# Adjacent Band Interference to Consumer Receivers

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National Space Based PNT Advisory Board
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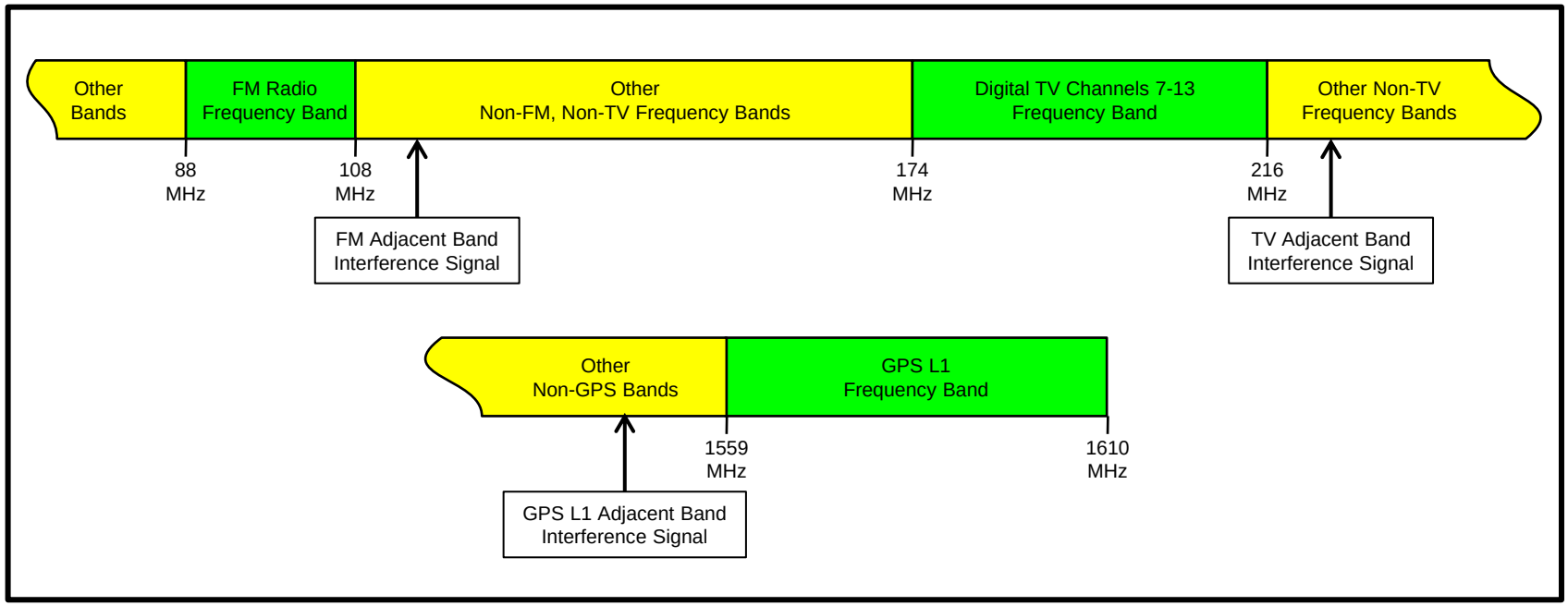
# Introduction

- The issue of adjacent-band interference to radio receivers has received recent attention
  - *In particular, adjacent band interference to GPS receivers*

- Leads to the question: How well do other types of radio receivers withstand adjacent band interference?

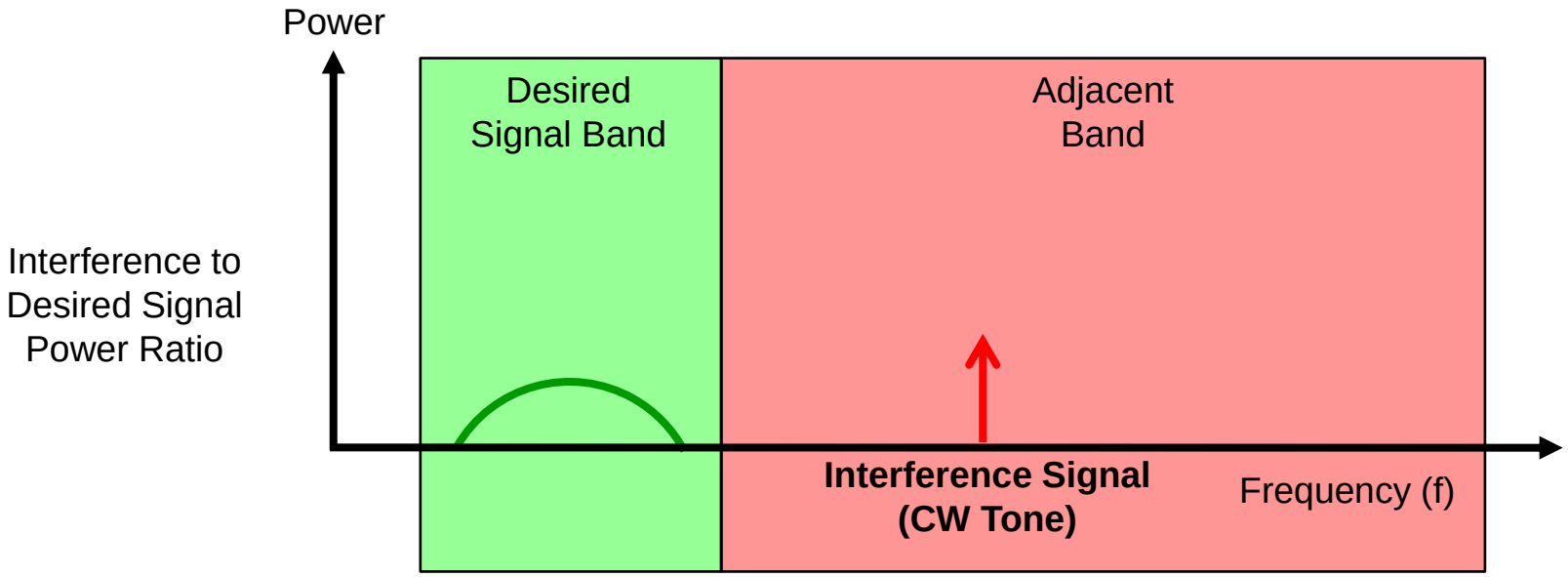
- The Aerospace Corporation tested a number of common consumer radio receivers against adjacent band interference signals
  - *Digital Television (Samsung LN52B530)*
  - *FM Radio (Sony STRDH100)*
  - *3 types of GPS receivers*
    - Garmin Montana 650t, uBlox LEA-6A, Novatel OEM 628

