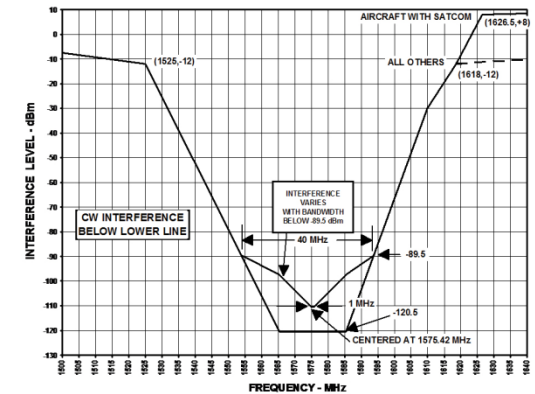
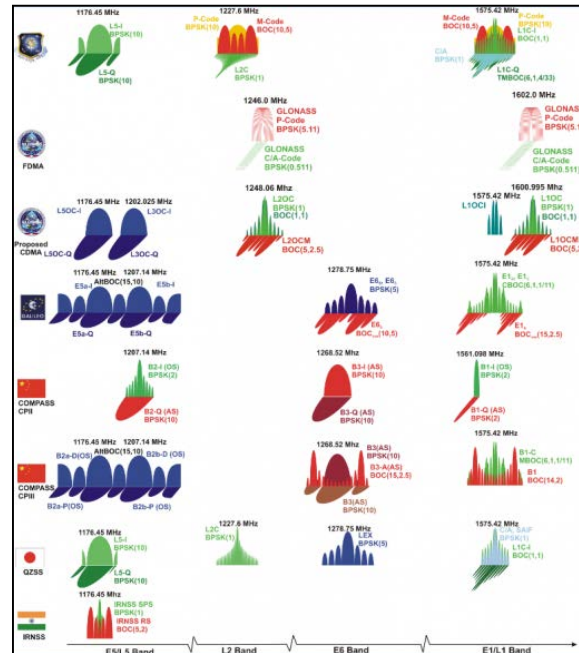
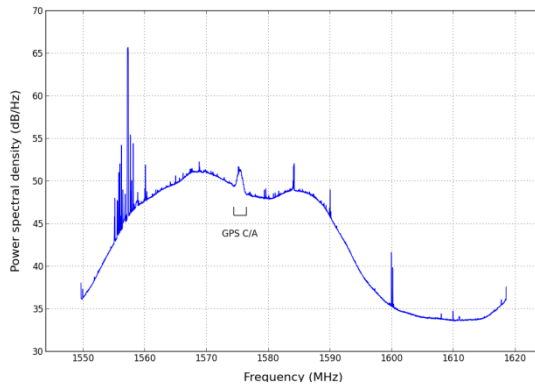


# Automation and results of Adjacent Band Emission testing



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# Agenda

- Problem Space
- Automation System – PANACEA
- Test Setups
- Example Test
- Example Results
- Findings
- Summary

 panacea



# Problem Statement

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- Adjacent band testing is not fully defined
  - Multiple groups conduct tests in various ways
  - Outcomes vary based on test setup and assumptions
  - No standard has been established to conduct such tests
- Spectrum is scarce and the need for compliance testing will only increase
- Simplified process is needed across the enterprise to conduct testing and analyze results

# What is PANACEA?

- GPS in-the-loop Test and Analysis Suite

- **Controls Environment**

- GPS Signals
    - Threat Signals
    - User Motion



- **Controls GPS Unit(s) Under Test**

- Receiver Initialization
    - Real-Time Monitoring

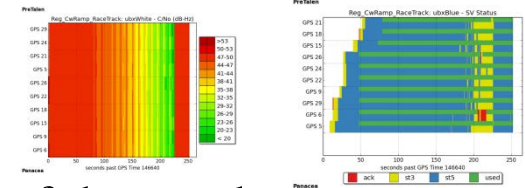


- **Collects and Stores Receiver Performance Data**

- Navigation, Measurement data collected and translated into common message structure

