NATO Consultation Command and Control Agency (NC3A)

ESA Ground Segment Technology Workshop

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Standards for Military Satcom Ground Segment

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Outline of the Briefing

- NATO's Ground Segment Context
- Leveraging Commercial Satcom Standards
- Mapping standards to NATO satcom network tiers
- Standardisation areas of interest to NATO
- Summary and Conclusions

NATO Satcom Ground Segment

- **Evolving very rapidly, under the IP convergence push…**
  - **Everything over IP, and IP over every-Satcom-thing**
  - Interworking and Integration of satcom in new **NATO Information Infrastructure (NII)**
  - **Information Assurance** and **Interoperability** shall prevail
- **Targeting the very demanding objectives of the NATO Network Enabling Capability (NNEC)**
  - **capacity pooling**; integrate whatever nations can offer
  - **federation of satcom networks**, NATO and national nets
  - **end-to-end Service Level Management**, across networks, satellite and terrestrial (wired and wireless)
- **Needs a sound architecture baseline, supported by standards, best-practice**

Today's NATO STANAGs for SATCOM

- **some are derived from commercial standards**
  - e.g. DVB-S2/RCS is behind STANAG 4622 for Satellite Broadcast Services (SBS)

- **others grown within military satcom community**
  - anti-jamming waveforms (frequency-hopping, FH)
  - waveforms for disadvatanged terminals, with DAMA

- **… yet, the boundary between the two is thinning:**
  - commonalities between **protection against jamming** and **protection against frequency-selective fading, shadowing/blocking**, common in satcom-on-the-move
  - dynamic bandwidth allocation and rate/code adaptation on FH carriers, through **TDMA, BoD, C2P, DRA/ACS, AC**

NATO is closely watching the works of …

- **SatLabs** (DVB-RCS interworking and interoperability)
- **ETSI TC-SES** Working Group, **Broadband Satellite Multimedia** (WG BSM)
- ETSI Specialist **Task Forces 214, 237, 283 and 344**
- **ITU-T SG13/13** (Satellite QoS and architectures)
- **ITU-R WP4B** (Satellite Performance)
- **IETF ipdvb** working group (IP over DVB standards)
- **TIA working group 34.1** (Satellite standards, DoD SNMS)

NATO Ground Segment Architecture

- **NATO's Satcom Ground Segment Reference Architecture (SGRA), divides the ground segment into five tiers (Tier-1 to Tier-5), and two bridging tiers (Tier-0, Tier-6)**

- **Each tier benefits from its own set of waveforms, standards, STANAGs, subject to:**
  - **network topology** of the tier (star, meshed, hybrid)
  - **terminal capabilities** (size, power, mobility, freq. band(s))
  - **traffic patterns** (i.e. requiring fixed always-on, shared on demand, or ad-hoc burstable capacity)
  - **availability** (resilience to jamming, interference, blockage)
  - **interoperability** with nations (more critical in some tiers)
  - **service criticality** (from operational point of view)
  - **transmission security** (TRANSEC), and IA in general

NATO Satcom Architecture Tiers (I)