# Test Design

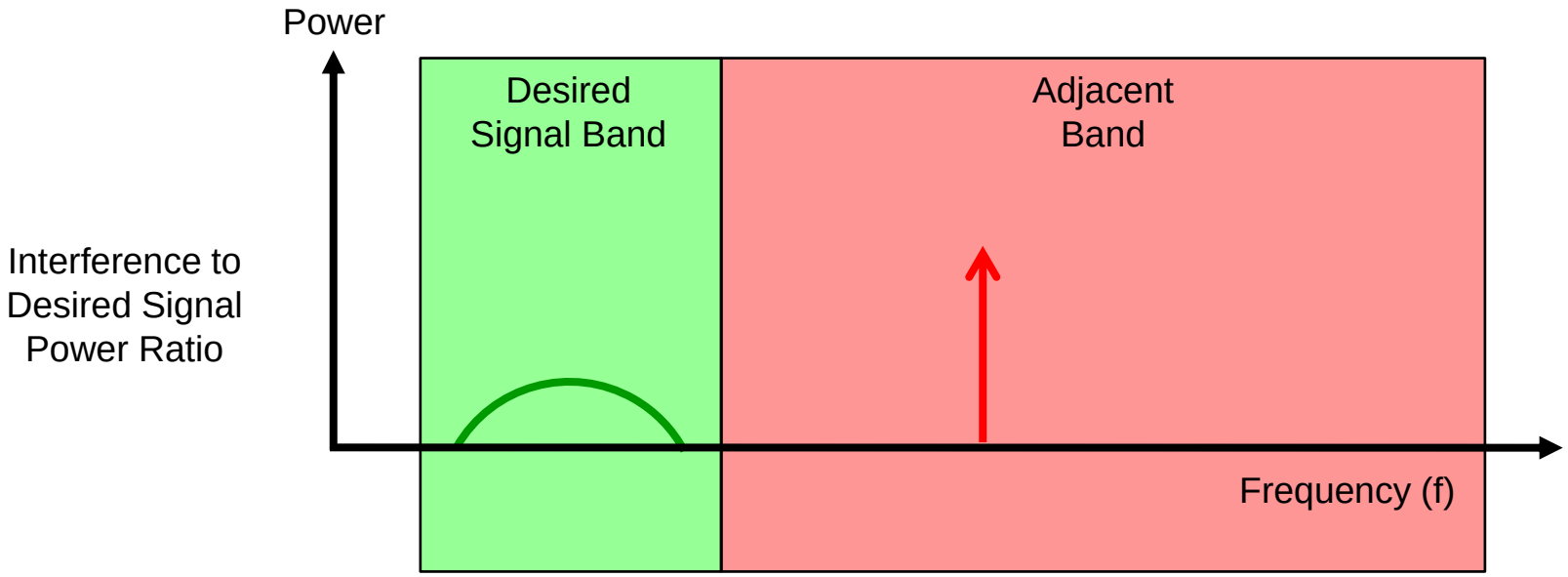



- All testing conducted in a controlled, laboratory environment
  - *Conductive or anechoic chamber - No external transmissions!*
- Continuous Wave (CW) signal transmitted at varying power and frequency offset from each device's operating band
  - *Interference signal transmitted outside of device's allocated band*

