THALES

Benefits of Using STANAG 5066 +ALE for MTWANs

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STANAG 5066 / ALE Summary

- STANAG 5066 originally (1996) developed to meet NATO/Allied HF needs for BRASS Ship Shore and MRLS
  - Key requirements
    - Fully Open architecture + Documentation + Open API
    - Hostable on "any" platform e.g. WINDOWS, UNIX/LINUX embedded ..
    - No requirement for a Real time OS, or GPS time input
- Widely supported by numerous vendors and wide range of implementations and fielded systems in service with many NATO/Allied Nations
  - Supported by Interoperability testing /verification by JITC, NC3A, DERA (QinetiQ)
- MIL STD 188 141 2^{nd} Gen ALE developed 1988
  - Wide range of implementations and fielded systems from multiple vendors
  - Established JITC Interoperability testing and verification process
  - Linking times dependent on the number of frequencies in use and the scan rate
    - Common ALE linking times are in the order of 8 – 15 seconds
    - Many/most 2nd generation ALE system can choose the best rather than first available frequency.

Use of 5066 with ALE

- STANAG 5066 first focus was NATO BRASS Ship -Shore and Ship-Shore-Ship
  - BUT first major deployable success was BFEM-66
    - Multiple email users sharing a single frequency LOS application
    - Listen before transmit for channel access
      - Inefficient for large number of users
- UK RN have introduced use of STANAG 5066 with ALE via the Thales outfit 4KMA solution for SR(S) 7397
  - and SR(D) 2024 Defence HF comms Service programmes, equipment provided by Rockwell Collins
- Many other programmes are in-service that use ALE
  - USAF HF Global Comms system,
  - US & UK coast guards programmes
  - BRASS enhancements etc ..
- *2nd gen ALE is one of the JTRS Waveforms ..*

Benefits of using ALE + 5066

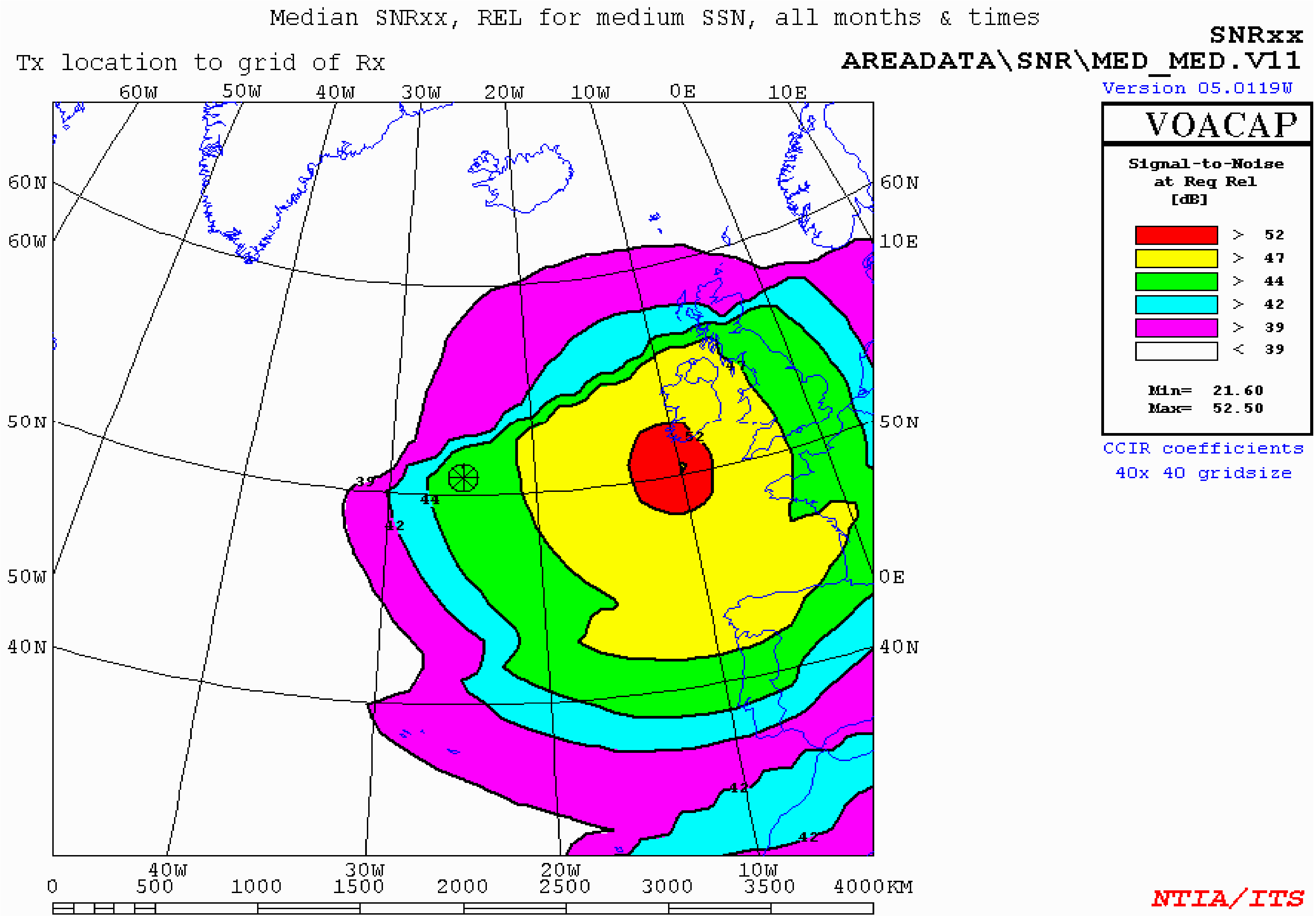
- Most nations have ALE capabilities and almost all modern HF radios/modems support 2nd gen. ALE
  - 3rd Gen ALE has full support for legacy 2nd gen. mode in both Nato STANAGs and US MIL STDs.
- Functionality / System / Performance
  - Simultaneous use of multiple frequencies will significantly increase overall network throughput
  - ALE linking /overhead offset by optimised data rate and improved range for all pt-pt links
  - Better use of frequencies, improved propagation and collocation performance
- Programme Benefits
  - Proven ALE + 5066 interoperability with multiple vendor availability
  - Limited need for Network Coordination /setup
    - Common ALE + 5066 Parameters still need to be set up
    - Use of Autobaud MIL STD 188 110B /STANAG 4539 means no need for initial data rate setting