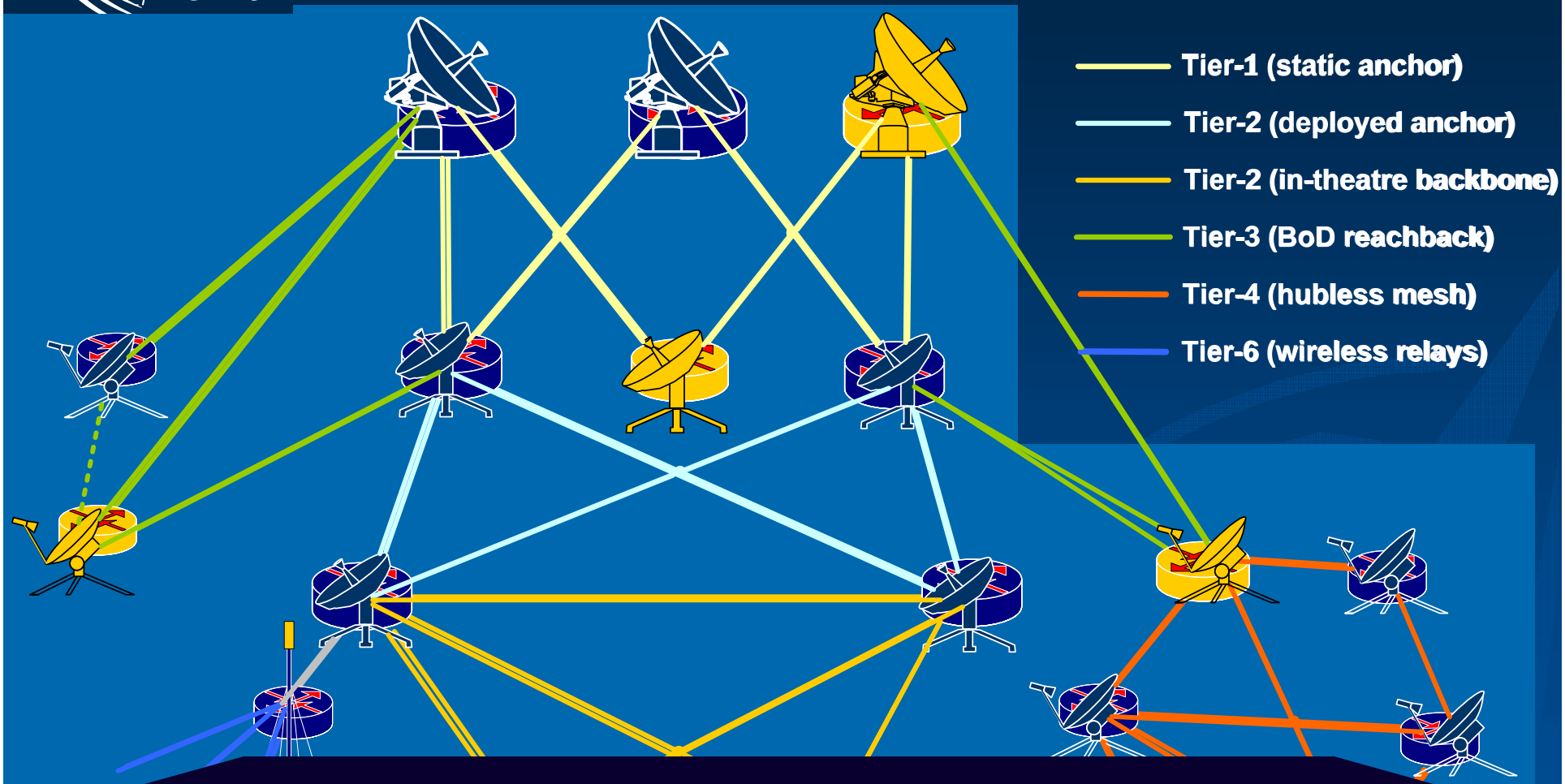
- **Tier-1**
  - **backhaul links**, deployed-to-static, fixed-rate FDMA/SCPC trunks, star topology, large terminals (static NATO and National anchor stations, similar to commercial teleports)
- **Tier-2**
  - **in-theatre backbones**, largely trunk-based, FDMA/SCPC or MCPC, star and partial-mesh topology, medium/large deployable terminals (in-theatre hubs)
- **Tier-3**
  - **reachback links**, bandwidth on demand, with static and **in-theatre hubs**, TDM/MF-TDMA, and **limited mesh overlays** (e.g. single-hop on demand);
    - any terminal size, usually **fly-aways** (alone, or clustered)
    - **Inmarsat-type** terminals, e.g. BGAN, GMPRS, etc.

NATO Satcom Architecture Tiers (II)

- **Tier-4**
  - **in-theatre, highly-mobile networks**, featuring highly-mobile, disadvatanged terminals:
    - **man-portable** satcom radios (UHF and X-band)
    - **hubless** and hub-assisted MF-TDMA **mesh nets** (bent-piped; a virtual **Ethernet SWitch-in-the-Sky**, SWitS)
    - satcom-**on-the-move** (SOTM; UHF, L, X, Ku, Ka …)
    - future **S-band broadcast** rx-only terminals would be in this Tier, with DVB-x repeaters in Tier-6

- **Tier-5**
  - **static, asymmetric augmentation overlays**, to off-load terrestrial links, provide one-way high-capacity for content dissemination services
  - use **standard VSAT** terminals, with BoD waveforms

Multi-tiered Network-Centric View



satcom terminals become IP nodes in a federation of NATO and National satcom networks

Mapping Standards to Satcom Tiers (I)

- **Tier-1**
  - SCPC/FDMA, **MIL-STD-188-165B** (STANAG 4486 ed.3); highest BW efficiency, 16-ary modulations, Turbo Codes
  - Fully IP enabled, suitable for **Ethernet bridging, VLAN to MODCOD mapping** with 802.1Q/P support, modem-VRFs
  - **Anti-jamming (A/J)** waveforms (STANAG 4606)
- **Tier-2**
  - **Same waveforms** as in Tier-1, including A/J, **but in-theatre**, often under spot beams
  - SCPC/FDMA (star, mesh) and **MCPC/FDMA (mesh)**
- **Tier-3**
  - **DVB-S2/RCS with mesh** extensions (STANAG 4622, and U.S. Joint IP Modem, JIPM / SNMS)
  - GMPRS/MSS for high mobility, L-band