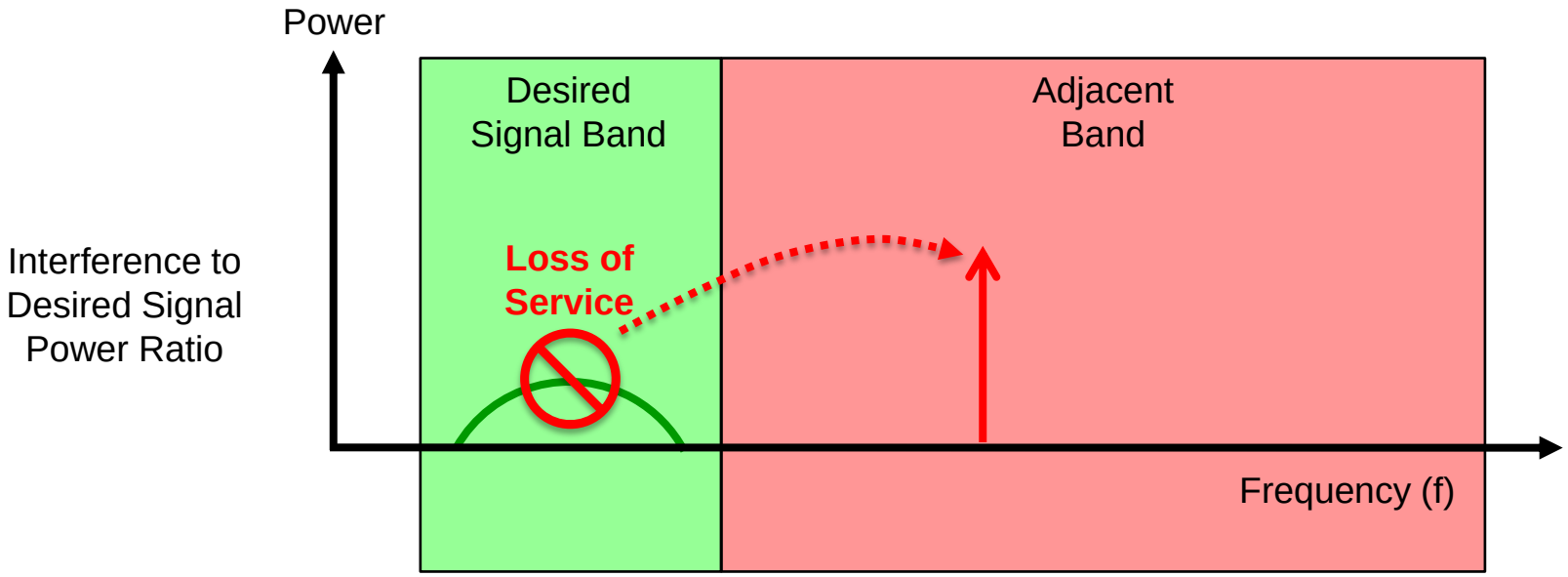
# Start with CW tone in adjacent band



# Increase power …

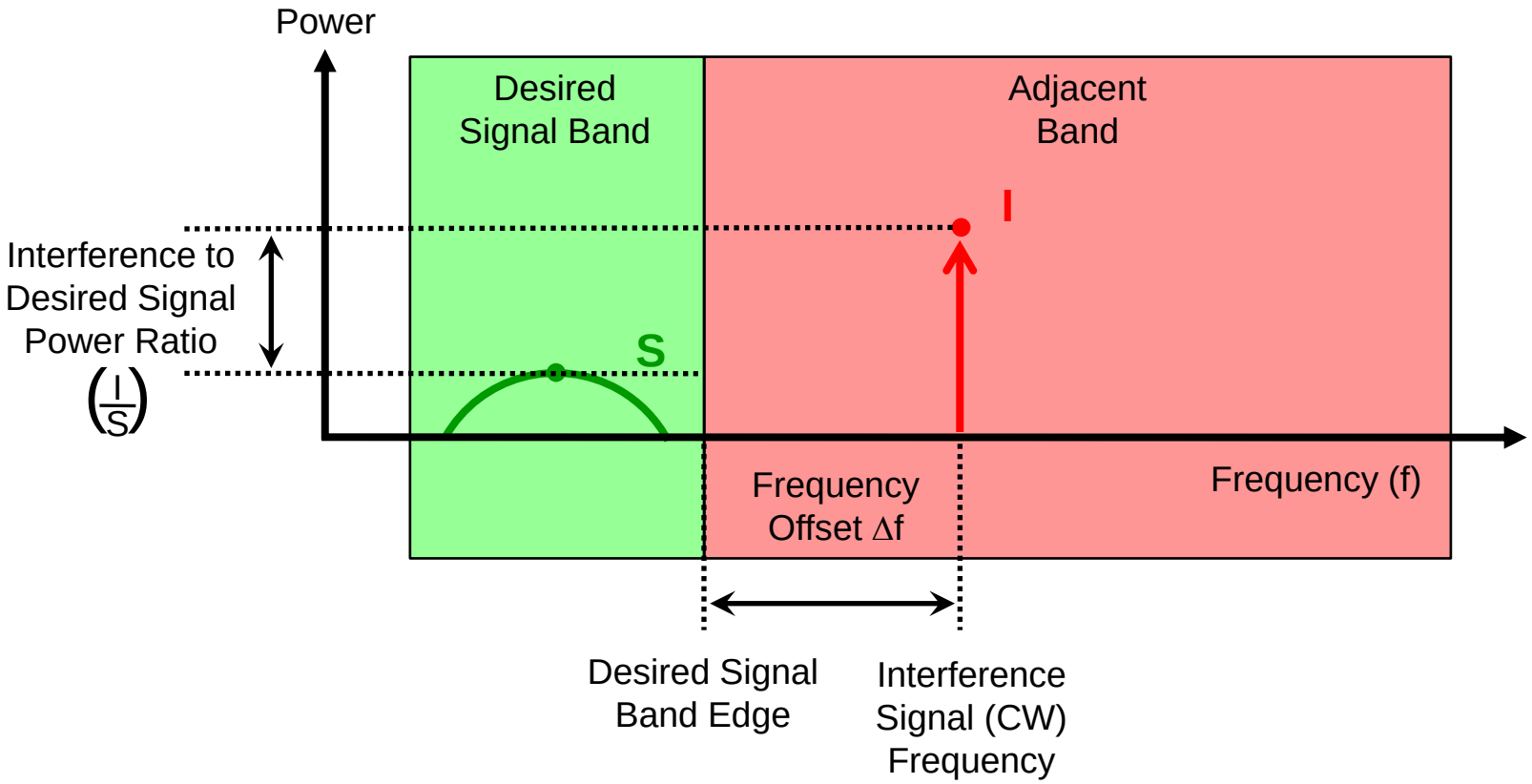


# … until device fails

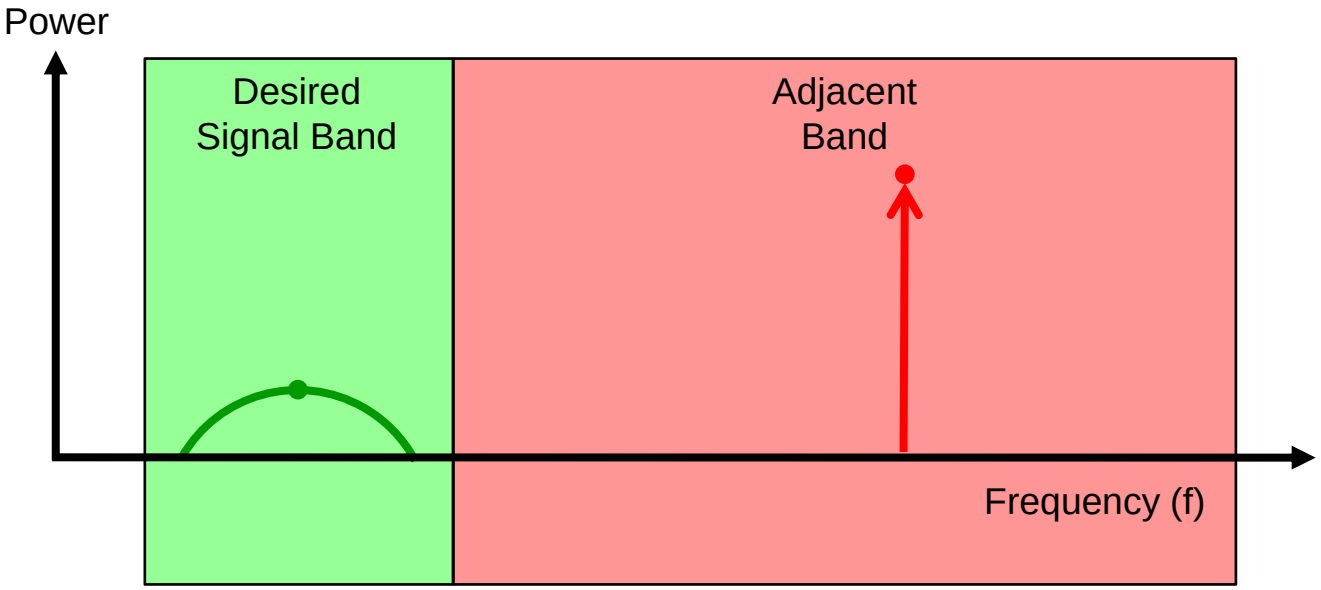



- Failure criterion was total loss of track of all signals