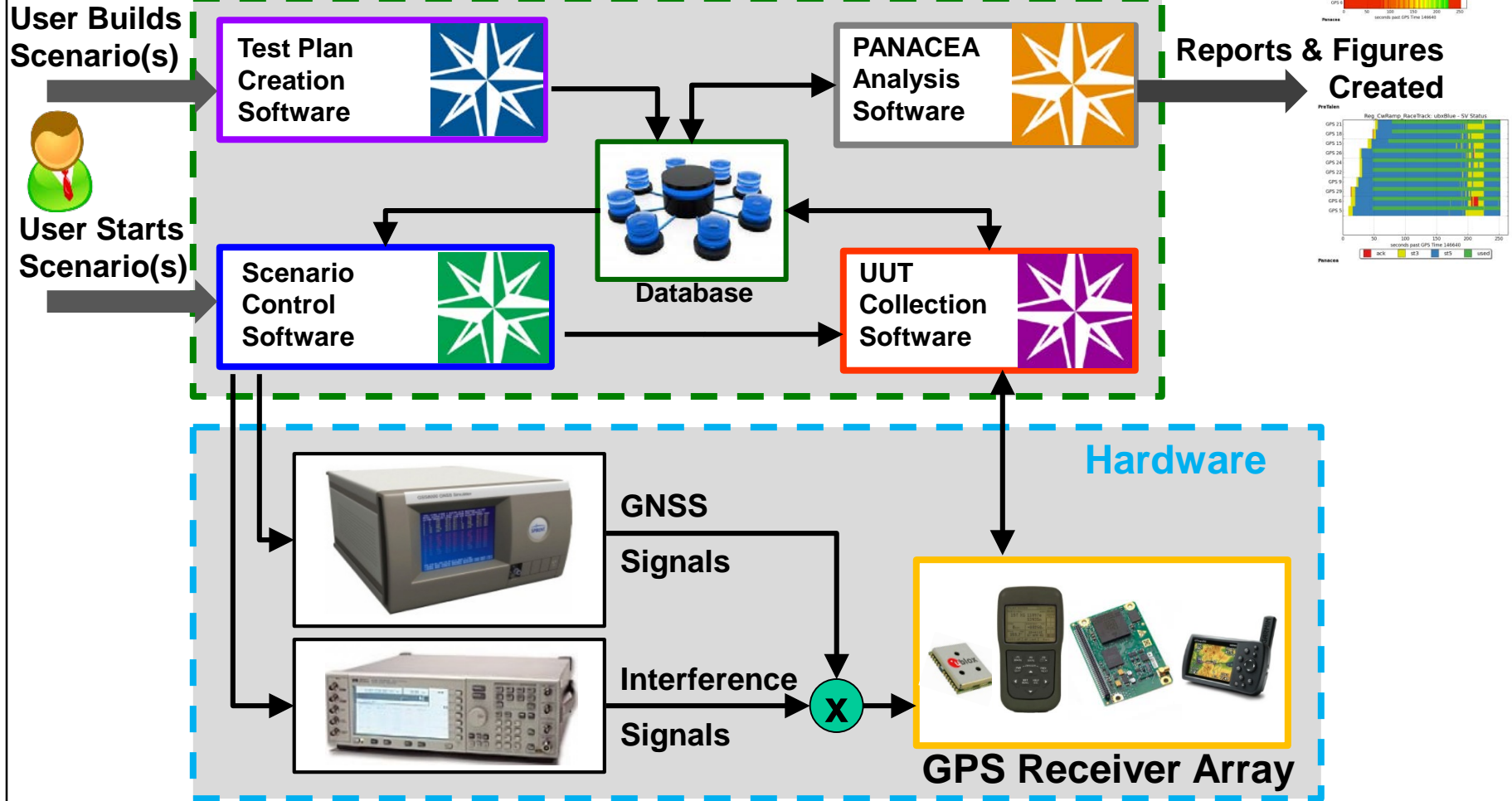
- **Produces Reports and Figures**

- Quick and Accurate way to begin Analysis of the results



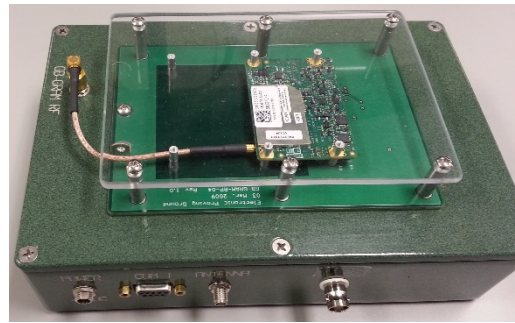
# PANACEA System Design

## PANACEA Software



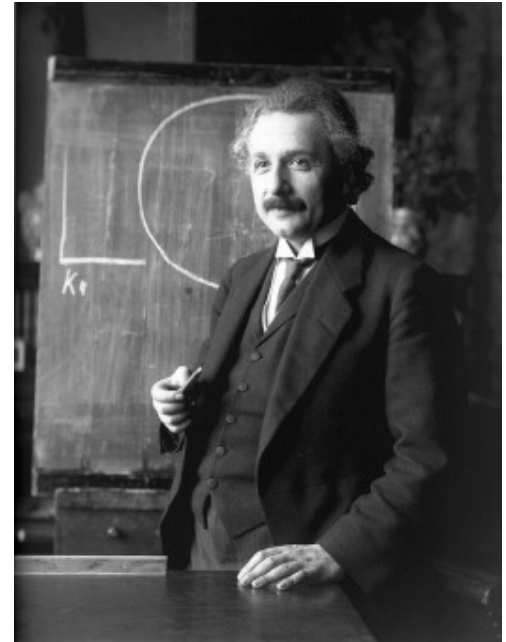
# Capabilities

- Version 1.3 interfaces with:
  - **GNSS sources:** Spirent (GPS)
  - **Interference sources:** Agilent (443x)
  - **GPS Receivers:**
    - Interface via USB, RS-232, RS-422, 1553 Bus
    - DAGR (all variants), GB-GRAM (all variants), NavStrike (all variants), MicroGRAM, PLGR, D3
    - uBlox (all variants), Novatel ProPack, TA-24, Trimble Lassen iQ, Trimble SK II, H746G EGI, CommSync II, Symmetricom Xli, Magellan 5000



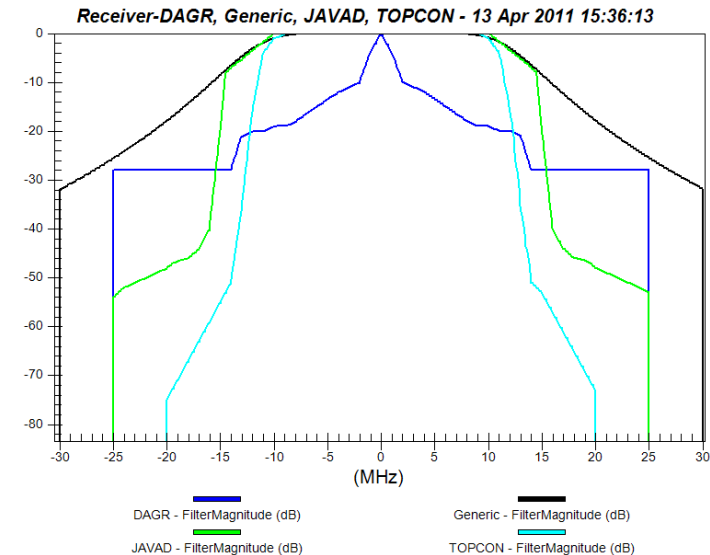
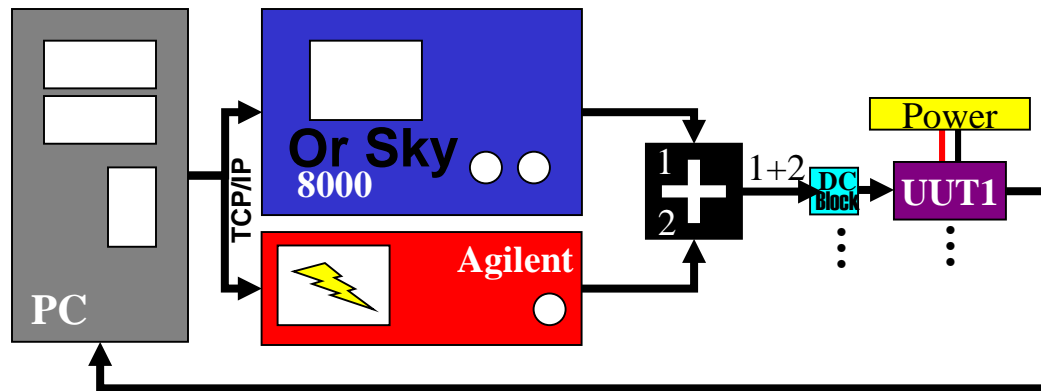
# Test Setups

- Basic approach
  - Setup tests one at a time
  - Single unit under test
  - Collect/analyze data manually
- Production approach
  - Parametric tests / automated execution
  - Multitude of units under test
  - Collect/analyze data as a part of execution



