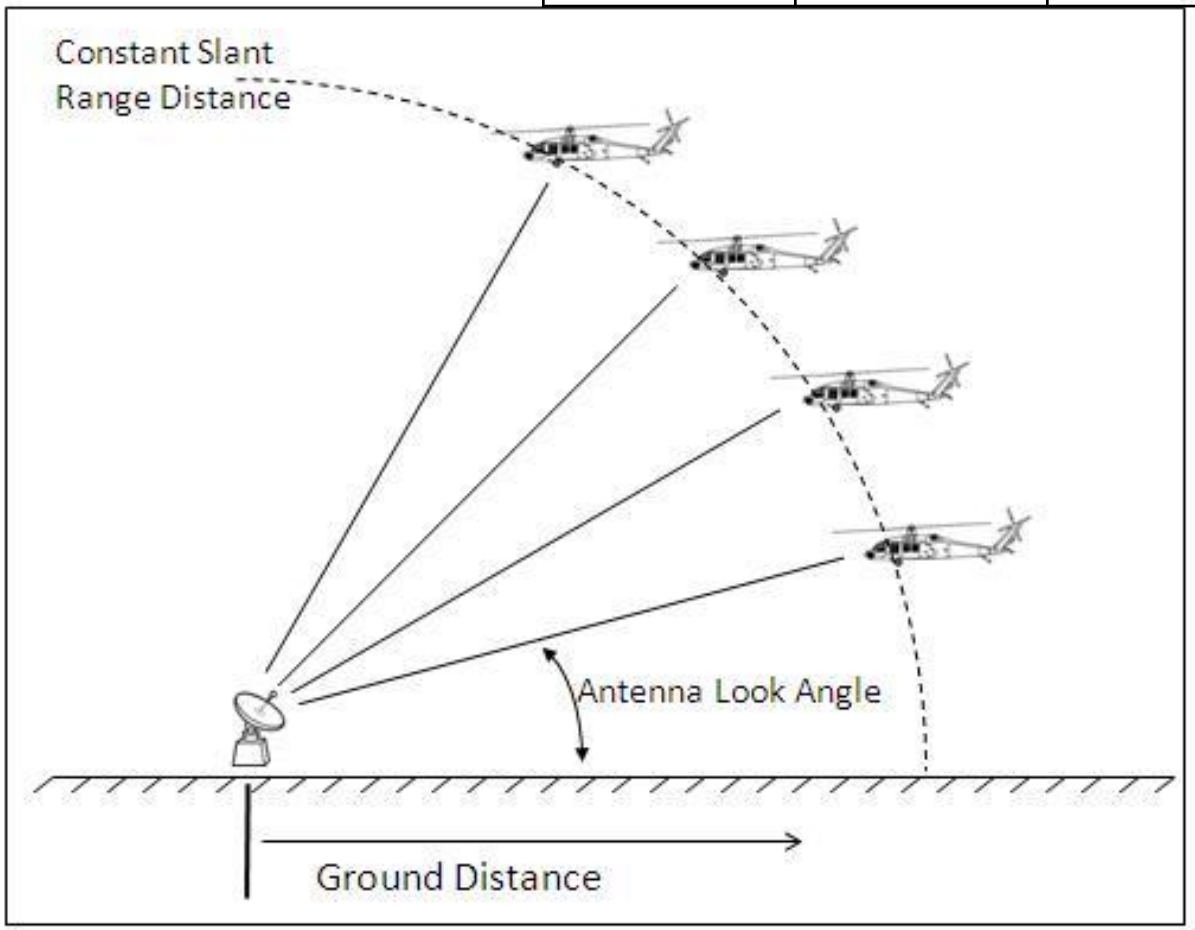
- **50 – 400 feet**
- **3 airfield locations**

UH-60 Flight Test Points (cont.)