- Used this criterion because signal-to-noise ratio degradation or similar metrics were not available from all devices tested
- Total loss of service enabled “apples to apples” comparison

# Record the CW signal power (I) and frequency offset (Δf) at failure point; Compute (I/S)



# Increase CW signal offset, repeat



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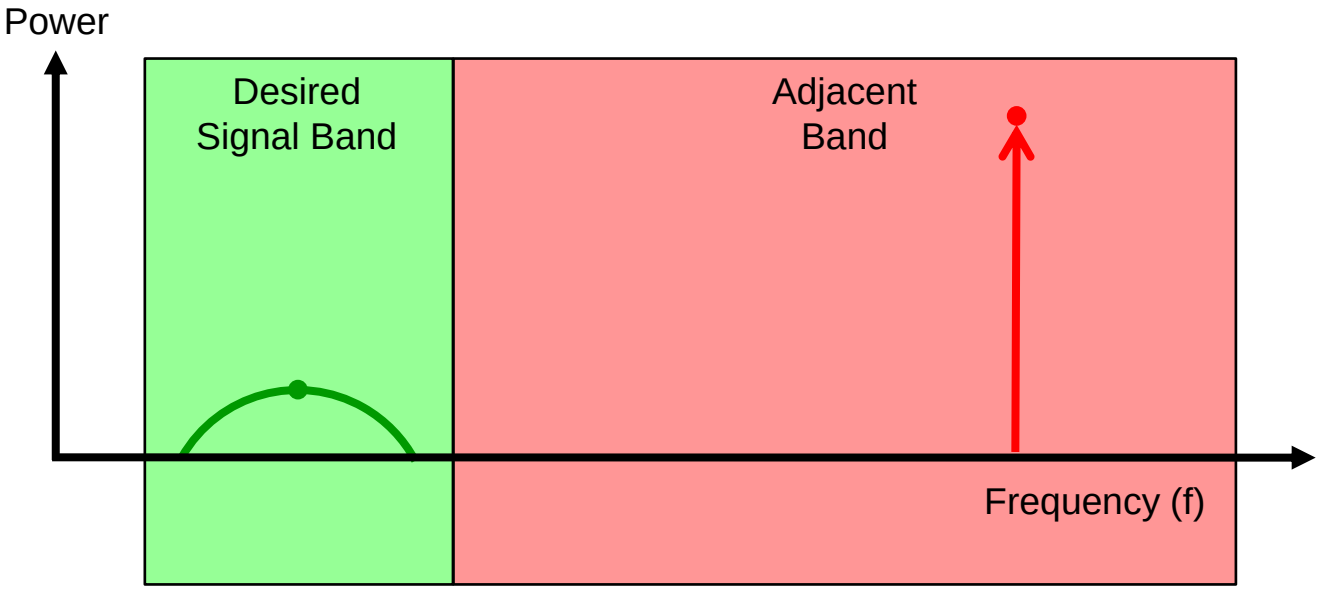
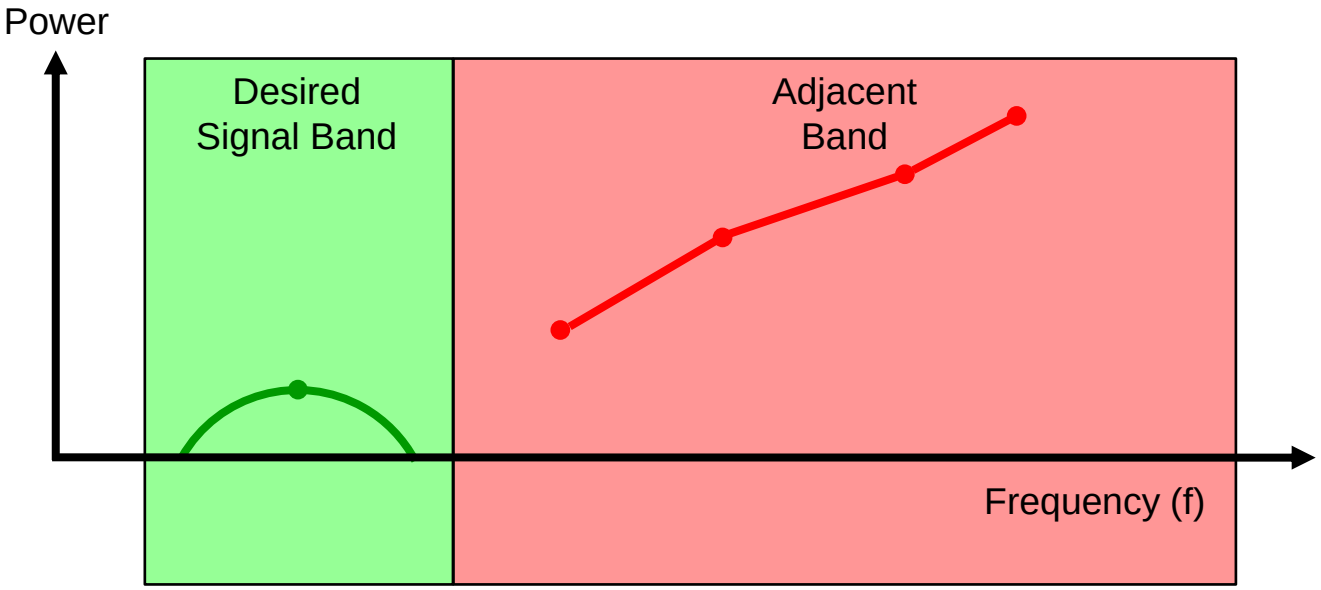