STANAG 5066 - Performance Features

- Minimal Packet Overhead
  - Flexible Multi-nibble 0.. 3.5 Bytes (28 Bits) plus support for non-ARQ modes supports a wide range of addressing schemes & applications
    - Can even use Zero byte addressing
    - Acknowledgement windows allow minimum size ACK packets
    - Can support streaming non-ACK clients
    - Selective Sliding window ARQ
      - Minimises repeats of successfully transmitted info
    - Variable packet size
      - Can be optimised for prevailing conditions
- Modem layer independence e.g. HF (SSB + ISB) : VHF & UHF..
  - Only requires 5066 configuration to accommodate a new modem - no s/w mods
  - STANAG 5066 used with wide variety of HF modems and also and UHF IP Unwired modem at 64 /72 kbps ***and ABOVE***
  - Provides an adaptive Data Rate Change to maximise throughput *(Thales 4KMA solution for the RN has UK CESG security approval)*

Average Ranges Achievable with HF and ALE

- ALE used to choose the best frequency from a set of typically 10-12 frequencies
- Modelling Parameters
  - TX power : assumed 125W transmitter
    - backed off to 60W (to make some allowance for peak-to-mean ratio of waveforms).
  - isotropic antenna models with moderate gain (4dBi TX, 5 dBi Rx).
    - Gain will be optimistic relative to whip for high angle (short range) paths.
  - Low, medium & high sun spot number, 4 months (01, 04, 07, 10), 6 times of day.
- Median of area coverage plots for high, medium and low sun spot numbers taken - not worst case.
  - With 90% reliability criterion.


Median SNRxx, REL for medium SSN, all months & times
Tx location to grid of Rx
SNRxx
AREADATA\SNR\MED_MED.V11
Version 05.0119W
VOACAP
Signal-to-Noise at Req Rel [dB]
> 52
> 47
> 44
> 42
> 39
< 39
Min= 21.60
Max= 52.50
CCIR coefficients
40x 40 gridsize
NTIA/ITS
60W 50W 40W 30W 20W 10W 0E 10E
60N 50N 40N
0 500 1000 1500 2000 2500 3000 3500 4000KM

Average Ranges Achievable with ALE

Data Rate (bps)	SUNSPOT Number			Average Range Km
	Low	Med	High	
300	1742	1613	1677	1677
600	1258	1387	1290	1312
1200	1097	1193	1129	1140
3200	903	774	839	839