Antenna Patterns

- **360 Pedal Turn**
- **Maintaining Altitude & Look Angle**

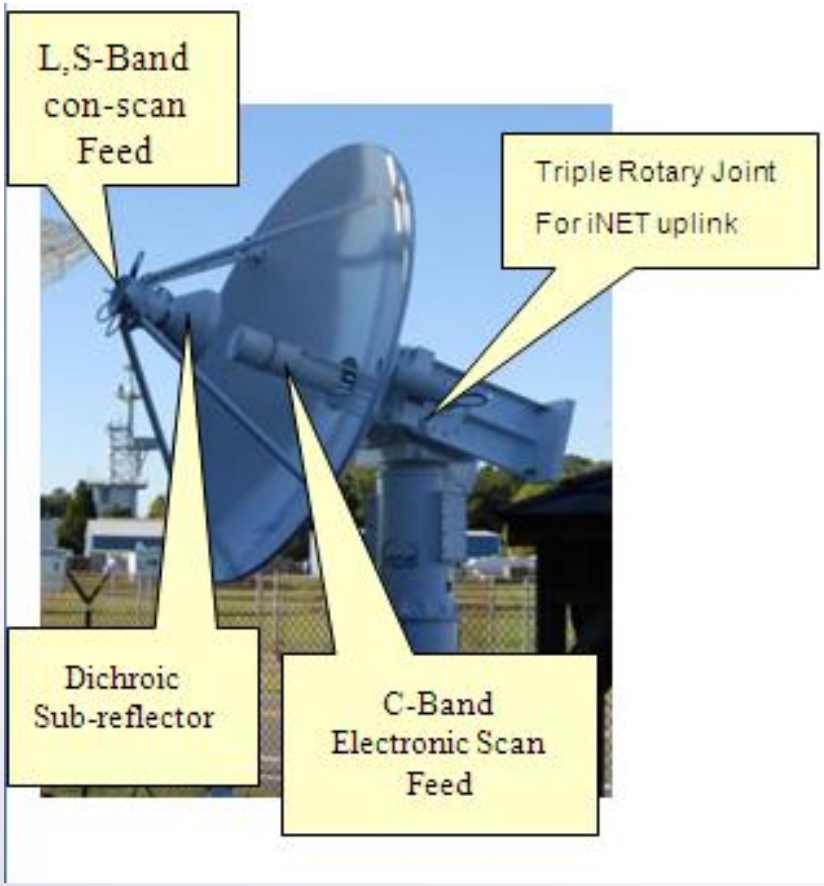
Look Angle (degrees)	Ground Distance (feet)	Altitude (feet AGL above antennae)
15	5870	1570
30	5260	3040
45	4300	4300
60	3040	5260



UH-60 Flight Test Points (cont.)

- Steep Approach/Climb out
  - 0 – 2000 feet
- Range Evaluation
  - 1500 – 5000 feet
  - 60 Miles

