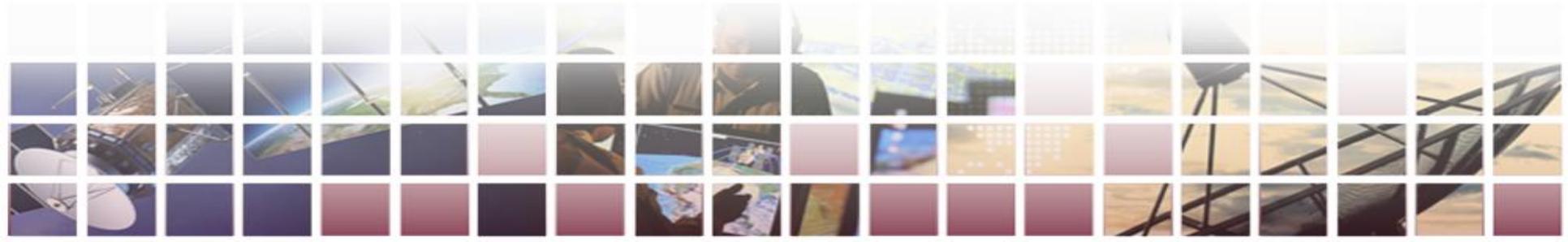




# Improving Satellite Signal Interference Resolution Time

3 APR 2017

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# SATCOM is Critical Infrastructure

- Commercial SATCOM
  - Communications
  - Financial and banking
  - Power grid operation
  - Security
  - Healthcare
  - Transportation
  - Disaster Relief
- DoD SATCOM
  - Command and Control
  - Reconnaissance
  - Monitoring
  - Weather
  - Relief and Warfare Communications

# Interference is a Substantial Operational Issue

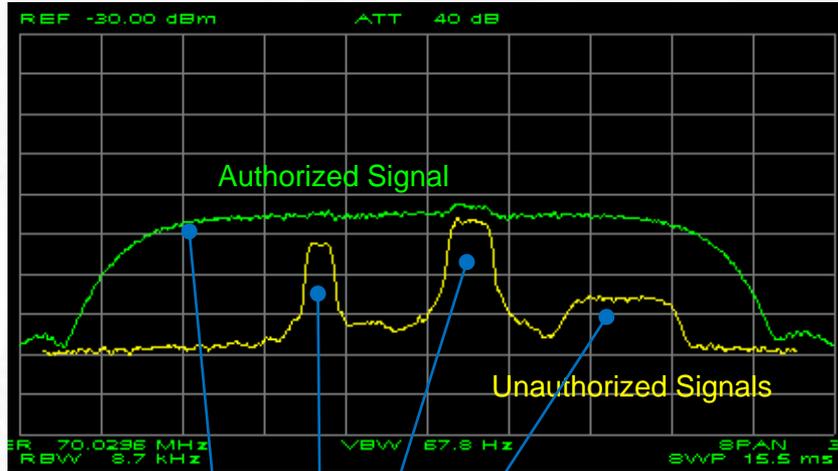


# Improving Interference Response Time

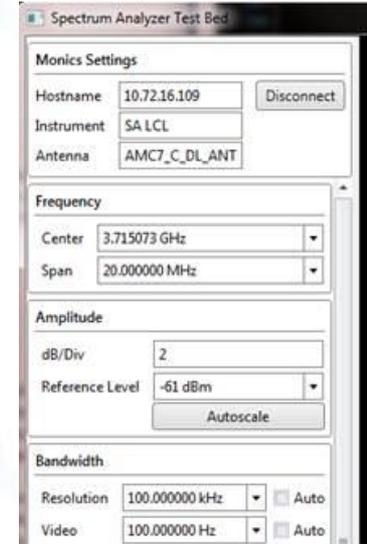
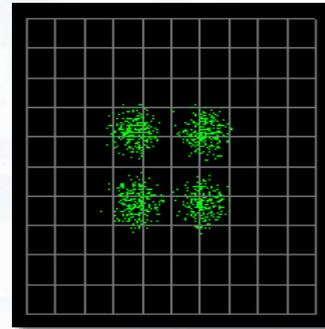
- Signal Monitoring
- Transponder / Satellite Monitoring
- Interference Geolocation
- Interference Cancellation/Reduction
- Training
- Integrated Solutions

# Signal Monitoring, Tactical Tools

## Advanced Spectrum Analysis (without a priori signal knowledge)



Constellation diagrams for enhanced EMI & signal recognition.



Easy to learn and use  
Spectrum Analyzer controls.