Network Needs for (Sub-net) Relay

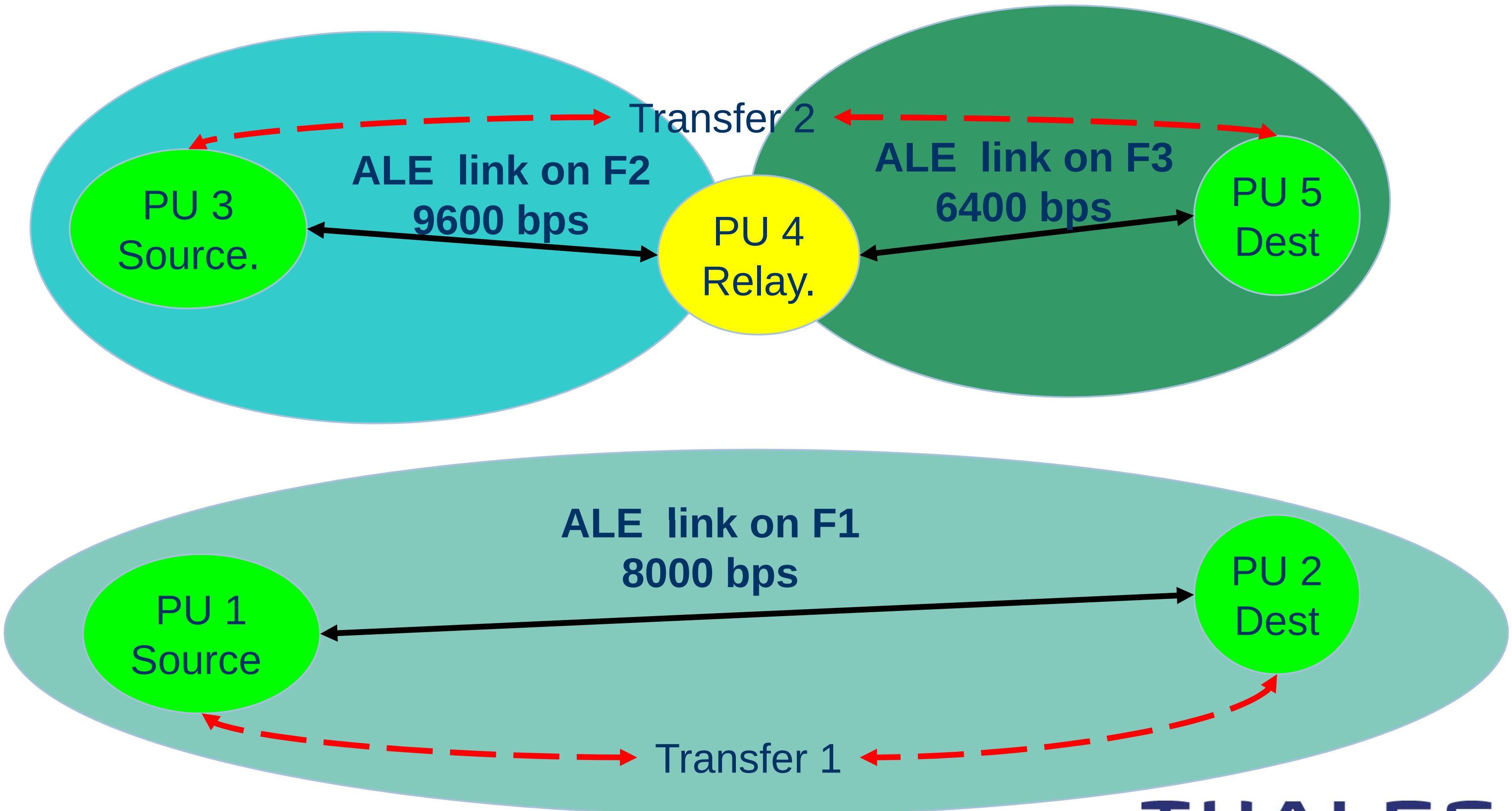
- For “seamless” end to end operation HF subsystem must automatically/transparently relay data where a physical pt-pt HF link cannot be established
  - Users do not want to deal with low level RF related issues
    - Channel access issues, range limitation due to frequency /power or Propagation effects
- Relaying at the **Subnetwork** predicated on efficiency, performance needs
  - probably essential for single frequency nets
- For tactical use ALE provides ranges that mean relaying unlikely to be required (***whether using IP or not)***
- ALE can of course be used to facilitate relaying / forwarding

Scenario – Two Simultaneous ALE links (one with relay)

Two (Simultaneous data transfers)

PU1 -- PU2 Linking on F1 at 8000 bps

PU3 – PU5 Linking on F2 at 9600 and then on F3 at 6400



"Analysis" of Relay With 5066 + ALE

- It is possible to relay the data at the application layer using the MMHS or Mail server without new protocols
  - Rules for relay /forwarding of military data will probably have to be set by user level policies – we are not talking the WWW here
- Example:
  - 5 Node Network with two 100 Kbyte data transfers
  - Two concurrent circuits
    - A - One pt–pt link at 8000 Bps :
      - 1 Link Setup + tear down Included (18 seconds)
    - B- One relay Circuit At 9600 Bps :
      - Two ALE Link Setups and teardowns needed
      - Allows 10 seconds fro system to decide to relay data
- Throughput per circuit (as seen by the users) *inc ARQ o/head*
    - Circuit A ~4600 bps
    - Circuit B~ 2140 bps (includes relaying the data)
- Aggregate on-air throughput seen by users ~ 6740bps