Tri-Band Antenna

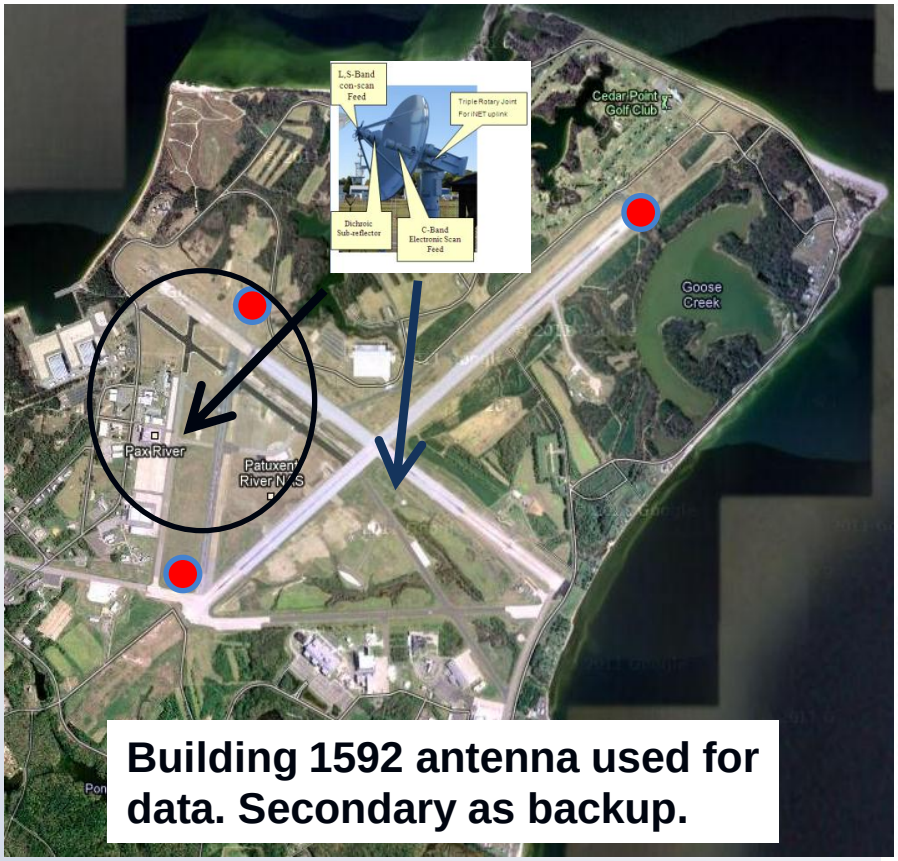


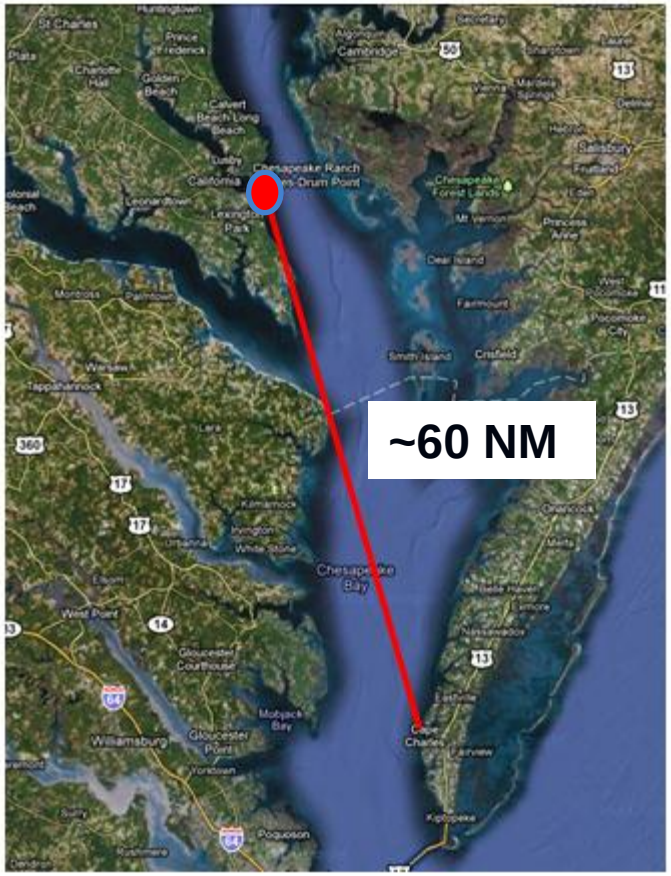
	RHCP G/T	LHCP G/T	Vertical	Horizontal
1435	3.804	4.361	3.517	4.497
1500	5.107	4.838	3.565	4.285
1535	5.94	5.284	5.549	6.822
1700	7.483	7.794	9.163	9.511
1800	7.798	7.922	9.133	9.486
2200	7.731	11.838	7.918	12.628
2300	9.684	9.809	10.782	10.543
2390	9.855	9.855	10.475	11.078
4400	13.077	14.101	14.226	14.717
4670	13.458	13.848	14.231	14.104
4940	13.719	13.977	15.098	15.58
5120	14.244	14.63	15.256	15.624

- **Antenna optimized for the C-band**
- **Max range Eb/No differences between the C- and L-band are negligible**