Mapping Standards to Satcom Tiers (II)

- **Tier-4**
  - **Narrowband DAMA/SCPC** (STANAG 4485), X-band man-portable terminals
  - **Narrowband DAMA/TDMA** (STANAG 4231), UHF man-portable terminals
  - MF-TDMA for **fully meshed** connectivity (MIL-STD-188-EEE)
    - any modem can act as network controller
    - **stackable**, **daisy-chained** MF-TDMA modems for increasing capacity, in large, or clustered small terminals
    - **FH or DS spreading** for TRANSEC, A/J, low ASI, LPD/LPI
- **Tier-5**
  - same as Tier-3, star topology only; DVB-S2 for broadcast
- **Tier-6**
  - 802.1Q/P satcom-to-wireless, end-to-end QoS to the last mile

Standardisation areas of interest to NATO

- **At network layer**
  - Bandwidth-request signalling and packet queuing based on **IPv4 DSCP, IPv6 flow-label**, **802.1q VLAN ID**, **RSVP/NSIS**
  - satcom modem as a **full-DiffServ capable node**
  - **VRF support**, to enable **Virtualisation of modems**; one modem <> multiple IP trunks (802.1Q tags mapped to DVB-S2 BBF ISI, modcods)
  - Introducing **MPLS**, and **MPLS interworking over satellite,** Tier-0 extensions… a phased approach:
    - **router as LER/PE**: modem not involved with MPLS
    - **modem as LER/PE**: mapping MPLS labels to MAC queues, capacity requests
    - **modem as LSR/P**, transparently carrying MPLS over the satcom channel, to the remote/deployed router (LER/PE)

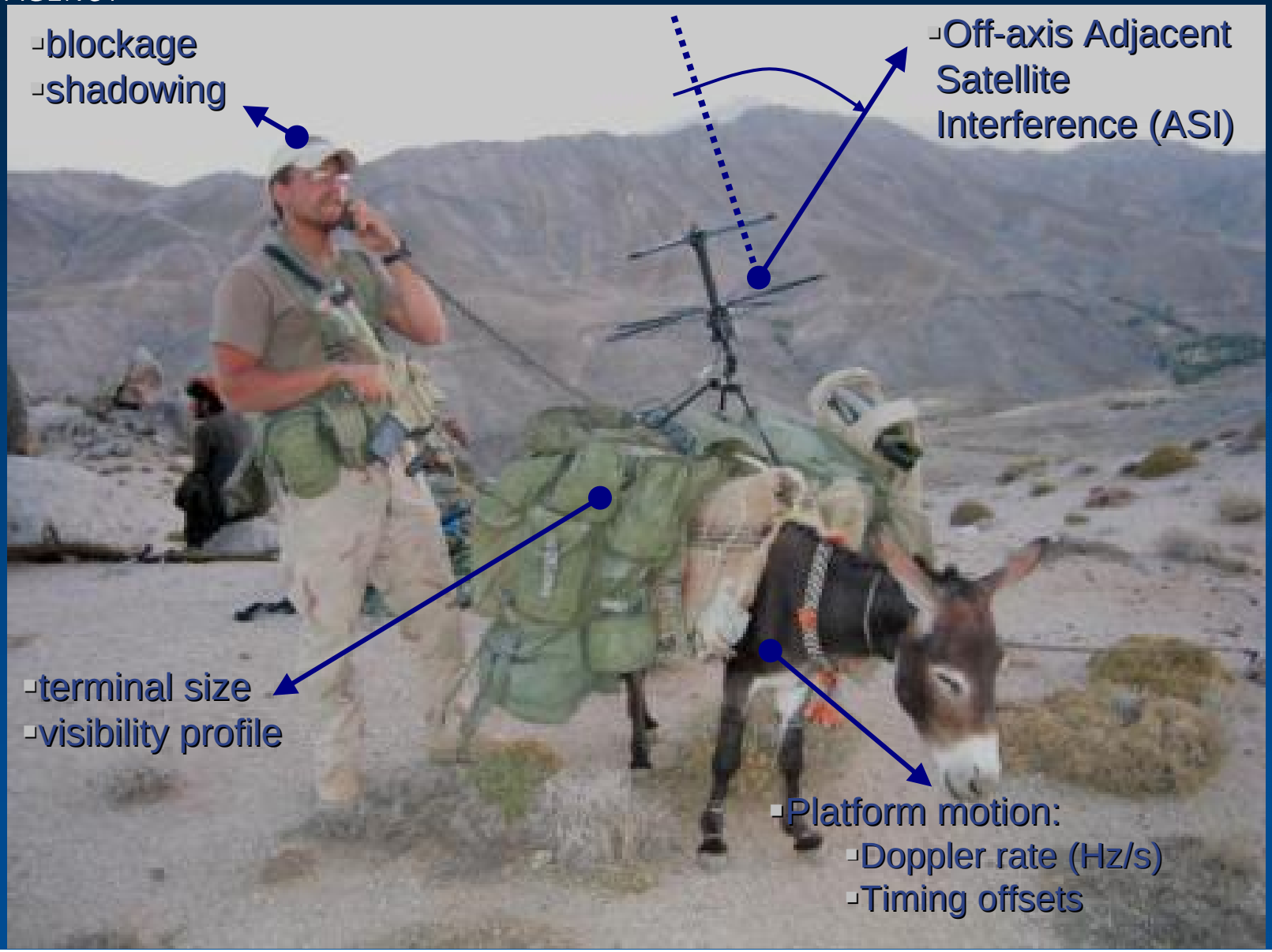
Standardisation areas of interest to NATO

