Improving Satellite Signal Interference Resolution Time

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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

- Accidental Interference
- Operator Error
- Equipment Failure
- Outside Satellite Footprint
- Intentional Interference
- Terrestrial and Space Weather
  - Compromised Missions (Comml, DoD)
  - Lost Revenue
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)

Authorized Signal

Unauthorized Signals

Constellation diagrams for enhanced EMI & signal recognition.

Automatic signal characterization leads to attribution

<table>
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<tr>
<th>Date/Time</th>
<th>Modulation Type</th>
<th>Symbol Rate(Kps)</th>
<th>Data Rate(Kbps)</th>
<th>Center Freq(MHz)</th>
<th>C/No(db/Hz)</th>
<th>Eb/No(db/Hz)</th>
<th>BER</th>
<th>C/I(db)</th>
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<td>BPSK</td>
<td>1999.999</td>
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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
- 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
Satellite / Transponder Monitoring
Interference Geolocation

Solid lines = Majority of Signal Energy
Dashed lines = Some Signal Energy

Geolocation System Receiving Station
Reference signal from Transmit Unit, or any other known signal from a known location.

Interference Source
Interference Cancellation/Reduction

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

Interference-impacted Signal

Isolated Interference

Reduction sufficient to increase MER for successful demodulation
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, Eb/N0, Es/N0, MER, EVM, BER)
  – FEC (Viterbi, Reed-Solomon, 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

Advanced Modem

IF In

IF Conversion
and A/D

Normal Modem Functions
Plus

Integrated Signal Monitoring

Integrated Interference
Cancellation

Integrated Training

Integrated Signal Geolocation

D/A and IF
Conversion

IF Out
Integrated Solutions

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

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

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