# Basic Test Setup (prior to PANACEA)

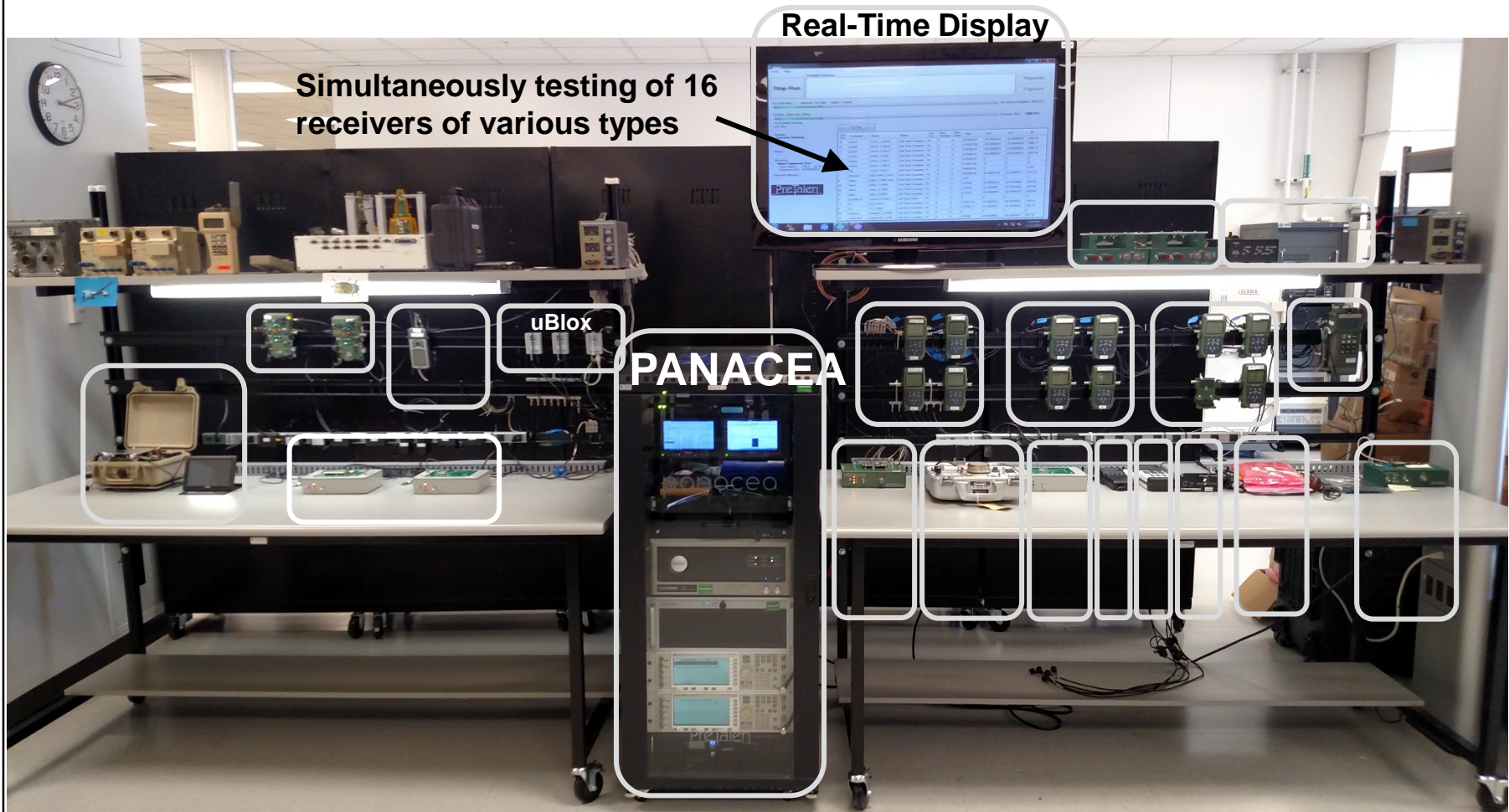
- Analyzed GPS receiver performance across the band
  - Stepped 2 MHz noise in 1 MHz steps from 1575-1550
  - Started power below the noise and stepped up 1dB / 5 sec
  - Collected transfer function across the band
  - Includes front end filter/gain and processing in the receiver
  - Does not include antenna/external gain effects



**Realistic receiver effects to interference**



# PANACEA Test Setup



Courtesy of Army CERDEC - APG

# Example Test

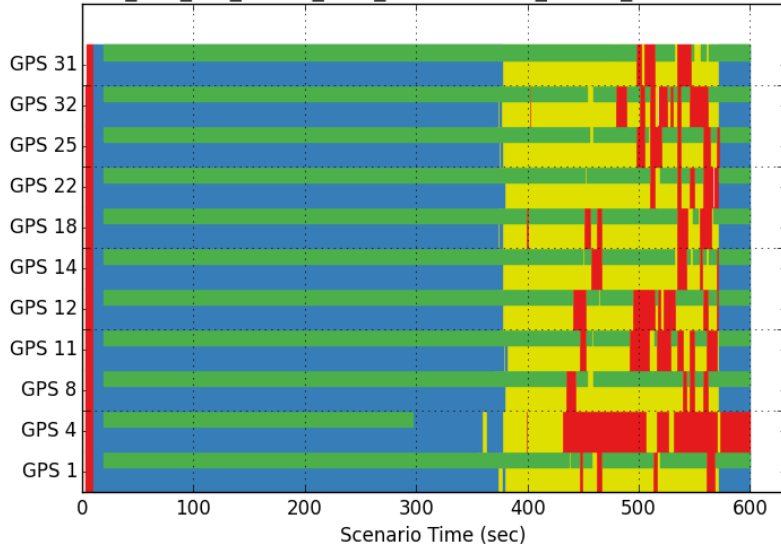
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- Purpose: Determine adjacent band interference susceptibility
- Tested uBlox5, 6, 8 and MicroGRAM Rcvrs
- Tested CW, AWGN, and Swept CW
- Test 1 – discrete frequencies ramping up power starting at 90 seconds (after good track) 0.5 dB every 3 seconds
- Collected tracking data – pulled results once 1 SV dropped and when track was lost