Single Frequency Operation (1)

- Fundamental limitation is that bandwidth available to an individual user is reduced in proportion to number of users sharing the frequency
  - (and heavily influenced by link turn-around time)
- Example (from ref 1)
  - 5 NODE network :
  - Link turn around time of about 1 sec approx the minimum achievable with COTS PC and HF Modem and vs. interleaver
  - On air rate of 6400 bps (error free)
- Network throughput ~ 5000bps (Token/TDMA) or 2500 bps (DCF/DCHF)
- On average each user will only get between ~1000 bps (token/TDMA) and ~500 bps (DCF/DCHF) on-air (NOT end to end) data rate
- These figures do not include ARQ overhead or make allowance for application + protocol overheads, TCP/IP initialisation,etc

ref 1 : "Impact Of Turnaround Time on Wireless MAC protocols" - Prof E Johnson

Single Frequency Operation (2)

- To be reliable a single frequency HF network must also use the lowest data rate achievable by all platforms in the net
  - In practise this may be 3200 or 4800 Bps despite higher rates e.g. 9600 bps or 19.2+ kbps (multi-ISB) being achievable on a point to point basis between pairs of the users
  - Not clear whether adaptive data rate change viable in a multi-user single freq. network
- Co-location problem may also make one frequency unsuitable for one or more of the platforms in a net thus reducing the effective Interoperability achieved in the field
  - There is no easy solution to this problem for a fixed frequency net
- Relaying issues - priority, authorisation, security etc. are common to single and multiple frequency nets.

Comparing like with like

- No one frequency will be optimum across a range of non-identical platforms
  - Different antennas and differences in their location on the platform
  - Co-location Interference impact of other users
  - Physical location and orientation of the platform
- ALE systems can use the optimum frequency for each pt-pt link thus allowing maximum data rate per link
- With STANAG 5066 adaptive DRC can be used to increase throughput over fixed rate transmission by very significant amounts
  - Could be 30% could be 200% (or more) dependent on conditions
- ALE is asynchronous - user can transmit “immediately” (after Listen Before transmit) delay
- Token Ring /TDMA initial latency waiting for Slot/token
  - Depends on the number of users and on-going traffic

Advantages of 5066 layered Architecture

- Modular architecture supports introduction of significant new capabilities e.g.
  - STANAG 5066 V2 – complete new token ring MAC layer
  - New clients have been added to 5066 since first developed e.g. CFTP
- A number of activities are underway into improved IP performance over HF e.g. NC3A activities on AHFWAN66.
  - IP payload compression
  - Robust Header compression
- TCP proxies/gateways such as those developed by IPunwired and others
  - Proprietary approaches may preclude widespread deployment
- Since these improvements are implemented above the HF sub network they can also be directly applied to use of pt-pt IP over 5066 with ALE.

Single Frequency vs. ALE Multiple Frequency

- Which is best ?
  - Depends on what you are attempting to do and the specific scenario being analysed
- It is however clear that use of ALE :
  - Will improve resilience and flexibility to cope with specific platform /antenna issues
  - Provide longer ranges reducing need for relay
  - Can greatly assist in provide and dynamic relay /forwarding capability

- ***But only if you have ALE radios***

- ***However the JTRS programme will provide ALE radios.***
- Wider availability of ALE within most nations /forces and under the JTRS programme will require more focus on how to maximise benefit from ALE systems
  - Should consider therefore an HF-IP approach that is utilises ALE and makes use of JTRS capabilities

- Existing 2nd gen ALE and STANAG 5066 V1.2
  - have most of the interoperability issues ironed out
  - provide improved throughout, resilience and support relay
- Customer are not always aware of, nor are they making best use, of the capabilities of existing HF systems
- Further work still required to analyse how best to support generalised IP routing and Interactive (Chat type) applications with ALE
- HF systems must maximise the benefits of HF and the optimise the HF spectrum/bandwidth available to the end users
  - If you have multiple frequencies ALE is the way to do it
- JTRS will bring ALE into wider service in most nations
- Single frequency Net will always face a bandwidth problem
  - UK BOWMAN programme is finding this a problem at VHF LOS
- HF-IP developments should consider integration of existing 2nd gen ALE and the impact of ALE enabled (JTRS) radios to maximise the benefits to the end user of multiple HF frequency approach