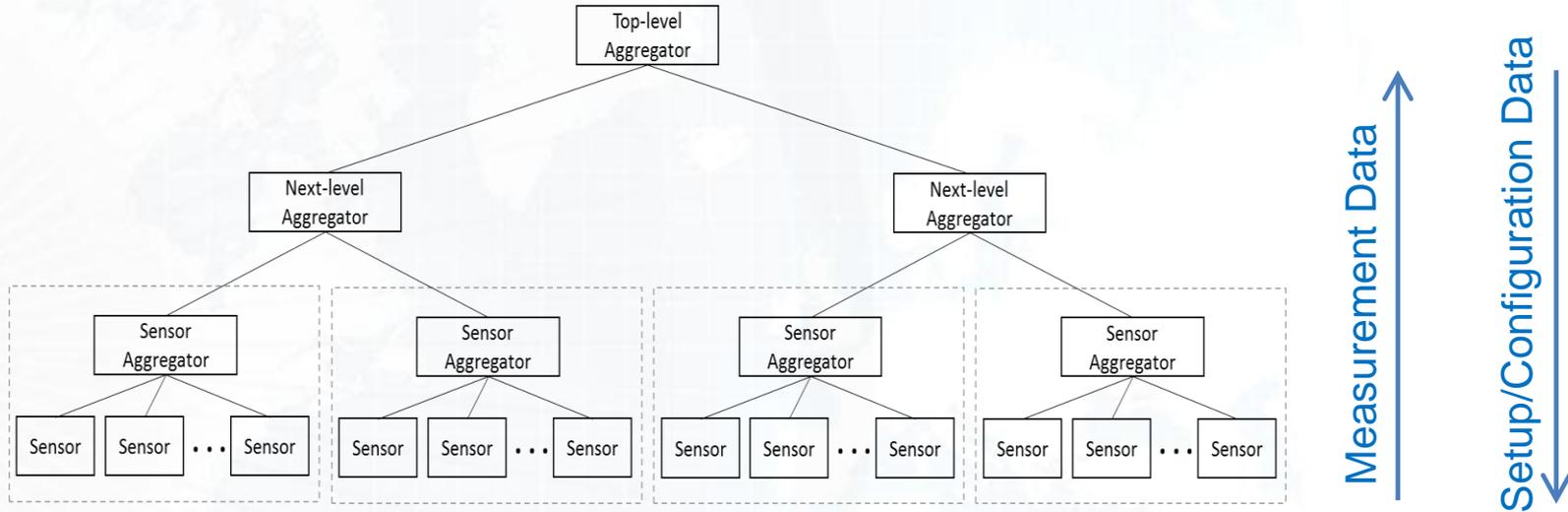
## Automatic signal characterization leads to attribution

Date/Time	Modulation Type	Symbol Rate(Ksps)	Data Rate(Kbps)	Center Freq(MHz)	C/No(dB/Hz)	Eb/No(dB/Hz)	BER	C/I(dB)
2010-04-08 14:26:11	BPSK	1999.999	1999.999	69.999999	74.03	11.74	2.328548e-008	11.02
(Carrier-0)	QPSK	99.997	199.995	69.600001	61.58	12.37	1.641439e-005	11.58
(Carrier-1)	OQPSK	149.999	299.998	70.200001	63.09	12.08	2.919565e-005	11.33
(Carrier-2)	BPSK	174.199	174.199	70.799999	50.82	1.37	4.879083e-002	-1.59

# Signal Monitoring

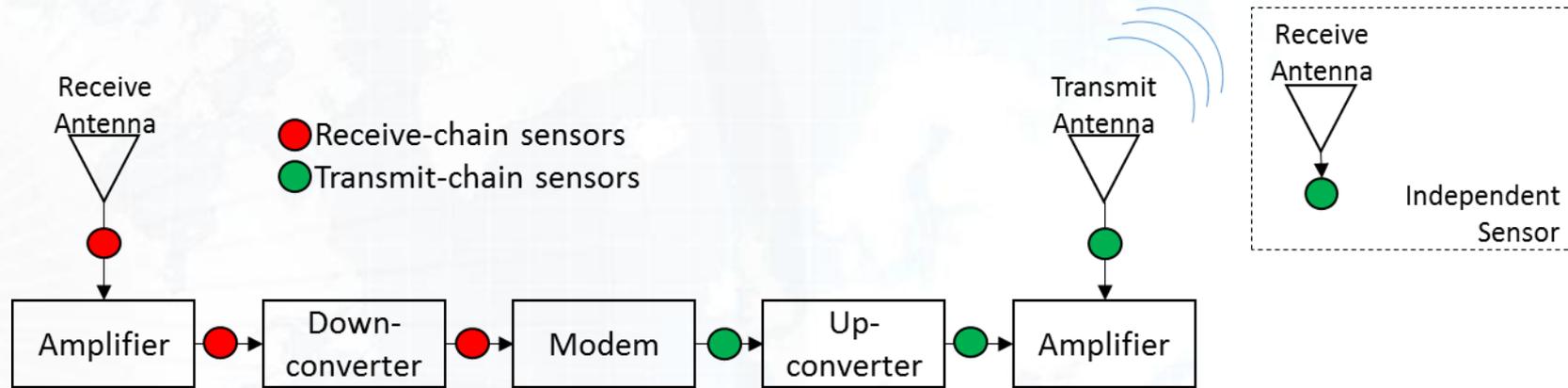
- Characterize Authorized and Unauthorized Signals
  - CF, BW, Power, MODCOD, Data Rate, MER, EVM, BER, etc.
  - TDMA, spread spectrum, PSK, APSK, QAM
  - Unattended operation: alerts and logs
- Decreased size, weight, power and cost
  - Multiple RU → 5 lbs. and dimensions measured in inches
  - Modem-embedded capabilities
  - Many, many networked sensors