# Example Outputs

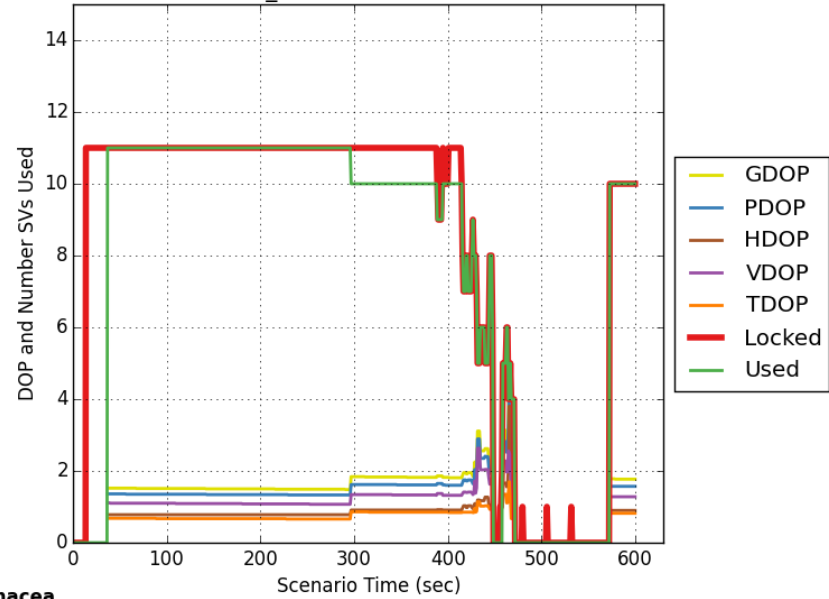
PreTalen

OOB\_test\_CW\_AWGN\_SWP\_00004: uBlox\_LEA6H\_23 - SV Status



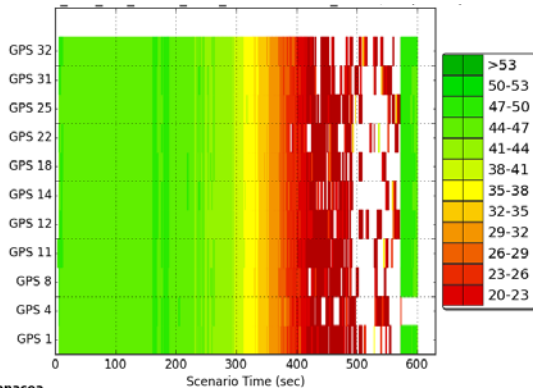
PreTalen

ublox5\_24 - DOP, Tracked, Used

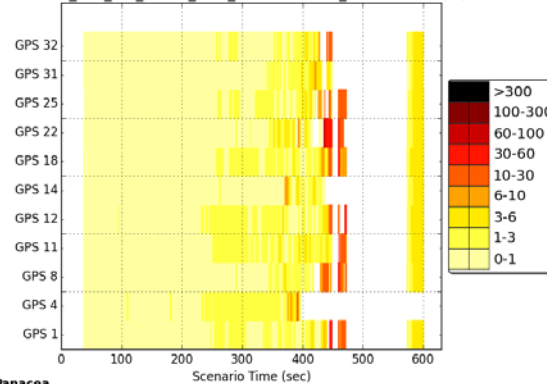


Pre1

Panacea



OOB\_test\_CW\_AWGN\_SWP\_00004: ublox5\_24 - PR Resid(m)

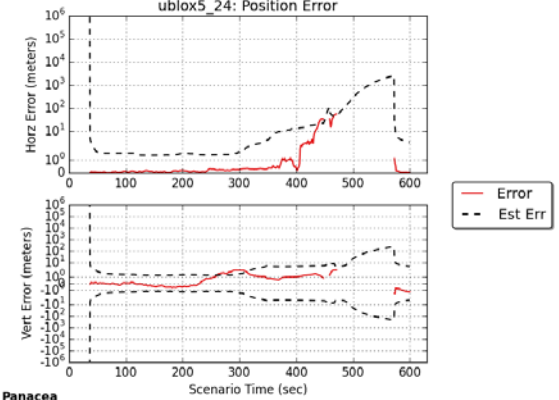


Panacea

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PreTalen

ublox5\_24: Position Error



PreTalen

# Considerations / Assumptions

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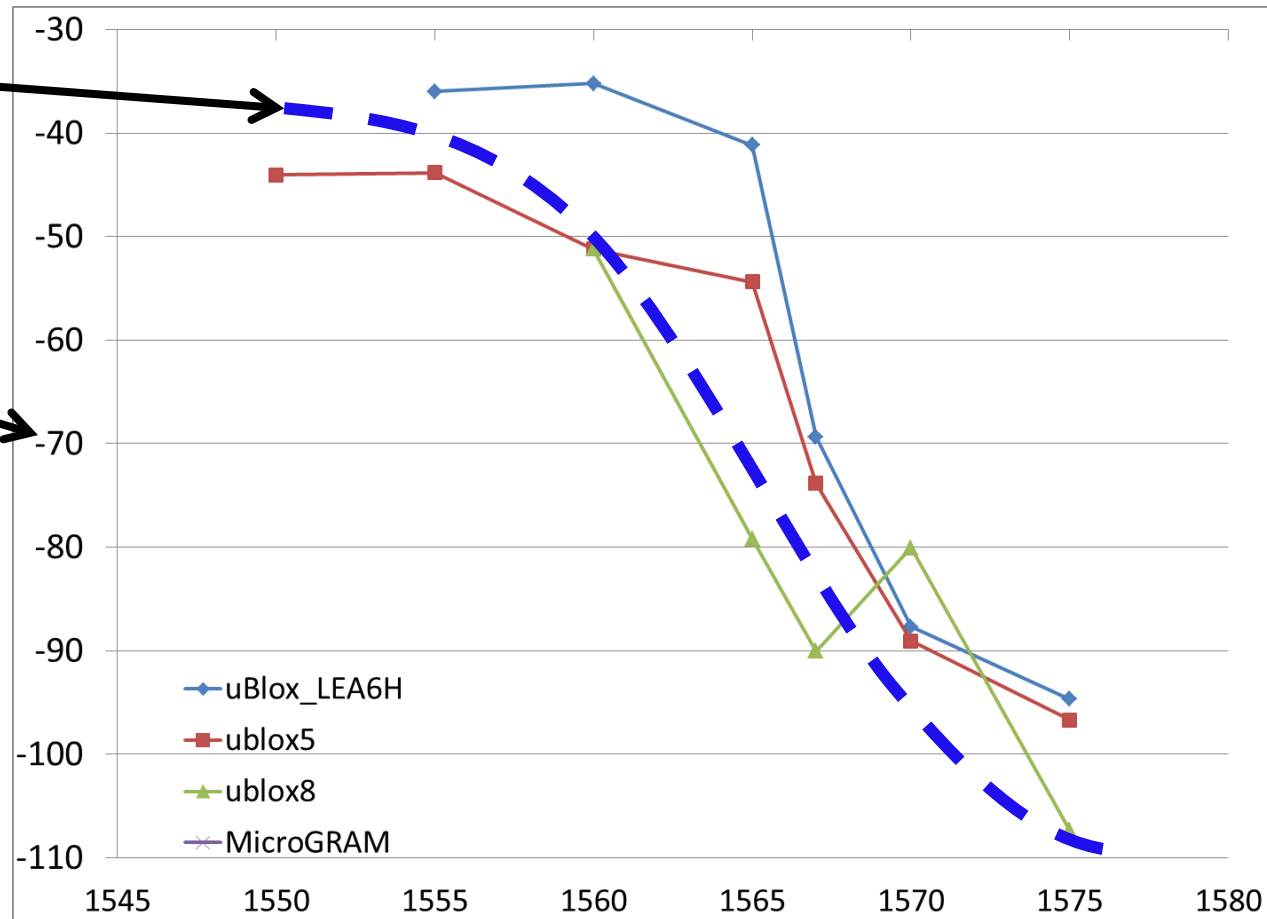
- Antenna and resulting filtering effects are not present
- Signals are “perfect” and free from intermodulations and environmental effects
- These conclusions are for demonstration purposes only and should not be used to make purchase or evaluation decisions