Antenna Locations

- Antenna locations relative to airfield and range evaluation test points





Flight Summary

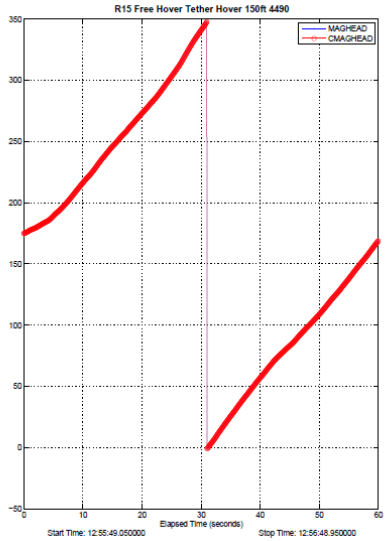
- Six flights
- Total of 11.5 hours
- Completed 114 dedicated test points
- 40,348 time history plots possible

Data Quality Metrics

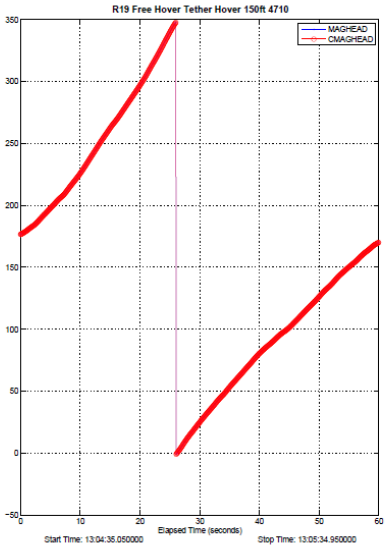
Average over all test points for whole flight

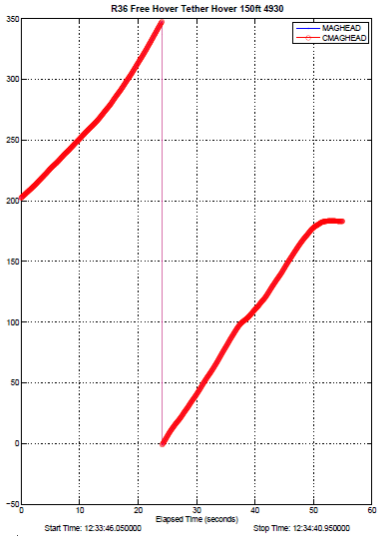
Flight Date	% Frame Syncs Captured L-band	% Frame Syncs Captured C-band	Signal Strength dB L-band	Signal Strength dB C-band	A/C Antenna Configuration
July 26th	98	95	-	-	Dedicated L, C
July 28th	91	91	49	46	Dedicated L,C
Aug 8th	96	94	53	52	Dedicated L, C
Aug 10th	92	94	35	48	Dedicated L,C
Aug 11th	87	96	41	44	Multi L Dedicated C
Aug 12th	92	98	58	47	Multi L,C

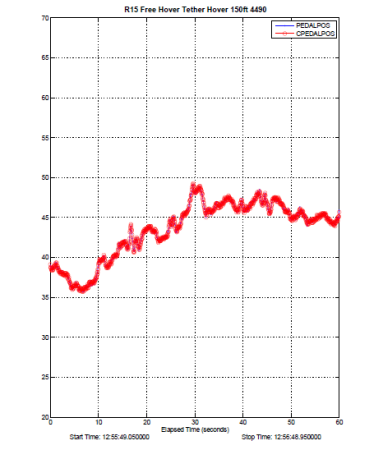
Dedicated L & C Antennas
360 Deg Hover Turn