# Networked Sensor Hierarchy



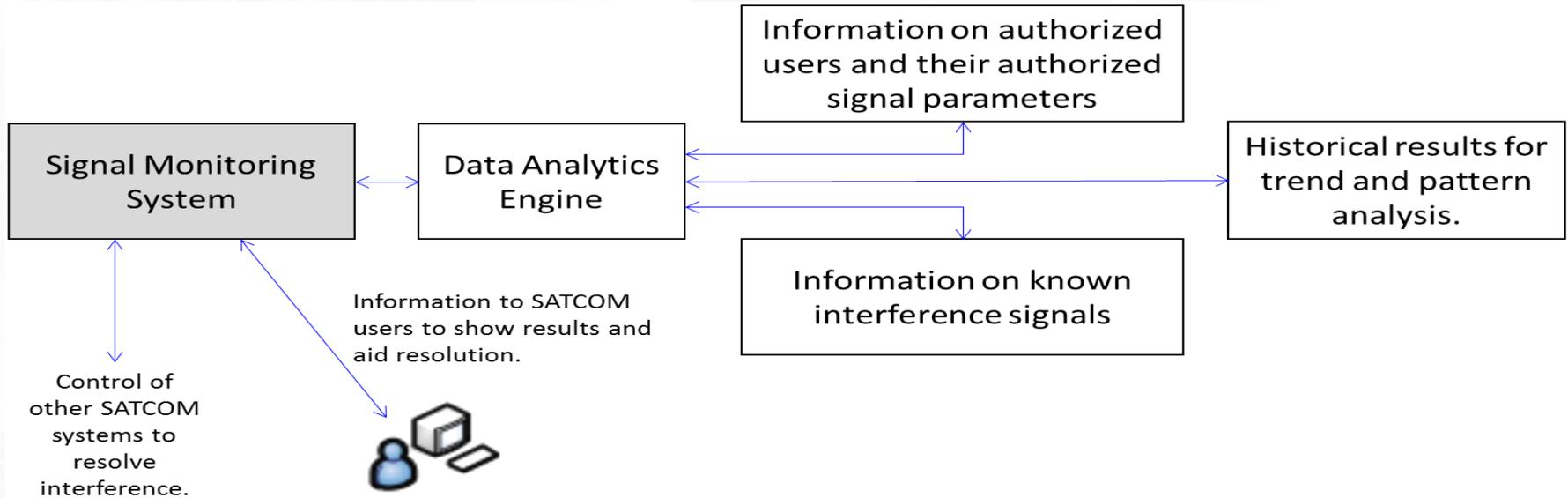
- Multiple views on signals to differentiate SATCOM from non-SATCOM EMI
- Broad area, in-beam coverage
- Redundancy and survivability (lower levels connected to multiple higher levels)

# Multiple Local Sensors



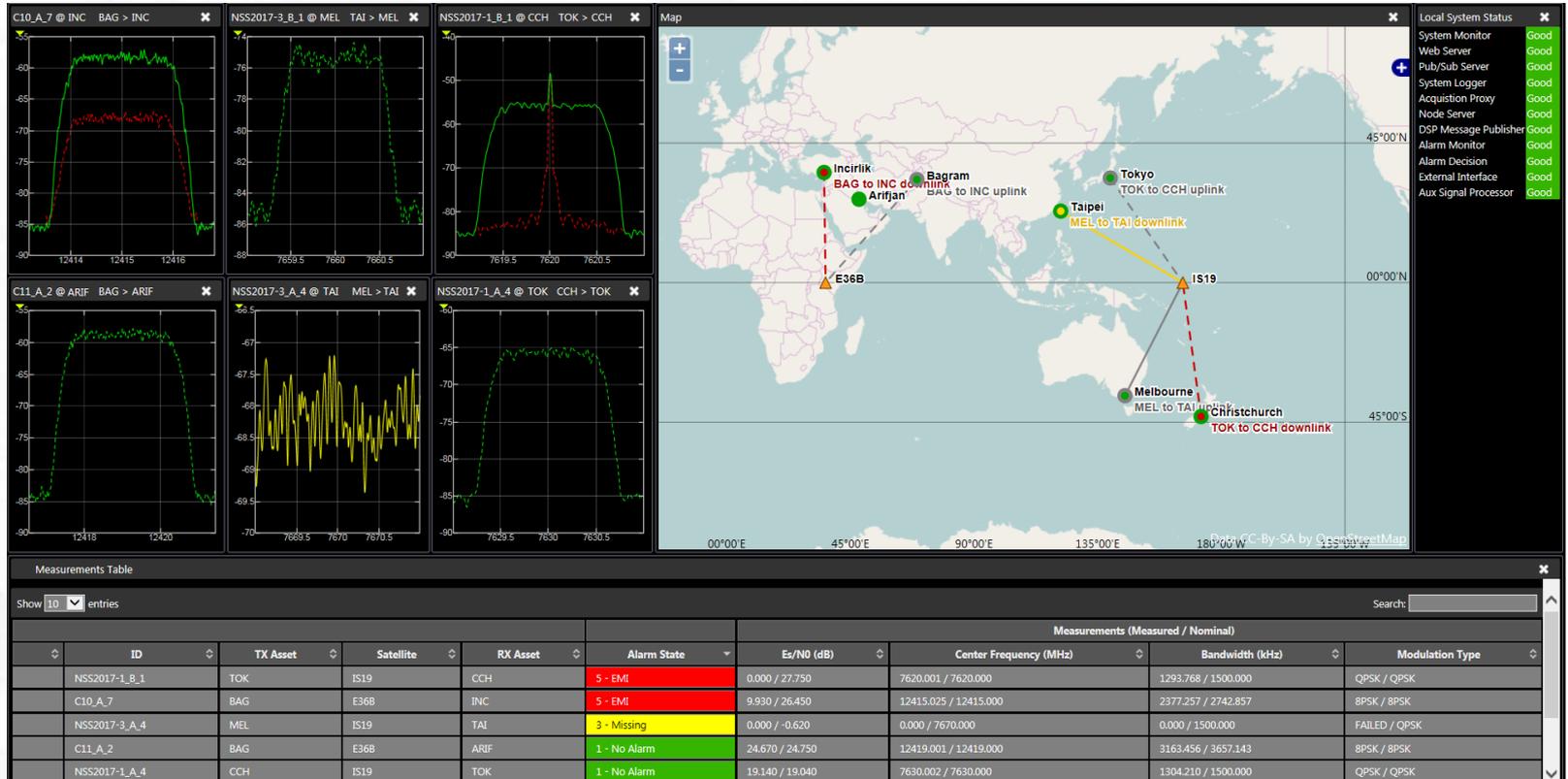
- Isolate equipment failures, and operator errors
- Differentiate uplink interference from transmitted signal faults
- Assure transmitted signal matches authorization, inhibit transmit if not

