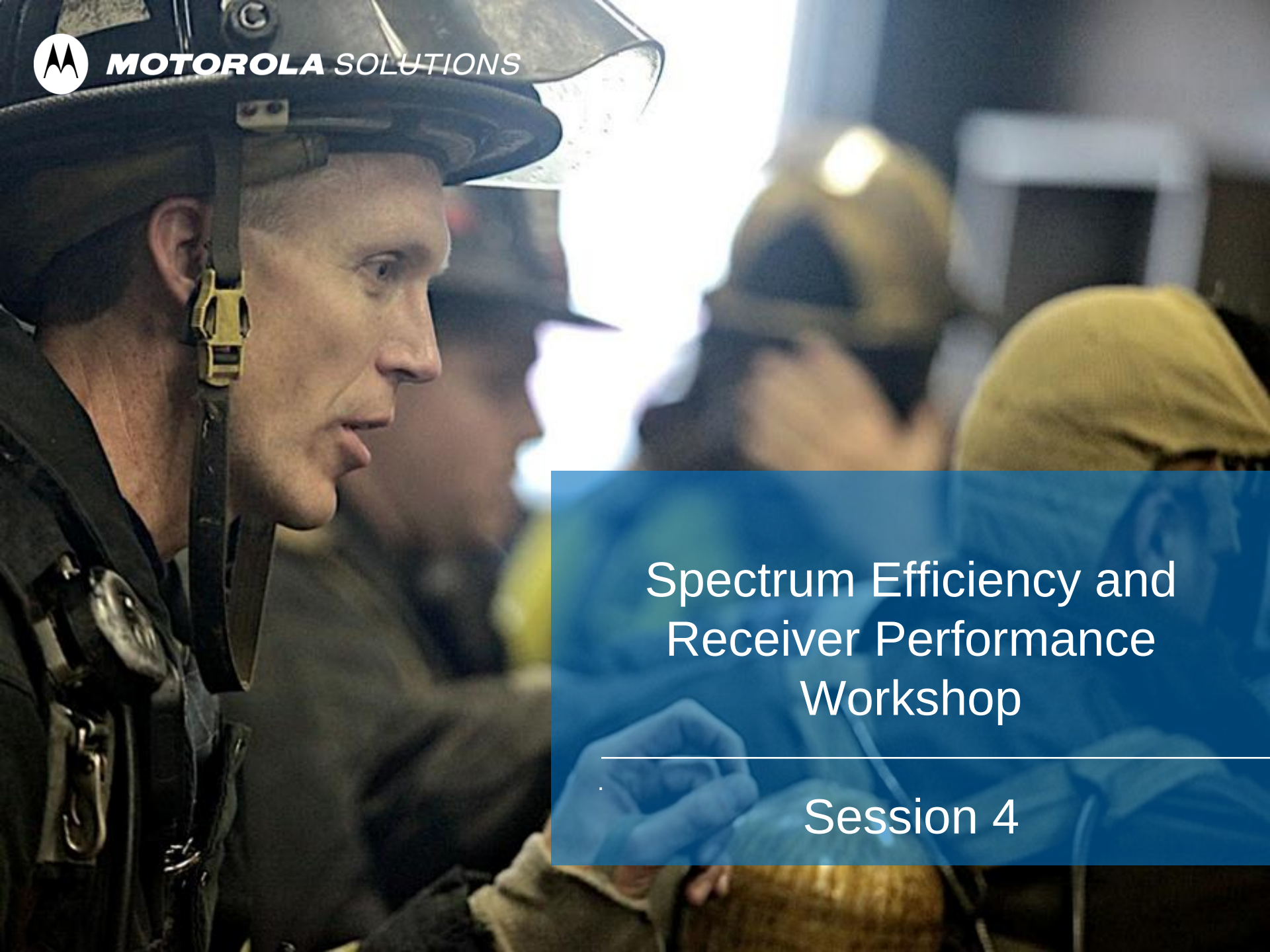


Spectrum Efficiency and Receiver Performance Workshop

Session 4

A Brief Introduction…

- Motorola Solutions supplies a wide variety of communications systems and services:
  - Two-way radio systems
    - Public Safety Radio systems / networks
    - Professional and Commercial Radio systems / networks
    - Integrated Command and Control
    - Accessories
  - Broadband Radio systems
    - Public Safety BB radio systems / networks
  - Enterprise systems
    - WLAN radio systems / networks
    - RFID systems
    - Mobile Computing Devices
    - Advanced Data Capture Systems
- Wide-ranging experience with cellular systems, two-way radio, consumer radios (e.g., WLANs, etc.), RFID systems
  - Have divested traditional cellular infrastructure and subscriber, cable, P2P and PMP businesses…

