DVB-RCS, Military Satcom and NATO Standardisation

NATO UNCLASSIFIED

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Briefing Items

1. What is STANAG 4622
2. Updating STANAG 4622, driving factors and candidate paths
3. Commercial and Military Standardisation Standpoints
4. Coalition Interoperable DVB-RCS Architectures
5. Overview of SBS Experimentation Programs in NATO
6. Conclusions
Why Leveraging Commercial Standards?

• A commercial open standard results in lower costs and allows for multiple sources of interoperable terminals

• Diverse national systems, with a core compliant to the standard, and their own sets of capabilities, can interoperate and share common resources in a coalition environment

• STANAG 4622 emerges as a set of recommendations based on ETSI’s DVB and IETF standards, to enable interoperability between national Satellite Broadcast Systems (SBS), as:
  – Modems from multiple suppliers connecting to the same hub
  – Roaming terminals connecting to different hubs, as they move or re-deploy, based on position, footprint or space segment of choice

• The STANAG becomes the baseline for the procurement and deployment of a NATO-owned SBS capability, over the military SHF band
STANAG 4622 Status

• **STANdardisation AGreement** for Satellite Broadcast Services

• U.S. DoD-led effort, coordinated by DISA. First issue of STANAG 4622 ratified by the nations in 2004

• Standardises DVB-S, IP over MPEG2 (MPE), and IP encryption for implementing interoperable Satellite Broadcast Systems across NATO

• Limited to first three layers of the OSI stack, including IP encryption, IP routing (unicast/multicast) and QoS

• Overtaken by technology, needs regular updating. DISA and NC3A working together for updating the STANAG through Annexes:
  – Return Channel Integration: DVB-RCS
  – Improved efficiency on forward channel: DVB-S2
Updating STANAG 4622 - Driving Factors

(1) Supporting Bi-directional Communications (priority: high)

(2) Adding Net-centric Enabling Capabilities (medium)

(3) Improving Broadcast Channel Spectral Efficiency (high)

(4) Decreasing Terminal Sizes, Supporting Mobility (medium)

(5) Providing Differentiated Protection to Individual Streams, User Groups, through Return Channel Feedback (medium)

(6) Improving IP-over-MPEG2 Encapsulation Efficiency (high)

(7) Exposing Link Layers to Bulk Crypto Insertion for Transmission Security [TRANSEC] (medium)

(8) Preparing for IPv6 Migration (low)
Updating STANAG 4622 – Proposed Paths

(a) DVB-RCS for return channel integration and deployed broadcast injection

(b) OSPF and BGP for dynamic unicast routing

(c) Unidirectional Link Routing and IGMP Proxying/Helpering

(d) Digital Video Broadcast version 2 (DVB-S2) with ACM

(e) Ultra-Lightweight Encapsulation Protocol (ULE)

(f) IP version 6 (IPv6) modem support

(g) DVB-RCS evolution: mesh support, C2P, security
Return Channel Integration: DVB-RCS

• Objectives: return channel integration at SBS modem level, enabling:
  – Dynamic multicast routing over the return channel
  – Secure VPN overlays, parallel to broadcast services
  – Deployed/theatre broadcast injection through the return channel
  – Homogeneous return channel management, difficult when multiple organic or ad-hoc, independent communication links are involved
  – Closed-loop automatic coding and modulation updates, for adapting error protection to propagation or power conditions of individual users within the same broadcast bearer (DVB-S2 ACM)

• Options:
  ✗ Proprietary MF-TDMA, D-TDMA, CDMA, VSAT-like implementations
  ✓ DVB-RCS: thereby assuring interoperability with deployed STANAG 4622 assets (IP/MPE/DVB-S) on the forward channel
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<thead>
<tr>
<th><strong>Pros</strong></th>
<th><strong>Cons</strong></th>
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<tr>
<td>• Standards Based, open to growth</td>
<td>• Commercial offer targeted at large deployments involving tens of thousands of terminals</td>
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<tr>
<td>• DVB-S (S2) outbound can feed rx-only STANAG 4622 terminals</td>
<td>– Low scale networks not cost effective</td>
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<td>• Low-cost IDUs, cheaper than VSAT-like equivalent</td>
<td>• Vulnerability to interference, jamming (both on forward and return links)</td>
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<td>• Multiple suppliers, although limited interoperability to this date</td>
<td>• Difficult QoS mapping between terrestrial and satcom segment</td>
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<td>• Will likely evolve with DVB and incorporate features from the many DVB ‘brands’ (DVB-H, DVB-MPH, etc)</td>
<td>• Single-source dependencies remain, since interoperability amongst competing sources is only partial</td>
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<td>• IP-based, seamless use of external, military IP cryptos possible</td>
<td>• Inefficient ATM and MPE encapsulation of IP packets</td>
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<td>• Multicast enabled, on forward and return (implementation dependent)</td>
<td>• Bit level encryption difficult</td>
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<td>• No mesh connectivity possible today</td>
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### DVB-RCS Commercial / Military Context