# Interconnection with other Sensors and Data

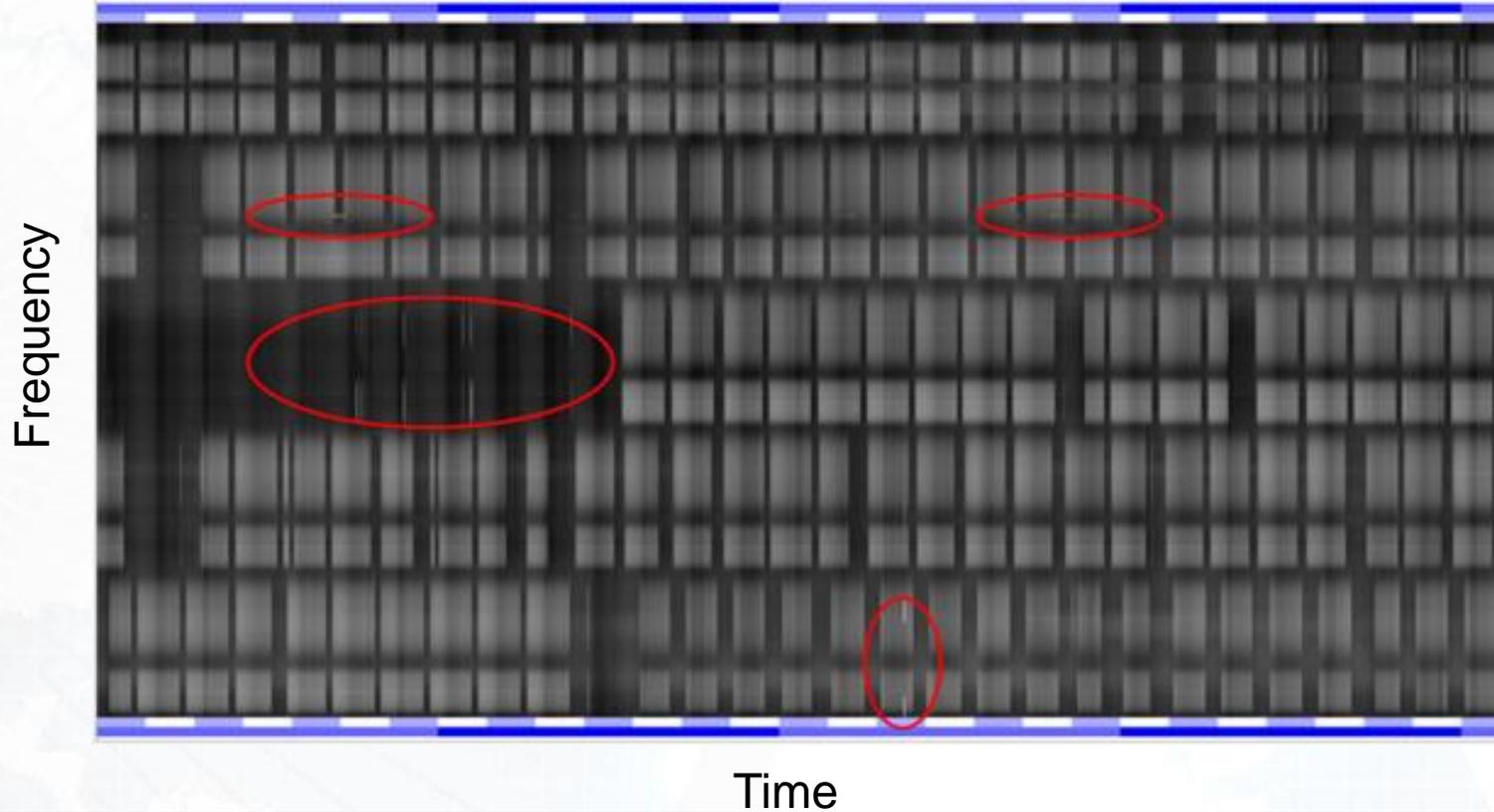


- Assists in verification and attribution
- Assists in automatic reconfiguration to resolve EMI