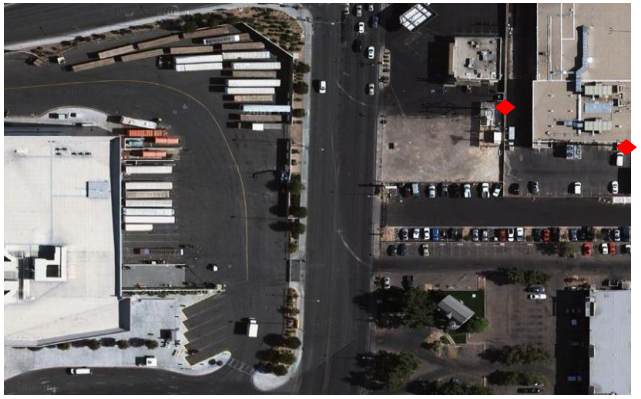
Field Interference Experiences

- Public Notice mentions four real-world interference cases:
  - Cellular Radio and Public Safety in the 800 MHz band
  - Satellite Radio and proposed terrestrial data services
  - Unlicensed WiFi and FAA radar systems in the 5 GHz band
  - Ancillary terrestrial service (on MSS spectrum) and GPS

- Often very difficult to predict all possible interference scenarios ahead of time…
  - Systems typically work very well in isolation (e.g., PS, GPS, etc.)
  - Systems sometimes optimize different parameters (e.g., noise figure in GPS) based on operating environment and requirements *at the time*…
  - Interference mechanisms can be very complex (e.g., 5th order cross-modulation terms), especially with mobile systems…
  - Often difficult to even come up with full set of cases to test interference
  - Extremely difficult to anticipate all possible system combinations that could cause interference…

SMR 800 MHz Band Interference

- Interference appeared to occur in small percentage of locations (<1%)
  - However, issue eventually impacted public safety radio use…
  - Compliant frequency interleaved cellular base-stations (BSs) causing interference
    - 5th order cross-modulation products appeared to be problematic
    - Low antenna height (fill-in) cellular BSs resulted in very strong interfering signals (up to ~ -10dBm) at PS portable / mobile radios…
  - Several steps taken to address interference…
    - Use best practices to limit BS TX power to necessary levels
    - Modify frequency planning where possible
    - Use antenna polarization to limit impact where possible
    - Utilize additional front-end AGC
    - Improve IM performance of radios
    - Ultimate re-banding of 800 MHz



Wide Range of Fielded Radio Performance

- There is a very wide range of performance requirements across all of these different systems:
  - 802.11g WLAN Systems
    - 16 dB adjacent channel rejection (for r=1/2 BPSK, -1 dB for r=3/4 64-QAM)
    - 32 dB alternate channel rejection (for r=1/2 BPSK, 15 dB for r=3/4 64-QAM)
    - ~ -25 dBr OOBE levels
  - P25 Digital Public Safety Radio Systems (mission critical base site)
    - 60 dB adjacent channel rejection
    - 80 dB intermodulation rejection
    - 90 dB spurious response rejection
    - 100 dB blocker rejection
    - ~ -67 dBr OOBE levels
    - ~ 97% coverage reliability
- Largely driven by industry/customer needs, economic considerations, power and size issues… (i.e., very complex trade-offs…)
  - Public Safety radios are already very high performance radios…
  - Performance levels are improving over time…
  - Public Safety coverage reliability (~97%) significantly exceeds traditional commercial cellular coverage (of 90-95%)…

Summary of Interference Issues

- Interference scenarios are very tough to predict and avoid…
  - Often very complex interference scenarios, involving multiple signals, and/or unexpected signals… (difficult to future-proof)…
  - Many factors come into play (e.g., antenna heights, terrain, polarization, etc.)…
  - Specification of high coverage test suites is very challenging…
  - Receiver performance is only one aspect of the overall system-problem…
    - Transmitter characteristics (e.g., OOBE) are also key limiting factor…
- Inherent incentives for all players to avoid interference
  - Interference mitigation tends to be costly, especially once equipment is fielded
  - Often involves modifying multiple system aspects to address interference
  - Economics of individual markets need to be carefully considered here…
- Wide range of performance expectations in the field…
  - Protecting mission critical (e.g., life-saving) communications is paramount
    - Includes protecting additional services such as GPS…
  - Performance specs typically much more stringent on mission critical equipment…
  - Consumers traditionally more tolerant of intermittent interference in the field (e.g., WLAN experience)