# Result is locus of (I/S) points where device failed

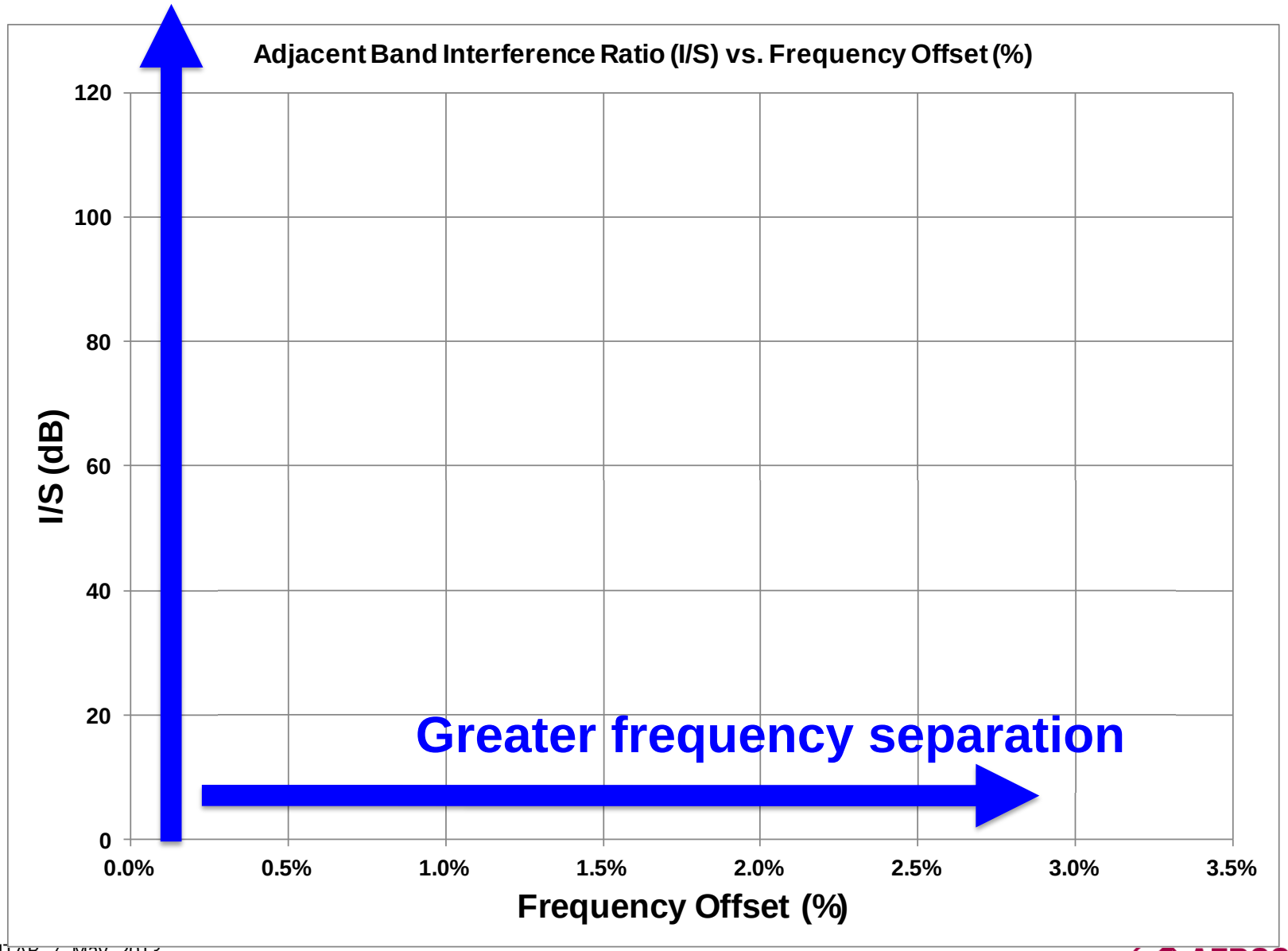


# Power and Frequency Offset Considerations

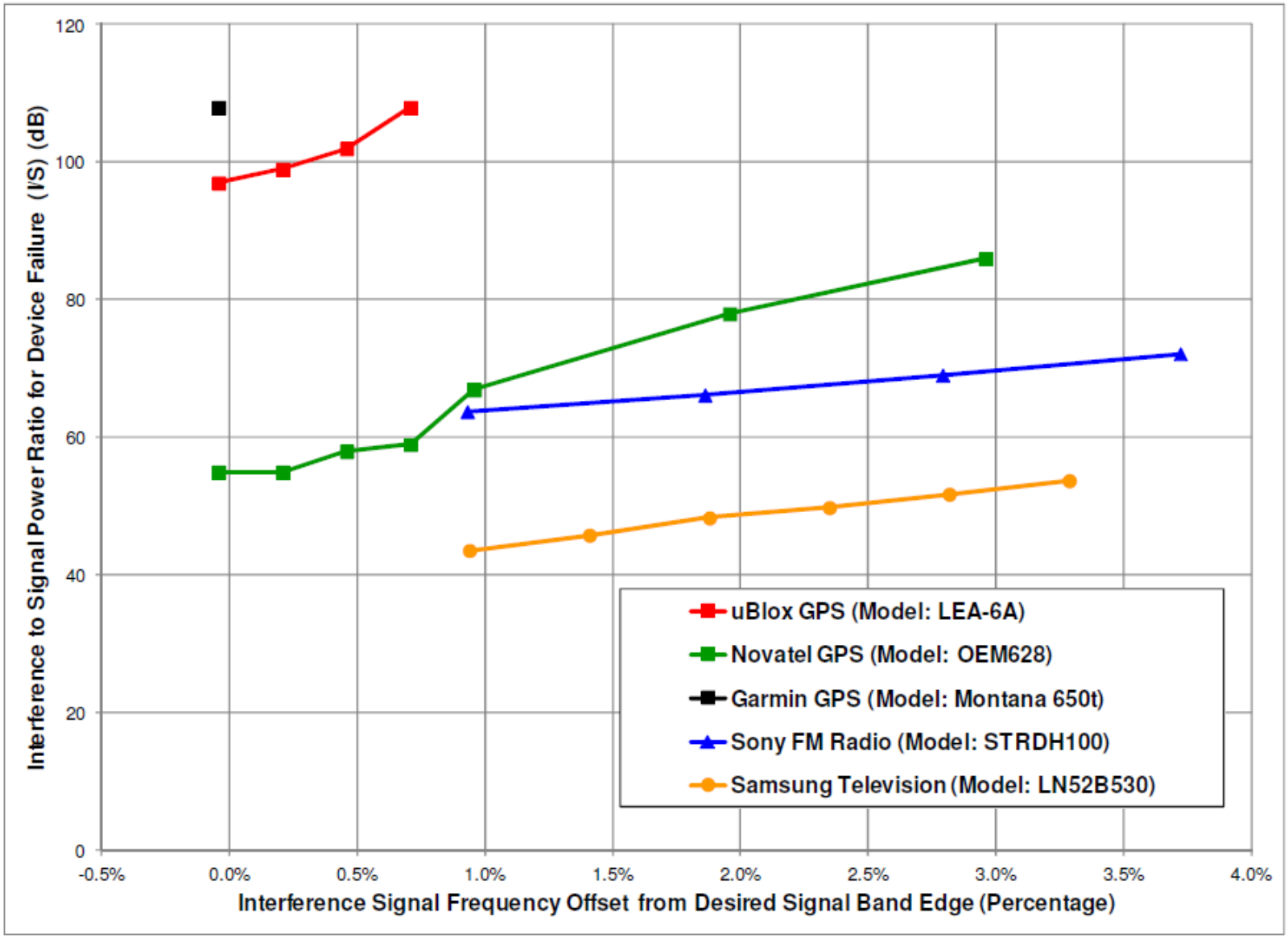
- Interference to desired signal ratio (I/S) is used because desired signal powers vary widely by service
  - *Simulated GPS signal power = -158 dBW (-128 dBm)*
  - *TV signal power = -51 dBm (77 dB stronger than GPS)*
  - *FM signal power = -67.5 dBm (60.5 dB stronger than GPS)*

- Frequency offset is plotted as a percentage of desired band edge
  - *Referenced from band edge to consider only adjacent band signals – avoid interference signals in desired band*
  - *Rationale for normalizing versus frequency*
    - Filter “Quality Factor” (BW/f) also scales with frequency
    - Commonly used to describe filter roll-off