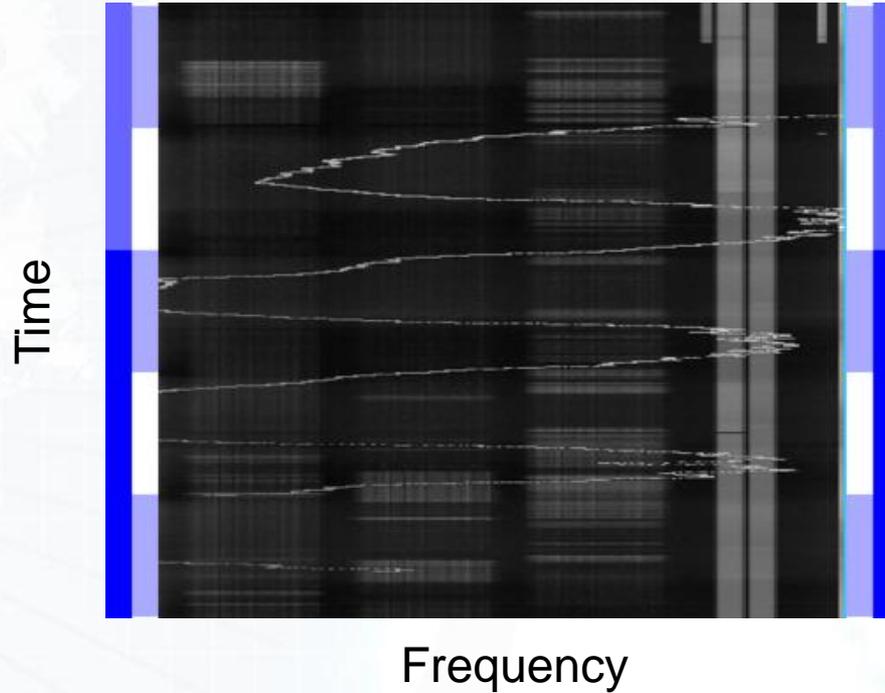
# Signal Monitoring, Strategic Tools



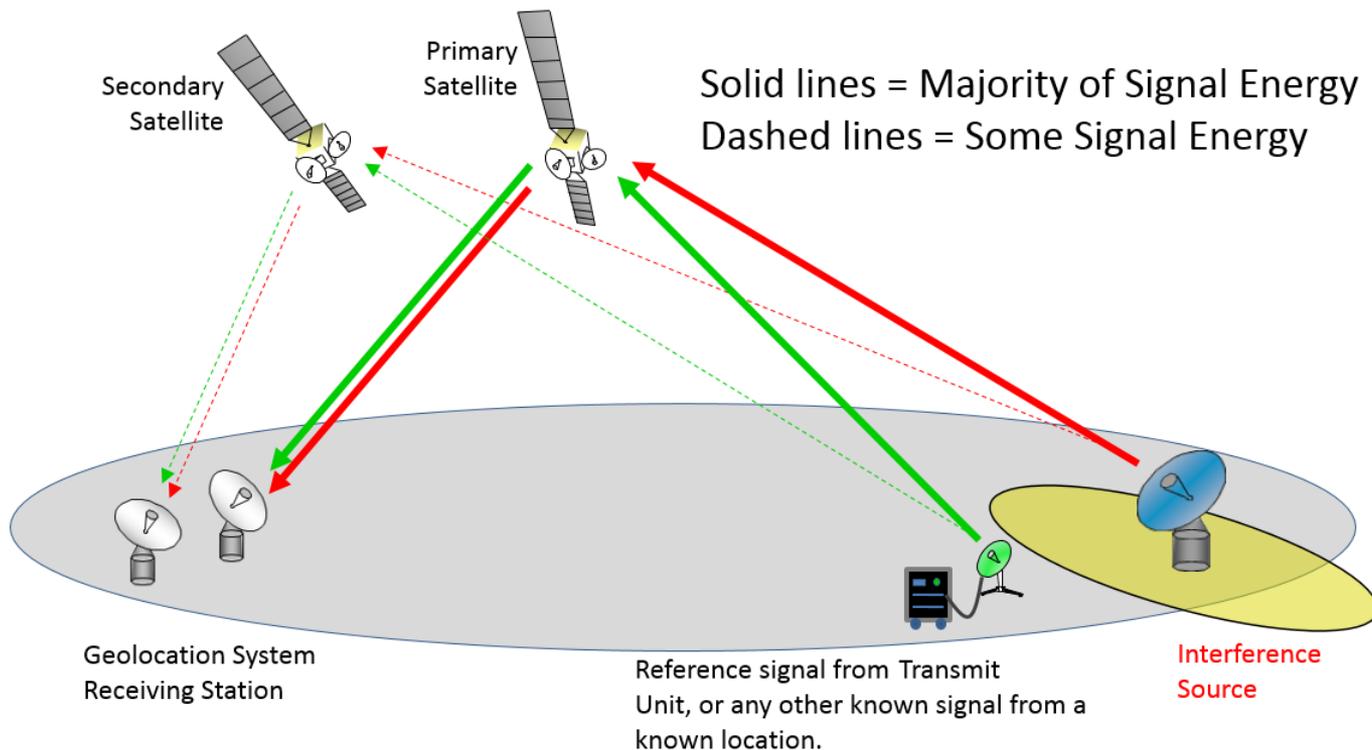
# Satellite / Transponder Monitoring



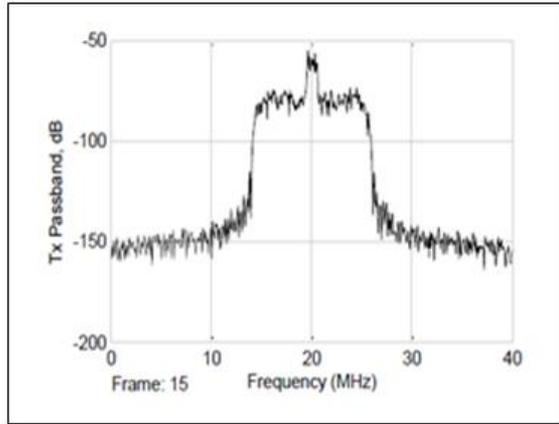
# Satellite / Transponder Monitoring



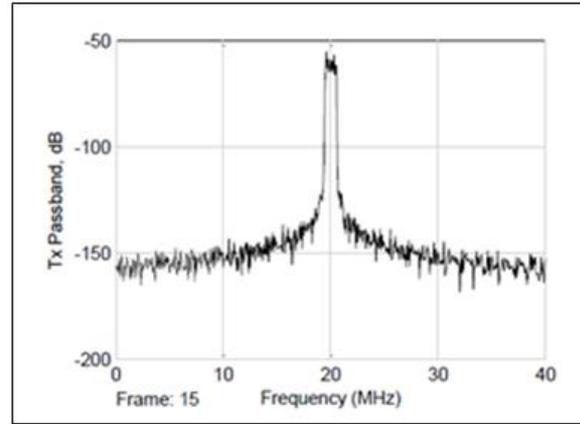
# Interference Geolocation



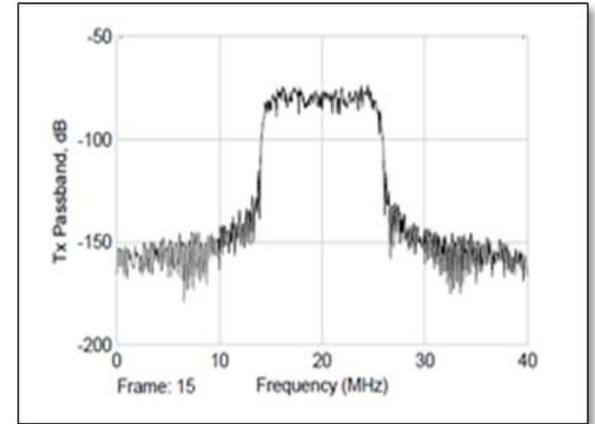