# Description of Results

Receiver “mask”  
can be  
approximated

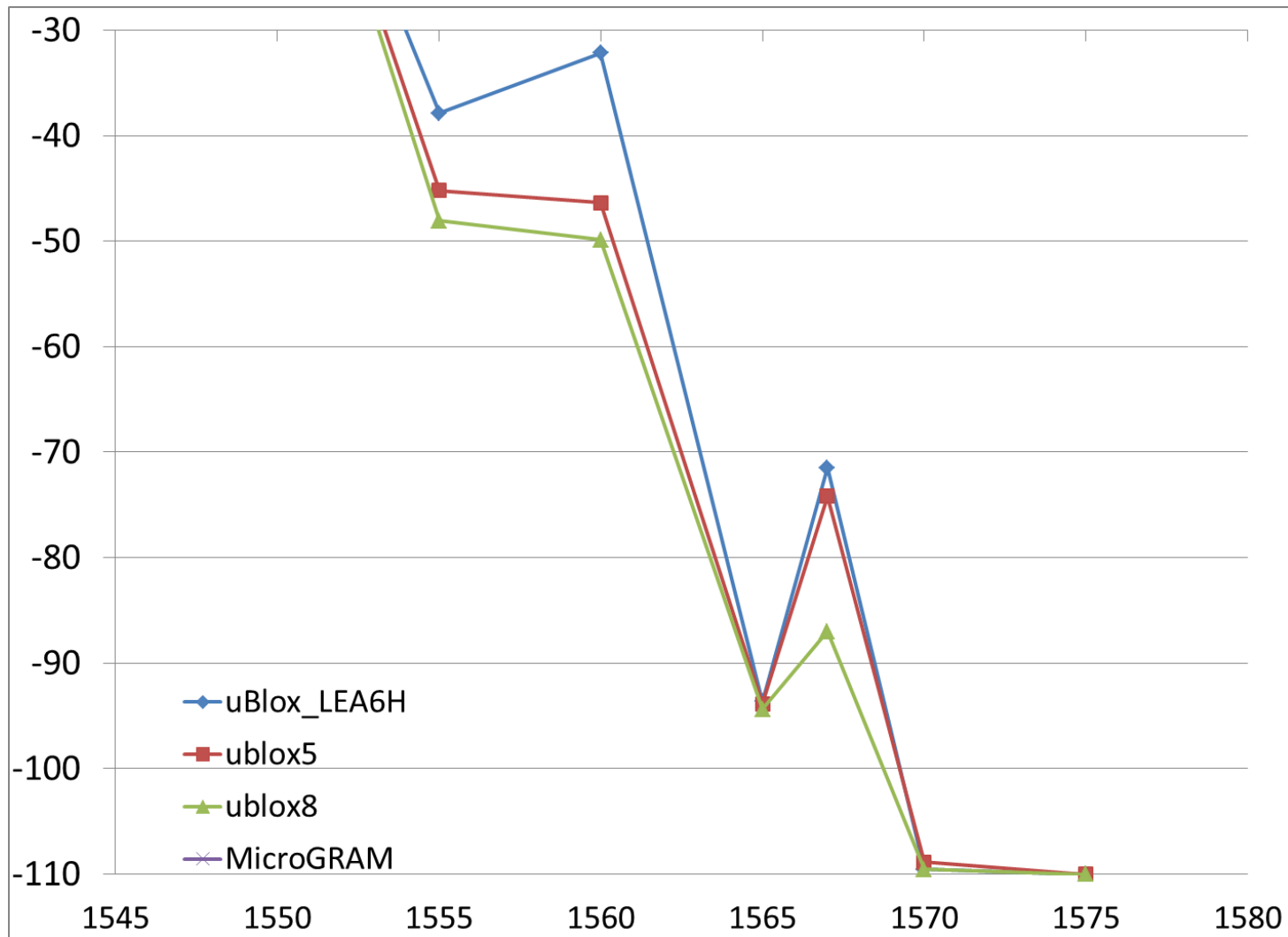
RF power (dBW)  
required to cause  
effect – less  
negative the  
number the better  
the receiver is in  
handling the  
interference

MicroGRAM  
results removed

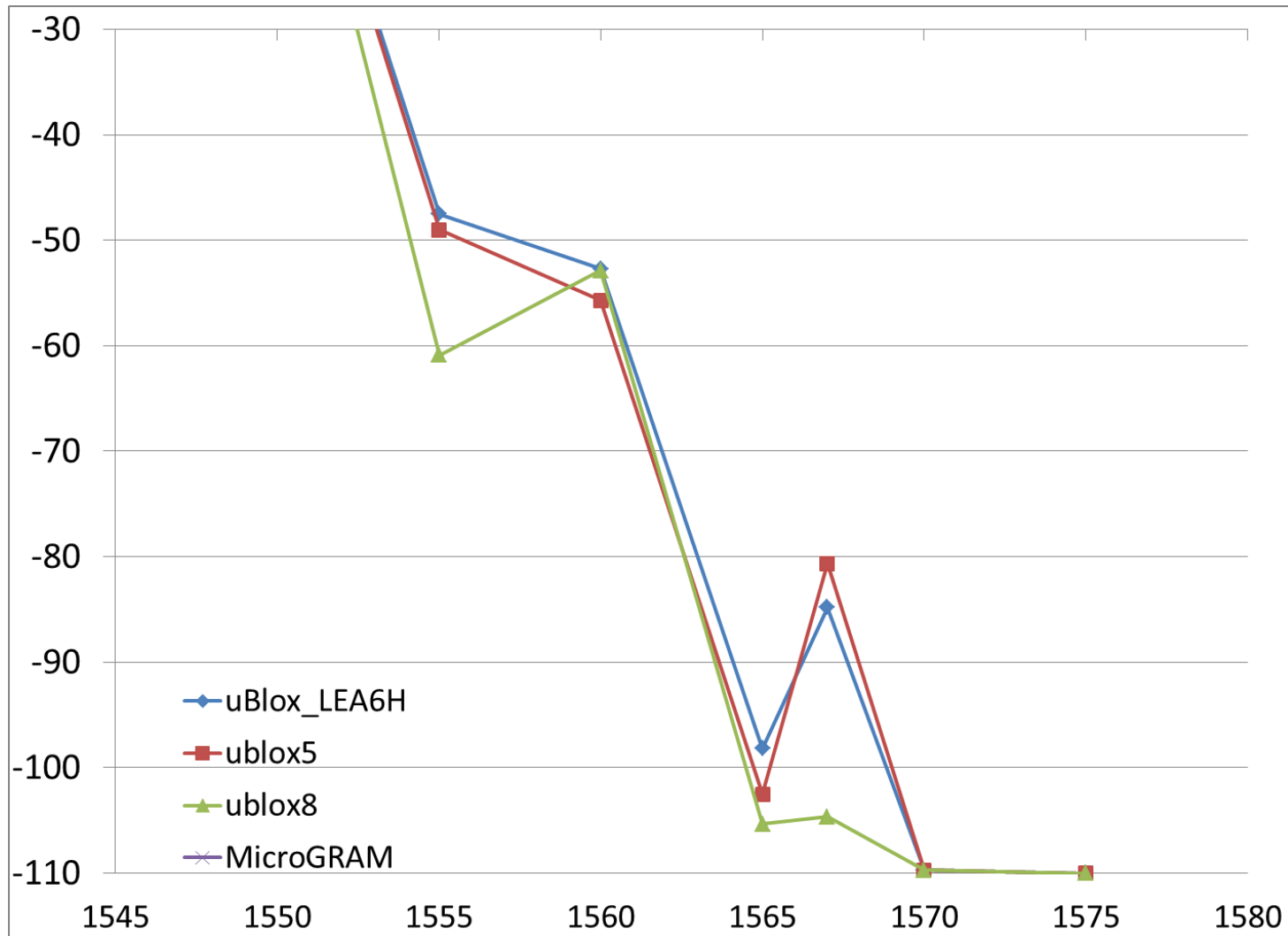


Frequency (MHz) of the interfering signal –  
power ramped 0.5 dB every 3 sec – started  
90 sec into the scenario