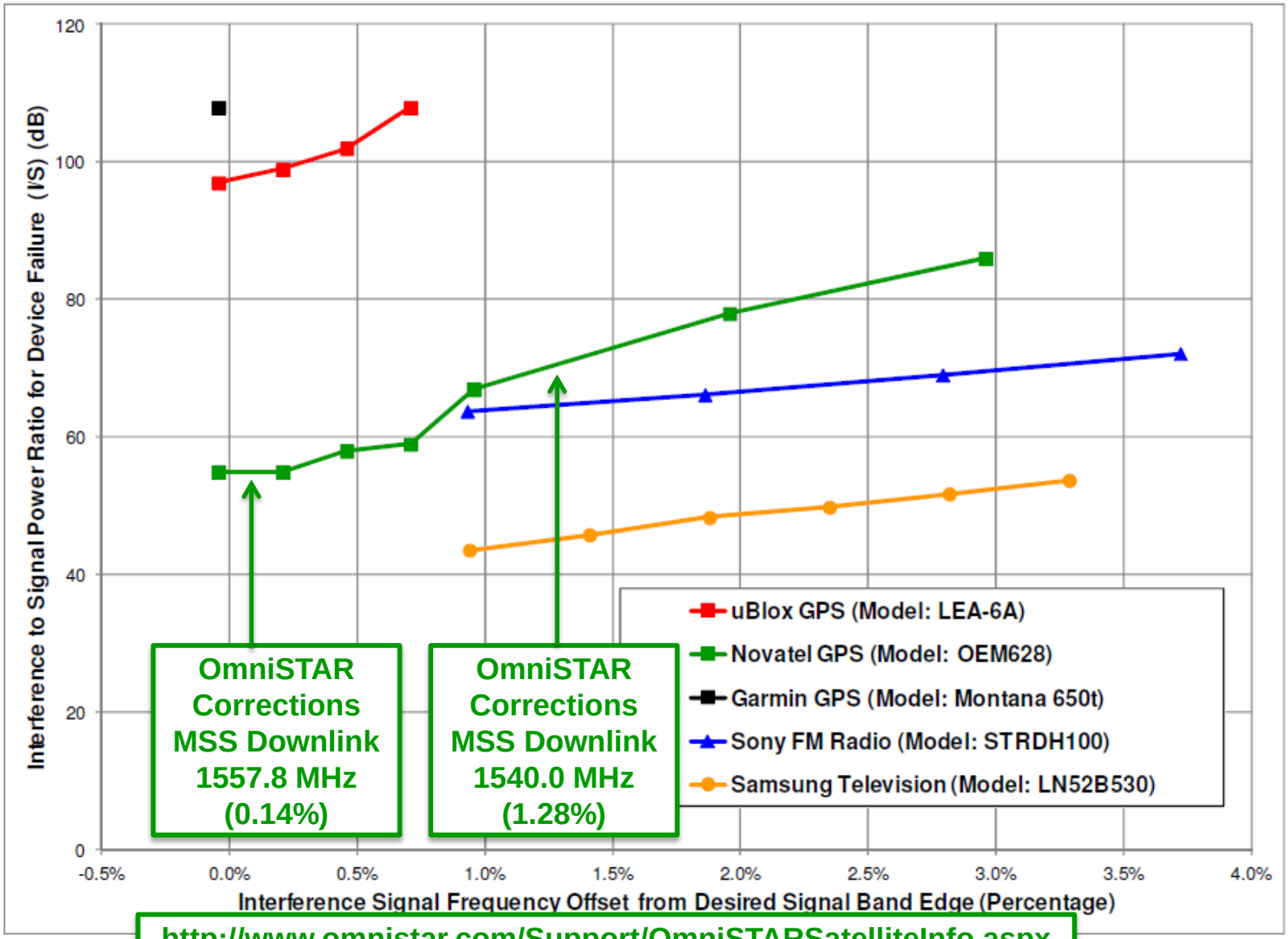
# More resistance to interference



# Test Results – (I/S)

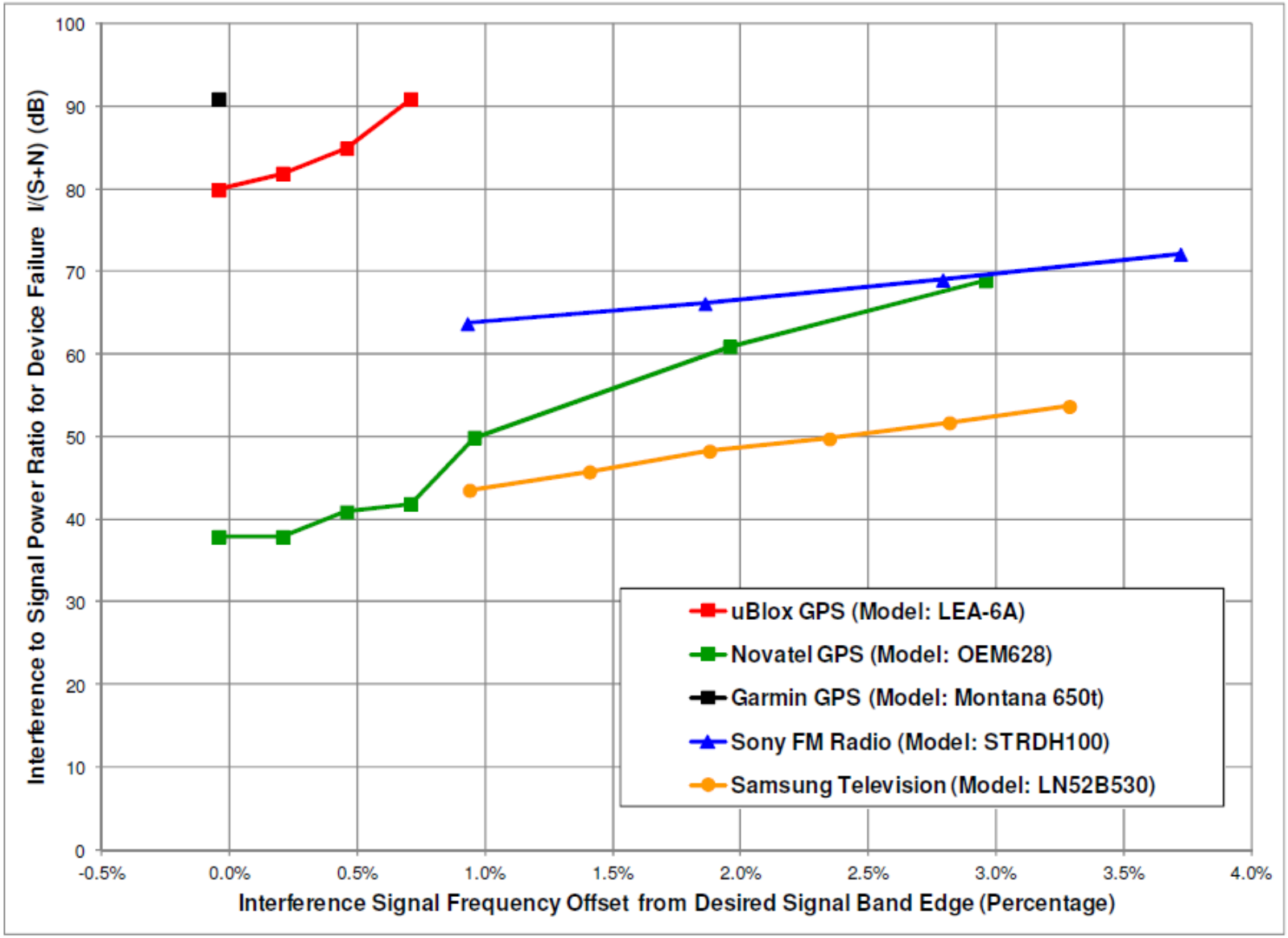


# Test Results – (I/S)




http://www.omnistar.com/Support/OmniSTARSatelliteInfo.aspx

# Test Results – Alternative Power Metric – I/(S+N)



# Summary and Conclusions

- Summary of test results
  - *3 different types of consumer receivers tested*
  - *All were susceptible to adjacent band interference*