# Interference Cancellation/Reduction



Interference-impacted  
Signal



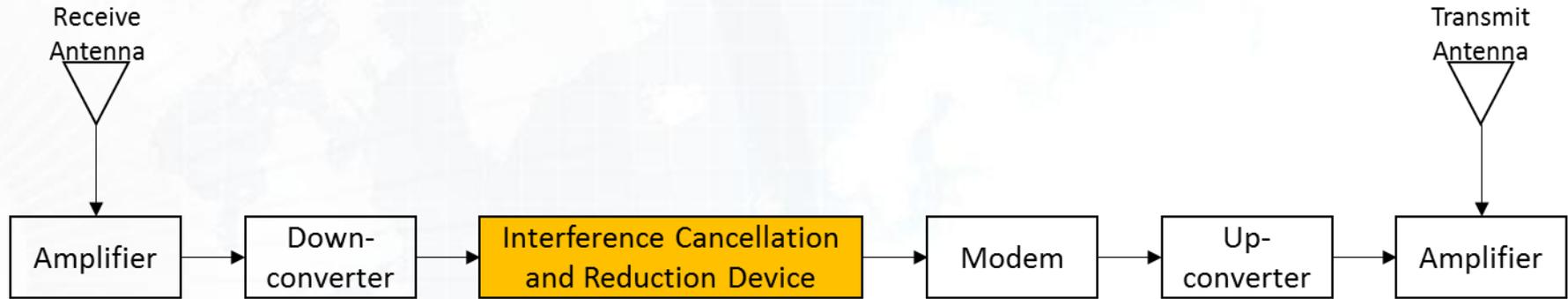
Isolated  
Interference



Reduction sufficient to increase  
MER for successful  
demodulation

- Should exhibit real time performance → minimal signal delay
- Should require no additional SATCOM bandwidth