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<th><strong>Commercial</strong></th>
<th><strong>Military</strong></th>
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<tr>
<td>Large terminal population</td>
<td>Reduced terminal population, highly segmented</td>
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<td>Two terminal categories:</td>
<td>Three terminal categories:</td>
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<td></td>
<td>Fixed (hub, 4.8 meter to 12 m)</td>
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<tr>
<td></td>
<td>deployed (up to 2.4 meter)</td>
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<td></td>
<td>Tactical / mobile (submeter)</td>
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<td>Domestic</td>
<td>Often aimed at supplying an additional waveform to existing, militarised, multi-band terminals</td>
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<td>SOHO + mobile (emerging)</td>
<td>Symmetric traffic volumes</td>
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<td>Aim at inexpensive, mass produced interoperable terminals (IDU+ODU)</td>
<td>Inclined Geo satellites (X-band)</td>
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<td>Asymmetric traffic volumes</td>
<td>Power limited space segment</td>
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<td>Fully stabilised satellites</td>
<td>Deployable, compact hubs (not shared)</td>
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<td>Bandwidth limited space segment</td>
<td>Guaranteed capacity preferred</td>
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<tr>
<td>Static, large hubs (can be shared)</td>
<td>Multicast from hub to remotes, and from remotes to hub/remotes</td>
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<tr>
<td>Dynamic capacity preferred</td>
<td>Non-negligible threat, vulnerability</td>
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<tr>
<td>Multicast from hub to remotes</td>
<td><strong>Low threat, low vulnerability</strong></td>
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Commercial Standardisation Standpoint

• One of the downsizes of standardisation, both in the commercial and military context, is rigidness, often resulting in capability constraints, loss of interest by suppliers

• From a Milsatcom perspective, the focus should be on interoperability at MAC chip, DVB/burst modem and network management levels
  – Interoperability at IP level is almost implicit if IETF RFCs are followed

• IDU manufacturers shall be free to incorporate value-added capabilities, to differentiate their products and stay competitive
  – That may include features tailored to specific requirements of milsatcom networking environments

• IDU suppliers need to ensure that their terminal can always be set to operate in a core-mode, where the basic interoperability is possible
Military Standardisation Standpoint

• Considering that:
  (1) embedded VoIP, TCP/IP acceleration, dynamic IP routing, VPN support, embedded IP encryption, RTP compression, etc. have little or no room in the military DVB-RCS picture, since all the traffic reaching the IDU is IP encrypted
  (2) these capabilities are better supported by external, separate devices, which will be isolated from the IDU through edge routers and IP cryptos

• ... one could just narrow DVB-RCS (terminal) standardisation down to core must-have capabilities (including selected options) that enable interoperability at waveform, management and control levels

• Military buyers should then be able to pick amongst:
  – COTS low-cost IDUs, which can be ruggedised
  – COTS medium-cost IDUs with Milsatcom-specific value-added features
  – tasking industry to build MOTS versions using interoperable and inexpensive DVB-RCS ASICs
  – embedding the core DVB-RCS waveform into existing software-defined military satcom modems
Standardisation and Cost Drivers

• In a military context, IDU cost can be traded-off against flexibility and versatility, key enablers of interoperability (i.e. software-enabled capabilities), considering that …

• … when operating in military frequency bands (X-band, EHF), with highly demanding environmental and mechanical requirements, the cost of the IDU may be a very-small fraction of the total terminal cost

• What is of real interest for milsatcom network planners and prospective military buyers?