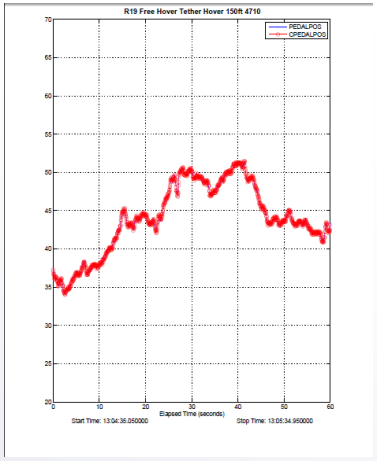
Heading

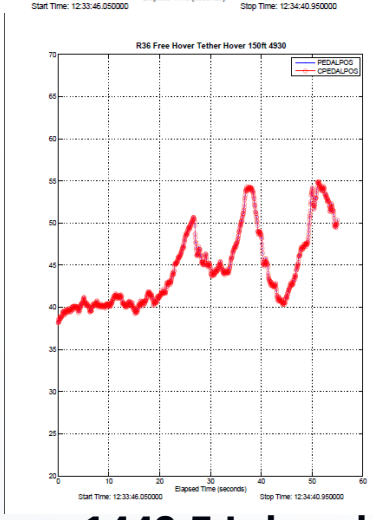






Pedal Position



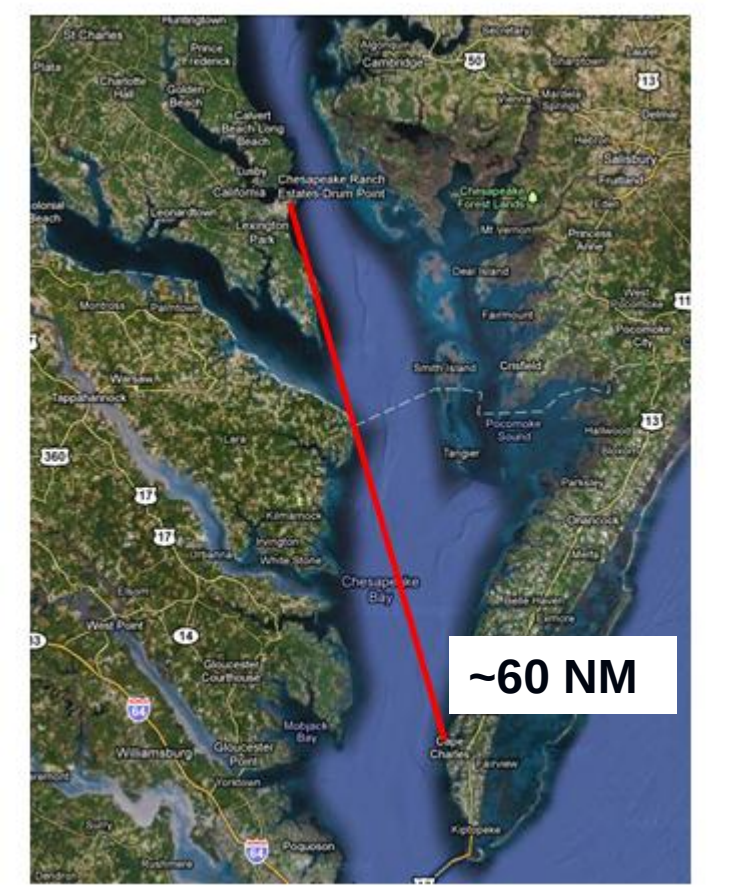


1449.5 L-band
4490 C-band MHz

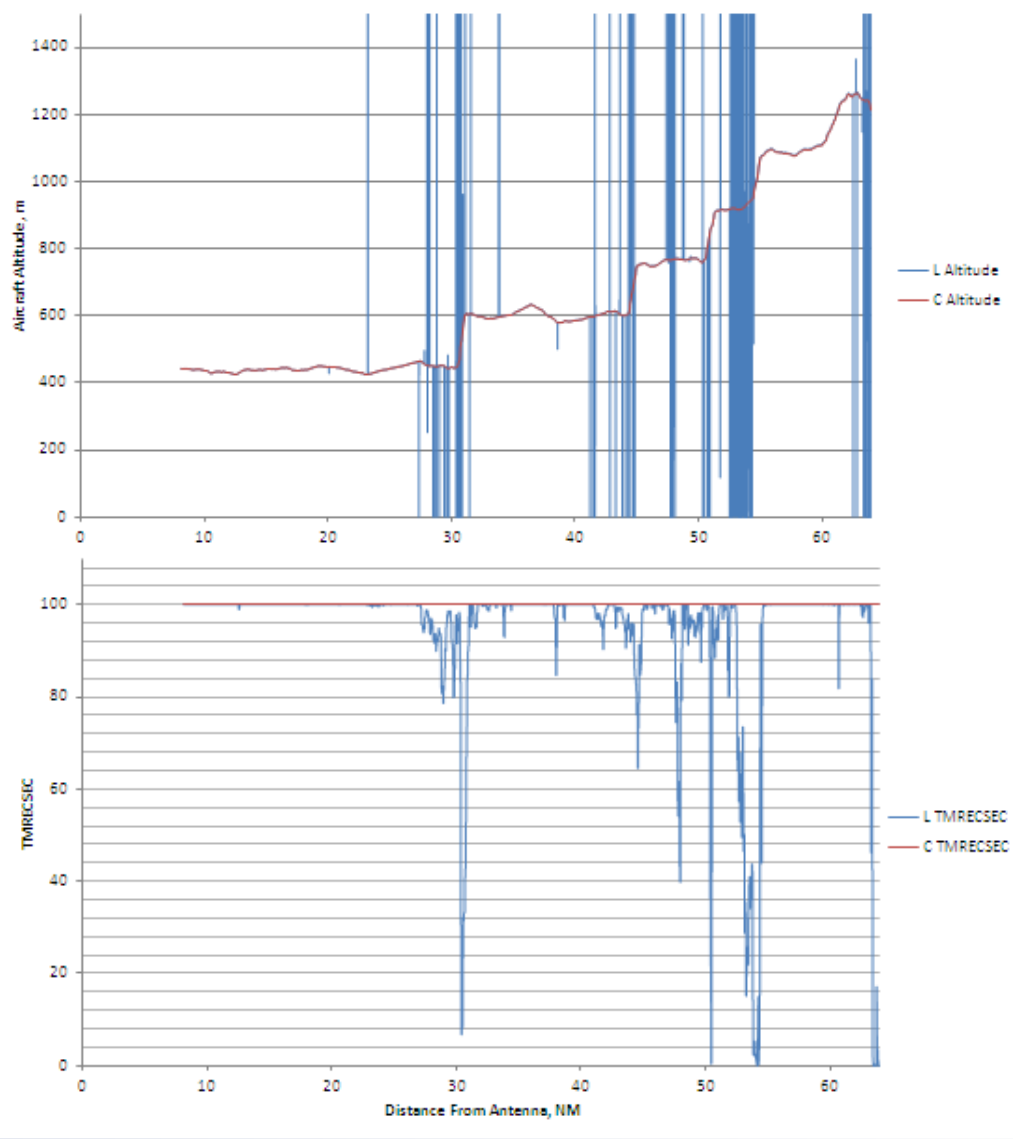
1449.5 L-band
4710 C-band MHz

1449.5 L-band
4930 C-band MHz

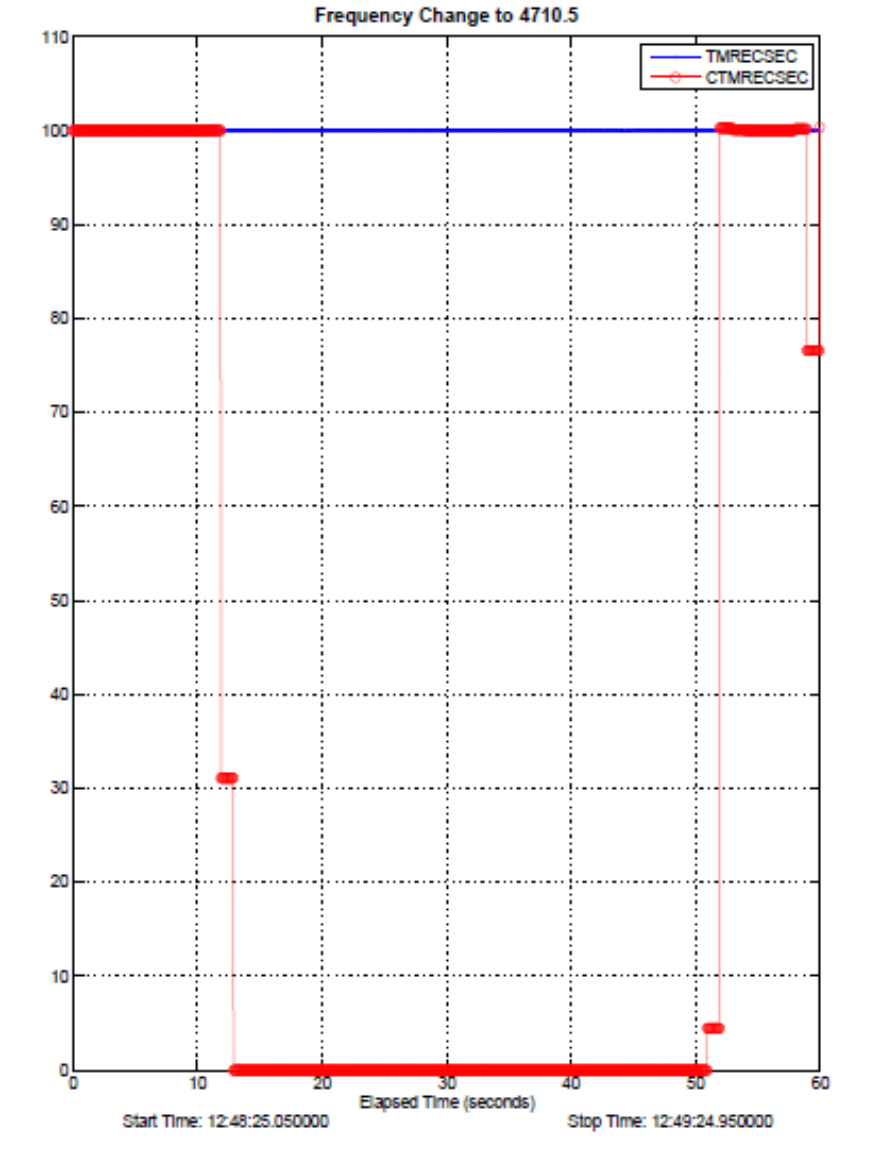
Range Evaluation
Dedicated L / Dedicated C



1449.5 L-band
4710 C-band



Points of Interest
Changing C-Band Center Freq using Network Transceiver



Answers to Questions

- How does the performance of C-band compare to L-band in a UH-60 at Patuxent River
  - *C-band and L-band performance is similar for airfield test points*
  - *C-band frequencies compared favorably to lower L-band on the range evaluation*

Answers to Questions

- How will C-band perform over the water?