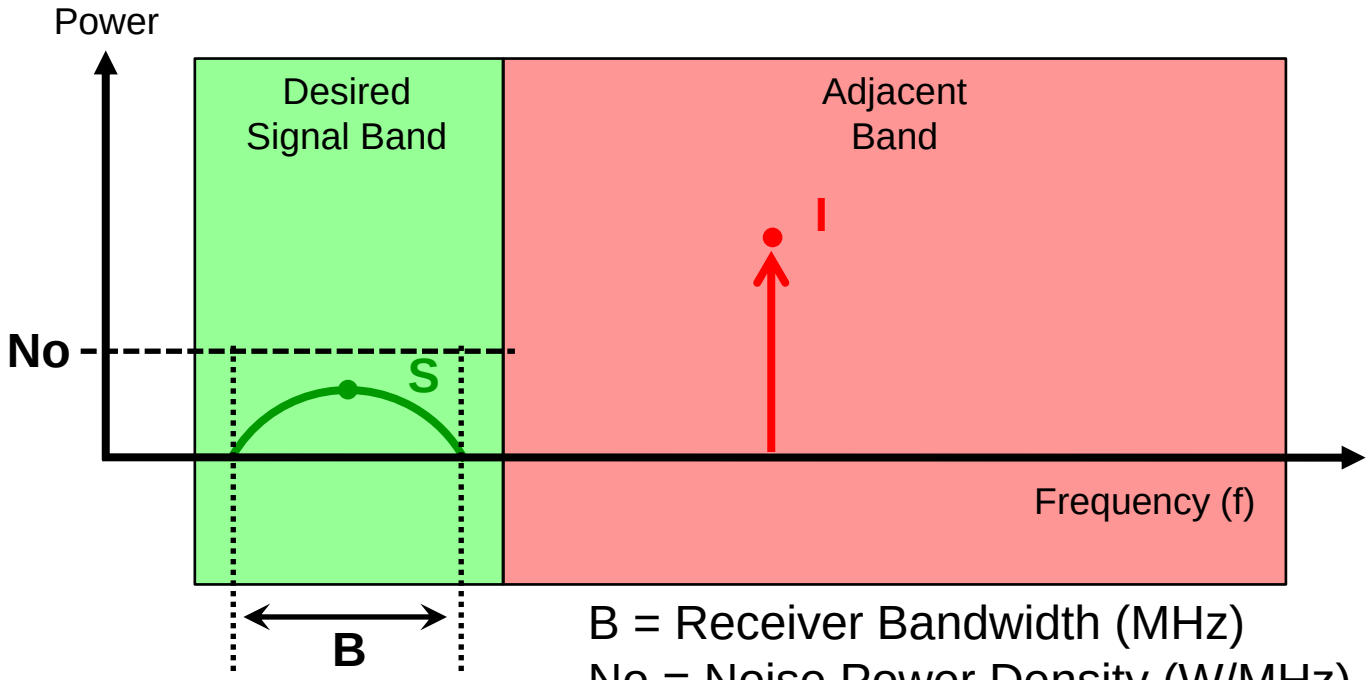
- Conclusions
  - *Any radio receiver can eventually be overloaded by adjacent band signals of sufficient power*
  - *Compatibility assessments should consider relative signal powers of adjacent band services*

# BACKUPS

# Notes on Novatel EOM 628 GPS Receiver

- Novatel OEM 628 is wide-band high precision GPS receiver
- Designed to receive differential correction signals from Geosynchronous satellites operating in the Mobile Satellite Service (MSS) band (1525-1560 MHz) below GPS L1
- As a result, some data points fell inside pass band of OEM 628 filter, even though they were outside of the GPS L1 band
  - *Novatel more susceptible to interference within 1% of band edge*

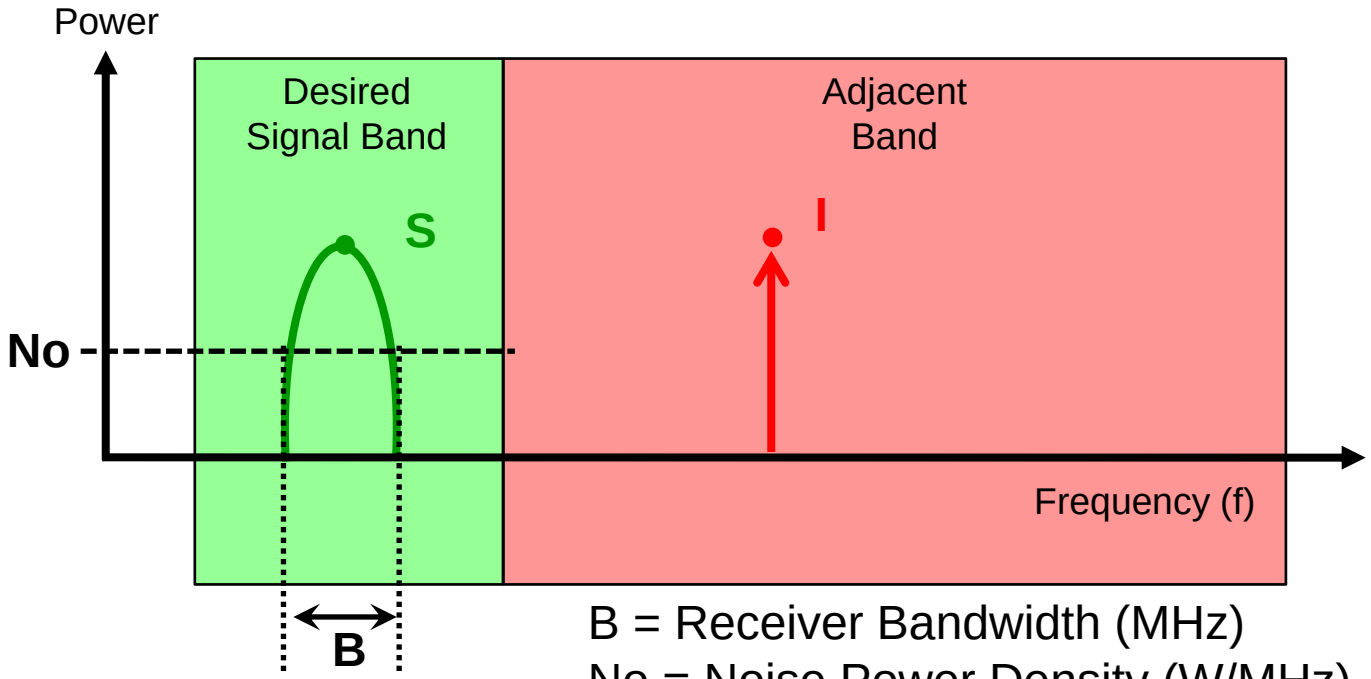
# Desired Signal Below Thermal Noise: N >> S
e.g. GPS




B = Receiver Bandwidth (MHz)
No = Noise Power Density (W/MHz)
N = Receiver Noise Power (W) = B × No

$$\left(\frac{I}{S+BNo}\right) = \left(\frac{I}{S+N}\right) \approx \left(\frac{I}{N}\right) \quad \textbf{for N >> S}$$

# Desired Signal Above Thermal Noise: S >> N
# e.g. TV and FM

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