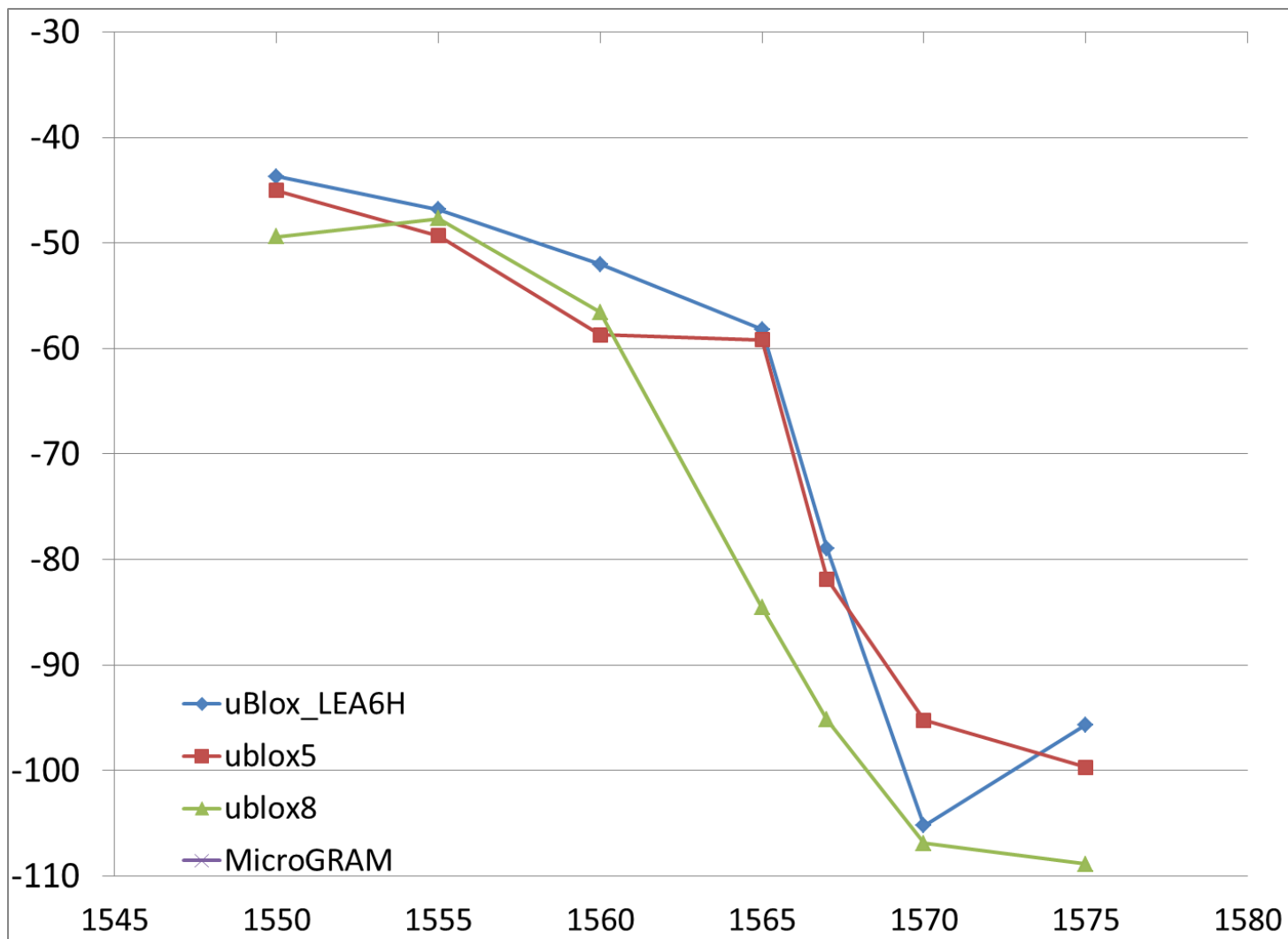
# Swept CW Effect Noticed



# Swept CW - Denied

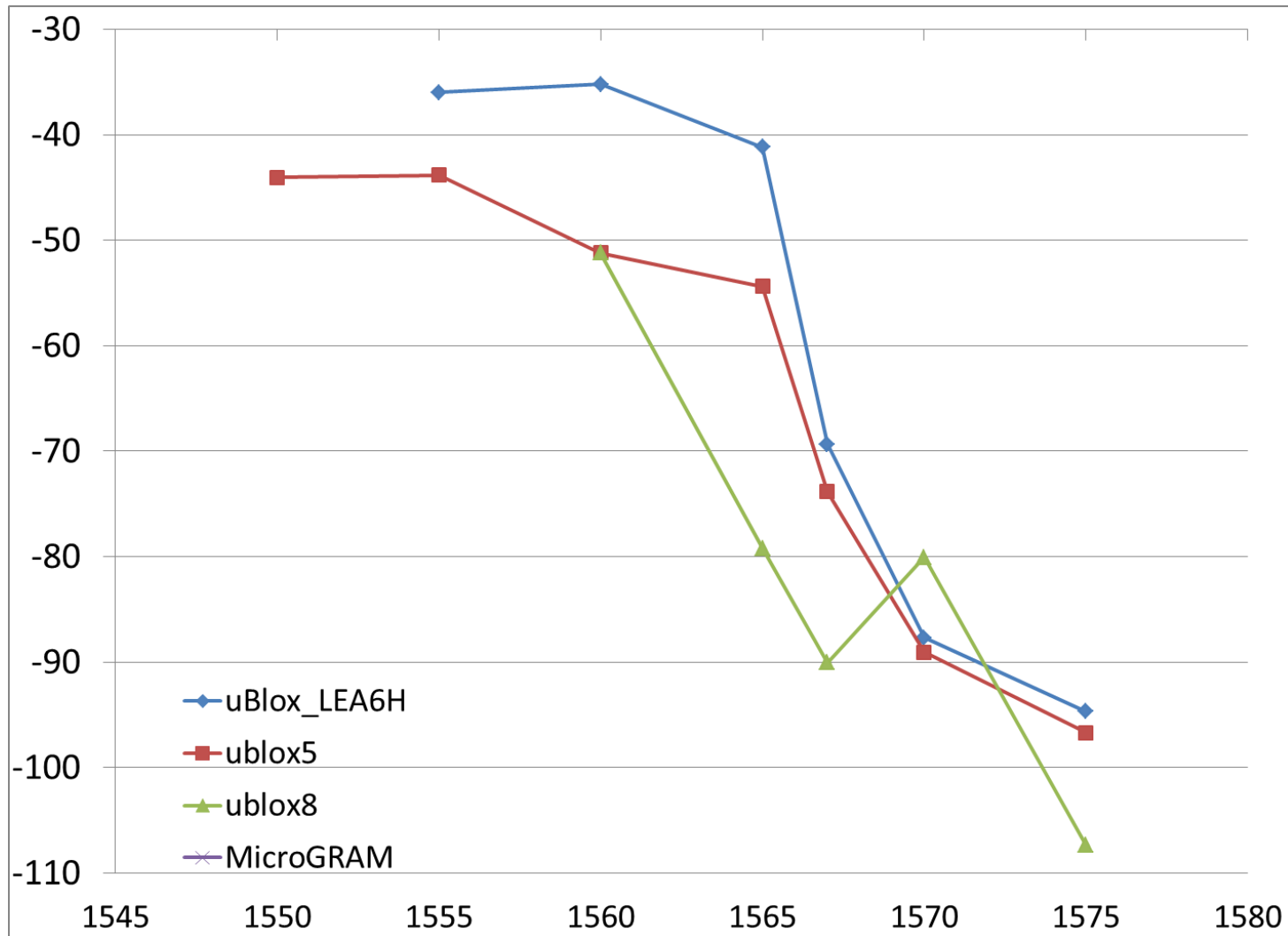


# CW Effect Noticed

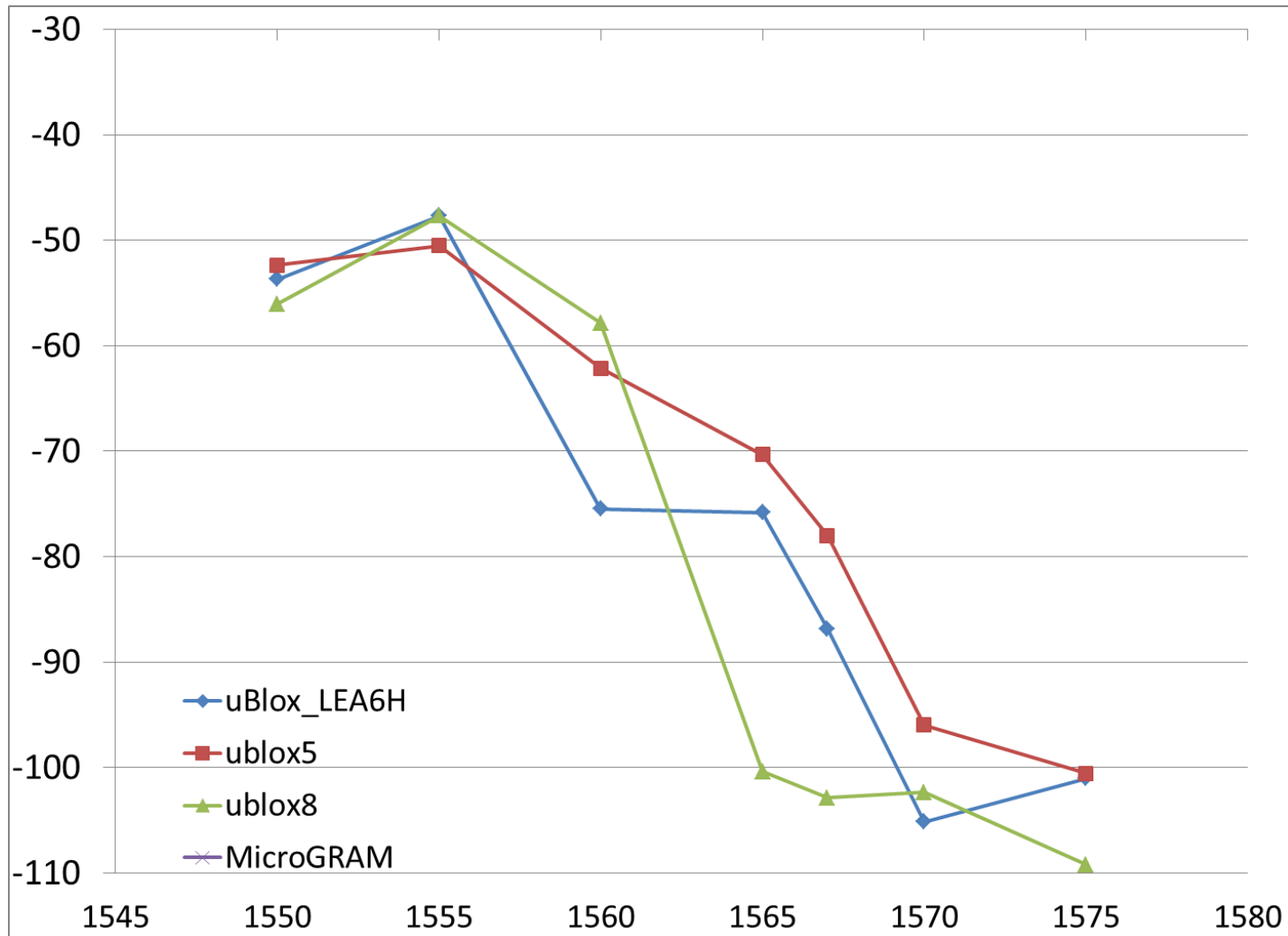




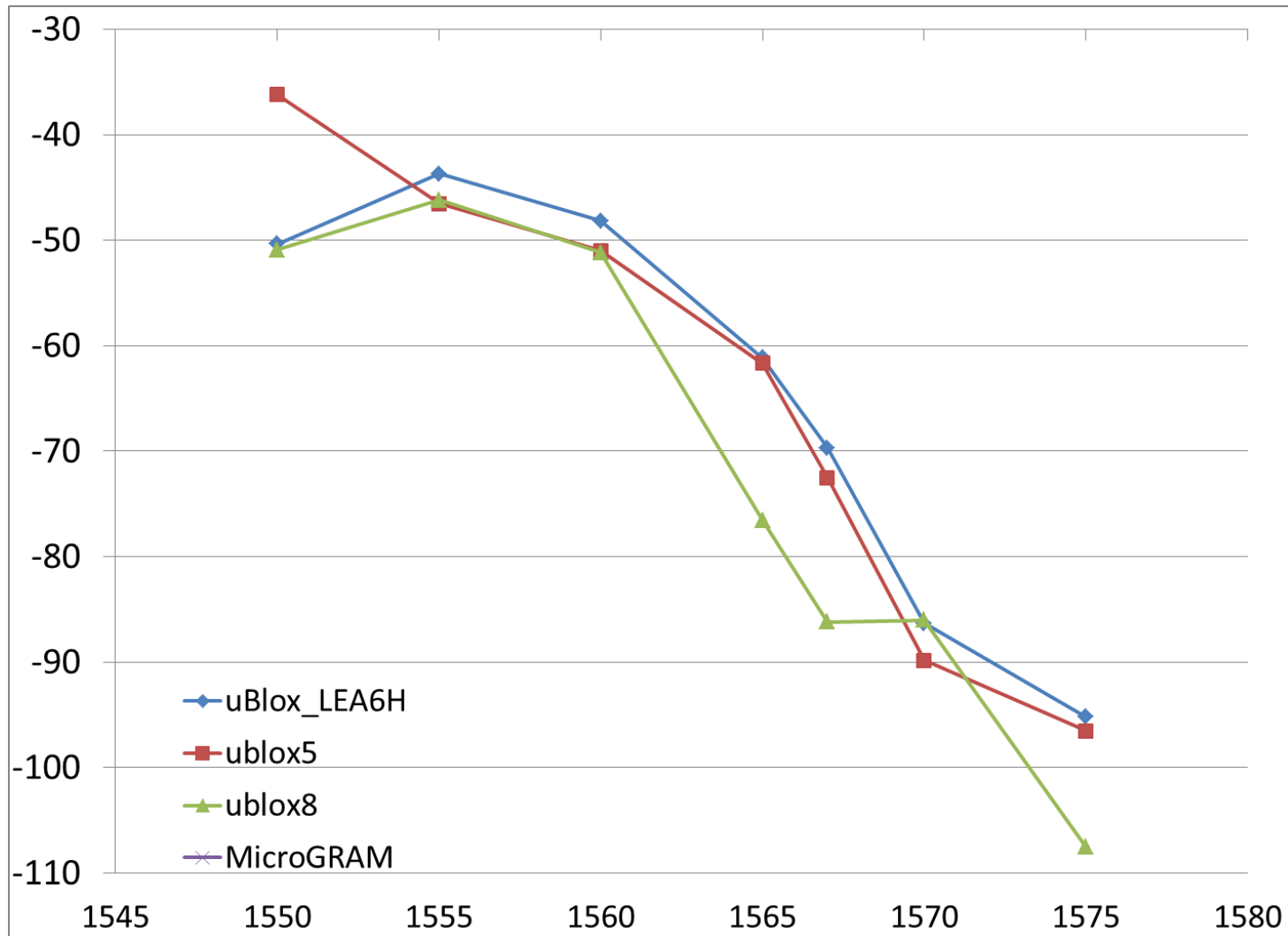
# CW - Denied



# AWGN Effect Noticed



# AWGN - Denied



# Findings

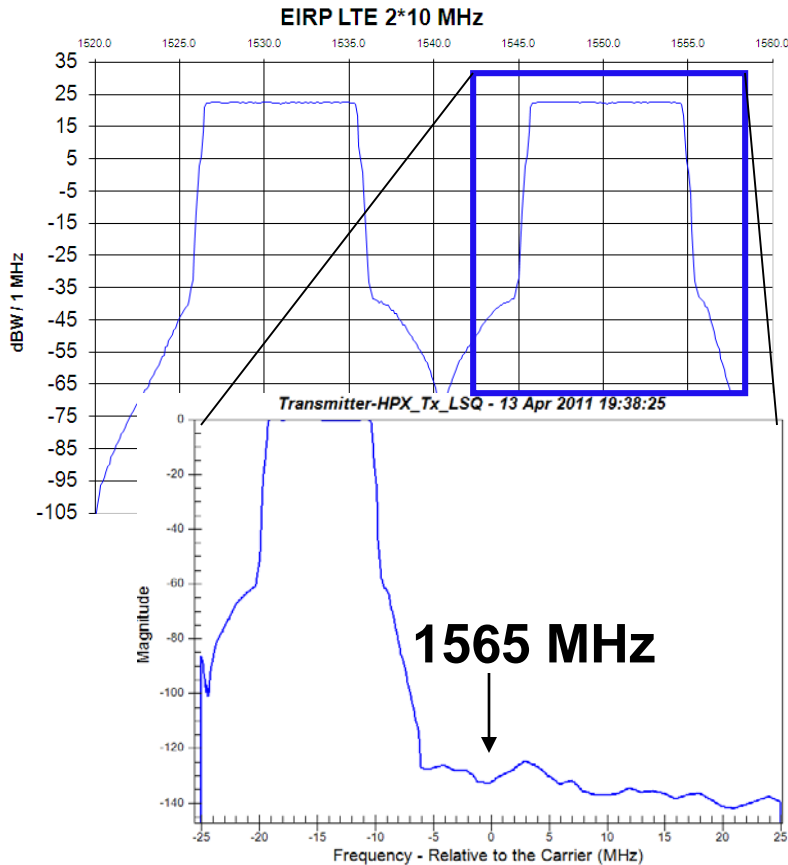
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- Receiver front end/susceptibility can be determined by the placement of test signals