  - *C-band over water performed well using antenna located at airfield*
  - *Sea states were very low*
  - *Next tests will use Point Lookout antenna for better look over water*
  - *Further investigation is needed*

Answers to Questions

- How do multiband antennas perform compared to dedicated band-specific antennas?
  - *Similar performance in the L- and C-bands for airfield test points*
  - *Degradation in signal quality in both the L- and C-bands during range evaluation test points*
    - *C-band performed better than L-band*
    - *Based on antenna plots this was not expected*
  - *Further investigation is needed.*

Summary/Conclusions

- Nick Wirz, Test Conductor

  "Using C-Band, no knock-it-off calls would have been given during representative Rotary Wing test points."
- C-band doesn't like trees. Significant loss of signal compared to L-band with obstructed views. This is an issue at PAX. Analysis continuing.
- C-band and L-band both lost data at relatively the same time but behavior was slightly different. Investigations continue.
- Multiband cable performed well as expected based on calculations, and lab tests compared to flight test results

Summary/Conclusions

C-band TM is effective for typical helicopter test points at Patuxent River

Path Forward

- Target new installations for C-band use
  - V-22 upgrades
  - CH-53K
- Instrument TPS F/A-18F test bed with S- and C-band transmitters with a network transceiver
- Brief flight test community on these results
  - Obtain flight test buy-in to target specific legacy aircraft for C-band use

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