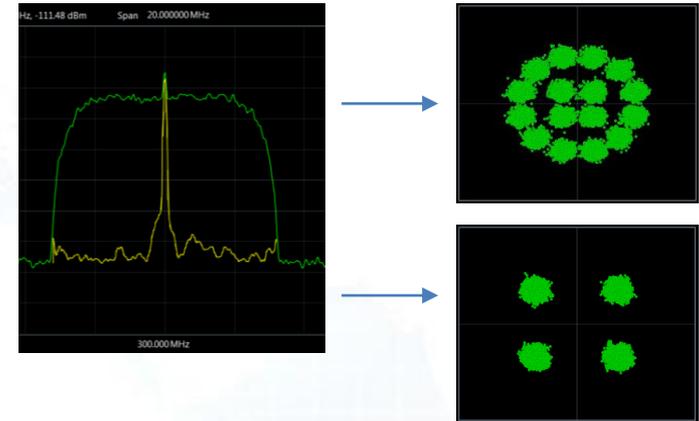
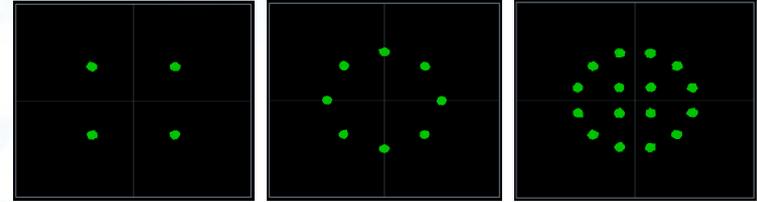
# Interference Cancellation/Reduction

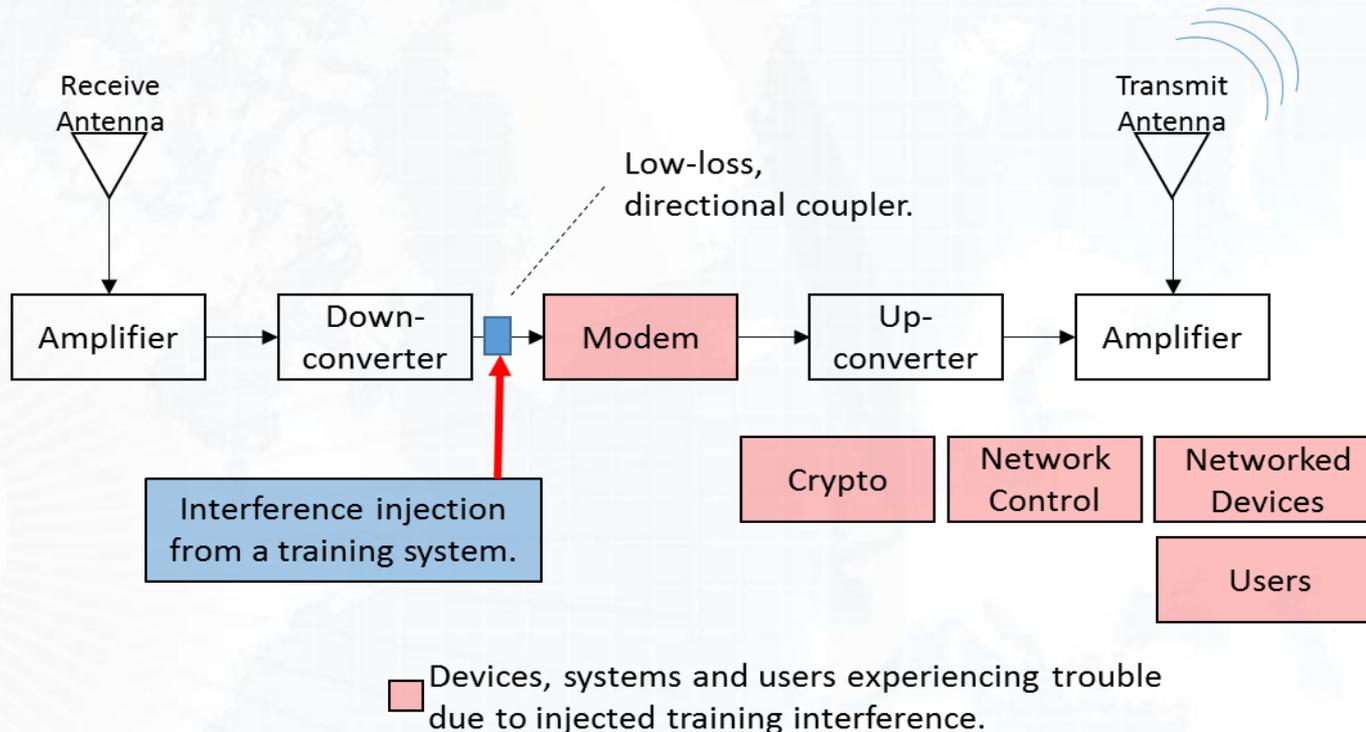


- No equipment should be necessary on the transmit side.
- Should work for point-to-point and point-to-multipoint applications.