→ Being able to fully decouple and independently conduct the acquisition of the hub and the acquisition of the terminal base, and …

→ Freely select/duplicate/upgrade the hub that best fulfills the mission requirement, while making sure that interoperability with a existing, heterogeneous terminal base won’t be an issue
Coalition Interoperable DVB-RCS Architectures

(1) Coalition Hub + WAN

(2) National Hubs & Coalition WAN

double-hop connectivity
Coalition Interoperable DVB-RCS Architectures

(1) Coalition WAN + Coalition RCS Hub:
   • Nations anchor their RCS terminals (RCST) to a NATO (coalition) hub
   • Through that hub, RCSTs can backhaul into Coalition and National data centres, using different encryption hardware connected to the same IDU
   • Field data can be exchanged amongst Nations both over a double-hop

(2) National RCS hubs + Coalition WAN
   • Nations anchor their RCST to their own National RCS hub
   • A coalition WAN supports terrestrial meshed connectivity amongst National hubs
   • National RCSTs can access both Coalition and National data centres, using different encryption hardware connected to the same IDU
   • Field data can be exchanged amongst nations both over the coalition terrestrial network and a double hop
NATO SBS Service Provision Initiatives

- Few nations with operational or planned DVB-RCS milsatcom networks today: U.S., France, Norway, Italy (others TBC)

- To this date, NATO has been very active pursuing a STANAG, but not deployed an SBS capability yet

- Requirements are slowly consolidating towards deploying SBS services over the new (SHF) NATO Satcom Post-2000 (NSP2K) Space Segment (FR Syracuse + IT Sicral + UK Skynet)
  - NSP2K provides assured coverage from 75 N to 30 S and from 90 W to 65 E

- SBS at X-band dictates requirements significantly different from Ku-band and Ka-band, specially when multiple coverage footprints need to be fed, and some use Earth Coverage beams (low power and very low antenna gains on board), vice Regional/Spot beams
A notional SBS architecture for content dissemination

Data Centre
- Data Sources
- Multicast tunnels

Gateway
- Multicast Router
- Return Channel Concentrator

NGCS
- Multicast Router
- Multicast Router

Footprint #1 (DVB-RCS)
- DVB-RCS tx/rx

Footprint #2 (DVB-S2)
- DVB-S2 Rx-only

Footprint #3 (DVB-S2)
- DVB-S2 Rx-only + indep. rtn

IP VPN
- Inmarsat
- ISDN/PSTN
- National Defence Net
- TSGT
- SGT

SGT

DVB-RCS

Multicast Router
DVB-RCS over Military X-band (SHF)

• Small terminal population (< 50) and hub deployability call for small, compact and scalable hubs

• The concept of ‘private hub’ takes precedence over the current enterprise-class hub implementation, at a small fraction of the cost

• Forward and return channels can be on the same or different transponders, in order to optimise transponder gains

• Individual setup of return link bandwidth per carrier => each terminal-class can be assigned to a different carrier

• NSP2K involves multiple satellites and teleports, Earth Coverage footprints, regional and spot beams. As a result:
  – FLSS and RLSS may often need to be decoupled
  – One RLSS may be reachable through more than one satellite
  – Besides the FLSS, there may be additional broadcast feeds
  – A typical user terminal may consist of one RCST, plus additional rx-only DVB-S terminals
A notional DVB-RCS “split” SBS Architecture

Standard DVB-S headend (acting as FLSS)

Terrestrial IP Network

Server Farm

Content

FLSS

ATM PVC

ATM

GPS

RLSS

DVB-RCS RLSS-only

B notional DVB-RCS “split” SBS Architecture
DVB-RCS over Military X-band (SHF) [cont.]

• Need to consider the timing errors induced by Doppler and slant range changes in military geosynchronous satellites with slight inclination (up to 7 degrees in some cases)

• The satellite motion can be modeled as a having an RCST on the ground moving at speeds from 0 km/h to 115 km/hour, over a period of 24 hours, along a 900 km long highway.
  – In a way, the context is very similar to that of mobile DVB-RCS for medium and high-speed platforms (ships, high-speed trains, etc).
  – Lessons learned from MOWGLY may apply

• According to the standard, after the acquisition "the NCC can correct all frequency and timing errors other than differential Doppler between the RCST and the NCC"

• For the initial sync procedure though, it is recommended to:
  – Make the ACQ time window sufficiently large in the TBTP to cope with the initial delay uncertainty, OR
  – Use the SPT to send ephemeris data to the RCSTs
Overview of SBS Experimentation Programs