- **At link-layer**
  - Efficient IP and **Ethernet encapsulation**: enables Ethernet bridging, PPPoE transport, multi-link PPPoE for bundling capacity from multiple modems
  - **Richer MAC/CoS queuing**, full DiffServ compliant PHBs at MAC level
  - **Segmentation and Reassembly**, prevents traffic analysis
  - Common **interface definition** for external or embedded **AES encryption modules** for TRANSEC
  - **Authentication** (terminal admission control) and **Key management** mechanisms (PKI-based, X.509)
  - **PPPoE** support; enables credit-based flow control for BW grooming, and more versatile QoS in router (RFC 4938)
  - **UL-FEC** for blockage mitigation (as in DVB-H, MPE-FEC)
  - Optional **Link-layer assured delivery** (ARQ, for SOTM)

Standardisation areas of interest to NATO

- **At physical layer**
  - **per-burst** adaptive uplink power control, coding and modulation, and **(per-carrier) adaptive symbol rate** (**ACM** on FL, **DRA/ACS/AC** on RL)
  - **MF-TDMA hubless** waveforms (following U.S. NCW, MIL-STD-188-EEE)
  - ability to accommodate very **heterogeneous population of terminals**, of different sizes, capabilities, within the same net
  - **FDMA/SCPC spreading** for SOTM forward link (DVB-S2/RCS+M)
  - **Adaptive MF-TDMA spreading** for SOTM return link (or SCPC/DSSS, SCPC/CDMA), switchable / selectable (per terminal, return carrier, burst)
  - **standardised Turbo FEC** implementations
  - **persistent slot** assignments (for SOTM users, fast blockage recovery)
  - **randomised burst placement** and fast F/H (for A/J)
  - … interest in **S-band broadcast** for small/handheld terminals, w. DVB-SH (situation awareness, dissemination of Common Operating Picture)
  - **multi-waveform terminals** (highly compact, software-programmable)
  - **advanced antenna designs** for SOTM (low ASI, low-elevation G/T, etc)

The Satcom-on-the-Move Challenges



Standardisation areas of interest to NATO

- **At Service level**
  - **Pre-emption** of services (at modem and NCC/Hub levels)
  - **Automated line-up**, authentication and **provisioning** of terminals
  - **Virtualisation** mechanisms for large satcom assets (e.g. hubs): Virtual Service Providers/Virtual Network Operators
  - **Performance management**
  - **Roaming**, Mobility, networking of Hub stations
  - **Standard interfaces** between NMS and OSS for **service level management** across terrestrial/satcom boundaries
  - **SOA** enablers

Summary and Conclusions

- **Current standards are considered sound enough to support capacity augmentation links (e.g. in Tier-2, Tier-3)**
- **yet, critical links (e.g. trunks in Tier-1, Tier-2) will largely rely on anti-jamming waveforms**
  - as prime, or backing-up highly bandwidth-efficient, commercial waveforms
- **work needed on standards for interworking with terrestrial networks, wired and wireless; satcom transit segment is just part of a complex end-to-end service delivery chain**
- **Tier-3 to Tier-6 is where most opportunities exist for emerging/evolving commercial standards**
  - satcom on the move
  - BoD waveforms
  - Hubless mesh networks
  - terrestrial DVB extensions (DVB-T, DVB-H, DVB-S/H)

- **The pressure is on … MilSatcom remains an appealing and dynamic market, with a clear preference for standards over proprietary solutions**

Thanks for listening

Questions ?