- Modulation of the adjacent band signal also should be considered (many receivers incorporate a narrow band filter)
- Both the transmission filter mask and the receiver mask should be considered

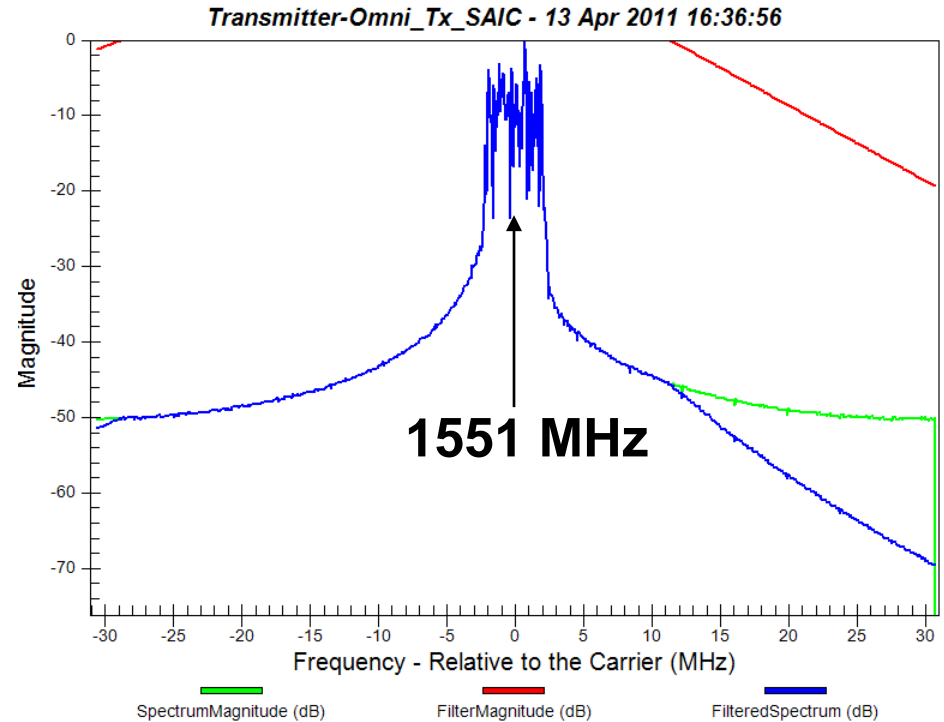
# LTE Signals – which is right....

Hypothetical Data Only

## LSQ provided envelope



## Actual signal emulating LSQ-OFDM



**Assumptions on signal out-of-band emission is key**

# Summary

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- Problem exists for a prescribed and consistent test setup/process for adjacent band emission testing across the PNT enterprise
- Numerous tests have been conducted and lessons learned/shared will arrive at a best of breed solution – working group fosters growth
- Several solutions are possible to resolve spectrum issues – tests will prove the potential