• NC3A has been active in coordinating pilots, demonstrations and workshops in coalition environments, sponsored by the Allied Command Transformation (ACT) and Allied Command Operations (ACO)

• Experimentation Program Objectives:

1. STANAG 4622 validation
2. Risk Mitigation prior to conducting future large acquisition of STANAG 4622 compliant broadcast networks
3. Emerging Technology evaluation for STANAG follow-ons (e.g. DVB-S2/RCS in 2006 SBS Pilot)
4. Closer interaction with industry, under a win-win approach (system debugging, product marketing and exposure to military customers vs. tailoring to military requirements, hardware loans, etc)
Experimentation Programs: SCoBE 2004

• The Satellite Coalition Broadcast Environment (SCoBE) demo in JWID 2004 was the latest SBS coalition trial, involving:

  • US, UK, Spain and NATO (NC3A)

  • DVB-RCS terminals deployed at both sides of the Atlantic

  • Dual footprint coverage (East Atlantic and European), via Hispasat 1C/1D, in Ku-band

  • NSA Type-1 IP security via coalition Taclane E-100s and KG-175s

• SCoBE’s Multicast Cross-feeding concept was demonstrated:
  – Secure multicast feeds injected from all sites, received by all sites, with dynamic multicast subscriptions (those channels with zero audience would not be transmitted over-the-air)
SCoBE / JWID 04 High Level Architecture

Dual Footprint (U.S. / Europe)
Multicast / Broadcast
Cross-feeding
over HISPASAT
DVB-RCS / DVB-S

U.S.
GBS

U.S.
DISA Eagle

UK
Porstdown West

UK
PDBS

CFBLnet

NC3A
The Hague

STANAG 4622
Rx-Only Suites

Spain SDS

SPAIN
Madrid

SPAIN
JWID Site
@ Lillehammer

NATO
JWID Site

SECRET
MULTICAST / BROADCAST

UNCLASSIFIED
MULTICAST / BROADCAST

Rx-Only Suites
SCoBE 2004: Multicast forwarding over Hispasat 1C/1D

Note: all contributions are transmitted and re-transmitted as multicast
SCoBE 2004: DVB-RCS terminals at NC3A

BIM: Broadcast Injection Module
ROM: Receive-Only Module

Deployed BIM

Static BIM

BIM back-end (CAVE)

DVB-RCS IDU

UNCLASSIFIED Content Server

SECRET Content Server

IP Encryption Device

UAR (BLACK)

SAR (RED)

IP-Z
SCoBE 2004 Screenshots
2006 SBS Pilot: DVB-S2/RCS at X-band

• DVB-S2 opens new grounds for utilising lightweight, compact and low-cost X-band terminals
  - Selectively supporting disadvantaged terminals or terminals operating under adverse weather or propagation conditions

• Thanks to LDPC, BCH and TPC codecs, forward and return links operate with sufficient margins, with relatively modest terminals, in terms of:
  • **Size**: 1.2 meter offsets, ~ 14 dB/K G/T at 10 deg
  • **Power**: highly compact < 50 Watt X/L-band transceivers
  • **Tracking**: az/el actuators for automatic tracking of inclined satellites

• Best of all, DVB-S2 can be backwards compatible with DVB-S, thus existing STANAG 4622 receive-only terminals can be easily integrated into new DVB-S2 or DVB-S2/RCS networks, with no modifications
Conclusions

• Easy mapping of DVB-RCS and DVB-S2 standards into a NATO STANAG, but …
  • oddities related to the Milsatcom environment shall be carefully considered and addressed on a case-by-case basis (frequency bands, multi-beam operation, inclined orbits, mobility, fading, etc)

• Suggested narrowing the standardisation effort to core capabilities, to avoid over constraining IDU and chip manufacturers

• Significant support by the U.S. DoD guarantees that DVB-RCS will stay in the Milsatcom focus for quite some time
  – TIA/EIA-1073: defines the requirements for a Satellite Network Modem System (SNMS) using Time Division Multiplexing (TDM) and Multi-Frequency Time Division Multiple Access (MF-TDMA) signaling
  – The SNMS in TIA-1073 shall fully meet the DVB-S2 and DVB-RCS requirements in ETSI EN 301 790 and ETSI EN 302 307
  – Ditto for the emerging DoD Joint Network-centric IP Modem System (JNIMS)
Thanks for your interest.

Questions ?