# Training

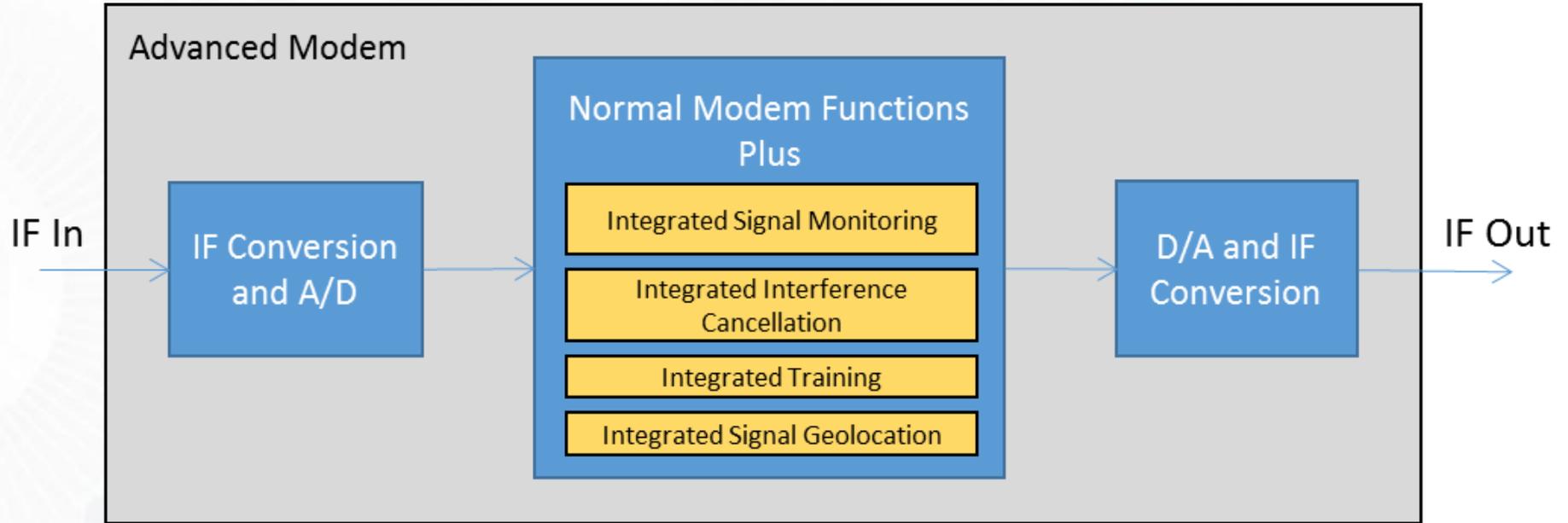
- SATCOM, Signals and EMI
- Assure realism
- Use real modems and T&M instrumentation
  - Software systems are possible as well
- Basics
  - Spectrum Analyzers, Constellation Diagrams
  - Cover CW through PSK, APSK, QAM
  - Data rate and bandwidth comparisons
  - Figures of Merit (SNR,  $E_b/N_0$ ,  $E_s/N_0$ , MER, EVM, BER)
  - FEC (Viterbi, Reed-Soloman, Trellis, Turbo, etc.)
- Interference
  - Impacts on Figures of Merit
  - Impacts on data integrity and data rate
  - Vulnerabilities of some modulation types over others

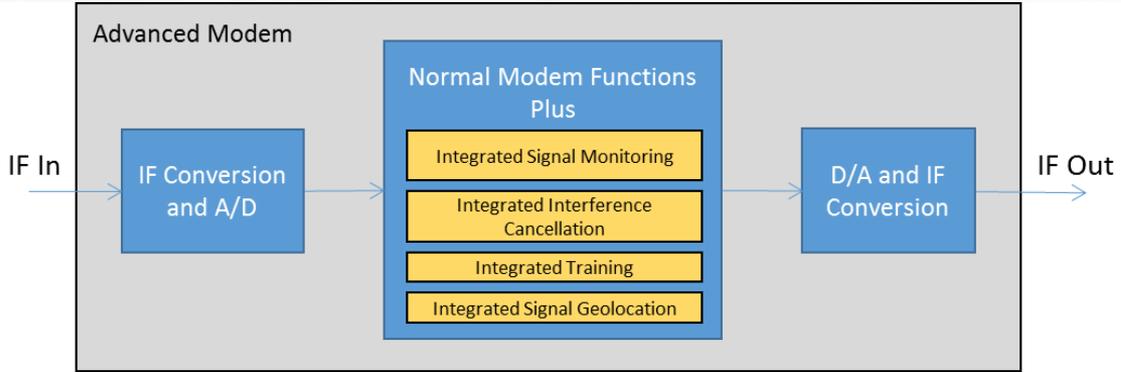




- Once proficient, move the students to real equipment.
- Require periodic recertification on SATCOM, Signals, EMI and Equipment.

# Integrated Solutions





# Integrated Solutions



Tactical Tools for EMI Detection, EMI Resolution, and Training.

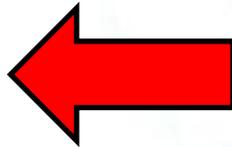
WAN



Strategic Tools for Situational Awareness, EMI Resolution and Training.

Networked signal monitoring sensors and systems, SATCOM planning systems, data analytics engines, authorized user data, known interferer data, news, geopolitical data, etc.

- Seamless operation
- No stovepipe systems!
- Interact and interoperate!



# Summary

- SATCOM is vulnerable to accidental and intentional interference
- SATCOM is critical infrastructure for Commercial, Gov and MIL
- Urgent needs to improve interference response time
  - Signal Monitoring, many layers
  - Transponder / Satellite Monitoring
  - Interference Geolocation
  - Interference Cancellation/Reduction
  - Training (classroom, self-study, live equipment)
  - Integrated capabilities
    - Within modems, for example
    - By interconnecting SATCOM-related systems
- Steve Williams, Kratos/RT Logic, [swilliams@rtlogic.com](mailto:swilliams@rtlogic.com), 719-884-6269