THALES

HF ALE – 2G, 3G and Wideband Some System Integration Perspectives

HFIA - Brussels September 2015

DR ANDREW F R GILLESPIE
THALES UK

ANDREW.GILLESPIE@UK.THALESGROUP.COM

Resurgence in HF

Currently there is increasing interest in HF from a range of users- military Civilian, Government Organisations and NGOs etc.

- In the RN Military Satellite communications increasingly seen as expensive
  - UK MOD do not own MIL SATCOM (SKYNET 5) assets - they are provided by a private consortium and using private finance
    - Guess who might have negotiated the best deal out of that ..?

Wideband HF seen as an increasingly attractive option relative to SATCOM for certain services and in certain roles in a multi bearer networks i.e. TACWANs, MARWANs ..

What could delay/ damage this current resurgence

- Lack of standardisation and hence risks in achieving interoperability for new HF capabilities e.g. Wideband HF and supporting ALE
- HF systems that are too complex to use and/or to configure and integrate
- HF systems that do not prove reliable in operation across a range of operational deployments - long and short ranges, networked operations, pt.pt star littoral
- Consequences of setting and then not meeting un-realistic expectations on the achievable wideband HF data rates

THALES

Continued Need for ALE

- The need for HF to be used by non-HF experts and as part of automated rather than manually operated HF systems were key drivers in the development of both 2G and 3G ALE schemes
- The other key driver being to improve the performance of HF as communications medium i.e. rapidly select a suitable HF channel for the traffic whether voice or data
- The ALE process is a separate supporting function for the HF system - many HF systems including NATO BRASS initially did not have ALE
- 2'nd Gen. MIL STD 188 141A 2'nd Gen ALE developed : 1980s
  - Asynchronous, easy to implement, 8-ary FSK waveform, very loosely coupled with radio
  - Wide range of implementations and fielded systems from multiple vendors
  - Linking times dependent on the number of frequencies in use and the scan rate
- 3'rd Gen. STANAG 4538 MIL STD188 141B : circa 2000
  - Improved waveform performance, improved linking performance for meshed and more heavily loaded networks
  - Synchronous TDMA operation requires network initialisation => increased complexity : Strict timing => more tightly coupled with radio and crypto
  - Separate traffic and calling channels

THALES

ALE in support of ARQ

- ARQ - STANAG 5066 was started (Ref 1) in 1996 to develop an ARQ process for NATO/Allied HF needs re: BRASS Ship Shore and MRLs
- Key 5066 requirements
  - Fully Open architecture + Documentation + Open API supporting Email, ACP 127, IP, broadcast clients etc.
  - Hostable on "any" platform e.g. WINDOWS, UNIX/LINUX embedded ..
  - No requirement for a Real time OS, or GPS time input
  - Industry support
- When developing 5066 the STANAG had to be independent of the channel setup and access mechanism (ALE process)
  - This was to provide maximum compatibility with existing HF systems using CARB /FAB techniques for ship shore access and to avoid forcing costs of implementing ALE on Nations who were not ready for it / did not need it
- The UK RN introduced 2nd generation ALE to support STANAG 5066 via the Thales Outfit 4KMA solution - in-service across the RN since 2004 providing HF email and support for formal e.g. ACP 127 messaging
  - Of course there have been and are a many other programmes world wide that use ALE - Army, Air, and Naval and multiservice as well as civilian programmes

- *Ref 1 Reynolds, P.D.; Gillespie, A.F.R., "Interim Profile For Maritime HF Data Communications." IEE 7th Int. Conf. on HF Radio Systems and Techniques, 1997, pp. 265-270,*

THALES

ALE- Listen Before Transmit (LBT)

- An important element of ALE system design(albeit importance is scenario dependent) is the LBT implementation
- LBT aims to try avoid collisions/ self interference i.e. transmitting on top of and hence disrupting on-going traffic from other HF users
  - This has applied to both asynchronous and synchronous (TDMA) 3G ALE schemes
    - 2nd Gen asynchronous ALE aims to avoiding collisions when attempting to set up links (or sounding) by use of LBT
  - To reduce the latency and hence reduced performance that would otherwise result from "strict" TDMA
    - Allows a user to "grab" a free HF channel rather than slavishly wait their turn
- Without a reliable and fast LBT process overall HF network performance will degrade - potentially very substantially in heavily loaded networks
- Introduction of extra HF waveforms - particularly variable bandwidth waveforms such as the new wideband waveforms -increases complexity of implementation of a reliable LBT process - => re use of existing 3G ALE elements should be considered
- This may be exacerbated by the near / far problem
  - E.g. long range 1000s of km HF transmission from shore to a naval platform using STANAG 4415 or STANG 4285 at 300bps - the (FAR) signal being received at a platform may well be at /below the noise floor - difficult to detect using simple spectral level occupancy measurement even by a near platform

LBT – Some challenges

- For LBT to be effective it has to be able to reliably and quickly detect all the waveforms that (legitimately) may be present on a HF channel (traffic or linking)
  - Analogue voice
  - Legacy Waveforms (FSK / Morse ?)
    - STANAG 4529, 1.24 KHz
  - Standard "3" kHz traffic waveform - which themselves consist of multiple waveforms
    - STANAGs 4285, 4539, (4415) and MIL STD 188 110x
  - Combined ALE and traffic waveforms (3G ALE)
    - STANAG 4538 MIL STD 188 141X
  - The new Wideband HF Traffic waveforms
    - MIL STD 188 110x - 3 to 24 kHz variable bandwidth in contiguous nominal 3 kHz increments wide (8 bandwidths)
    - STANAG 4539 App H (XL) - combinations of 1 to 16 individual nominal 3 kHz channels spread across 200 kHz
    - And supporting wideband ALE waveforms- if distinct from existing waveforms .. (TBD)
- In any scenario other than where a "simple" spectral occupancy measurements approach is sufficient the LBT mechanism for wideband HF will require careful design and implementation and may need to use a wider range of information to be effective

THALES

ALE – Some Wider integration issues (1)

3rd generation HF introduced the concept of traffic setup as part of the ALE linking process

- i.e. setting the initial parameters (multiple – esp. if ARQ config included) for the traffic circuit
- Allowing setting up a traffic circuits on frequencies other than the calling frequency
  - 2'nd Gen. ALE "default" was to link on the calling channel

These concepts are being /have to be extended for wideband HF

- E.g. Specifying the bandwidth of the contiguous 110 W/band waveform / the (initial) subset of frequencies for the composite i.e. non contiguous STANAG 4539 App. H waveform
- Specifications of Traffic types and initial data rates need also need to be (re)considered

These traffic set up parameters have to be transferred to/from a platform HF subsystem from higher layers of the communications system

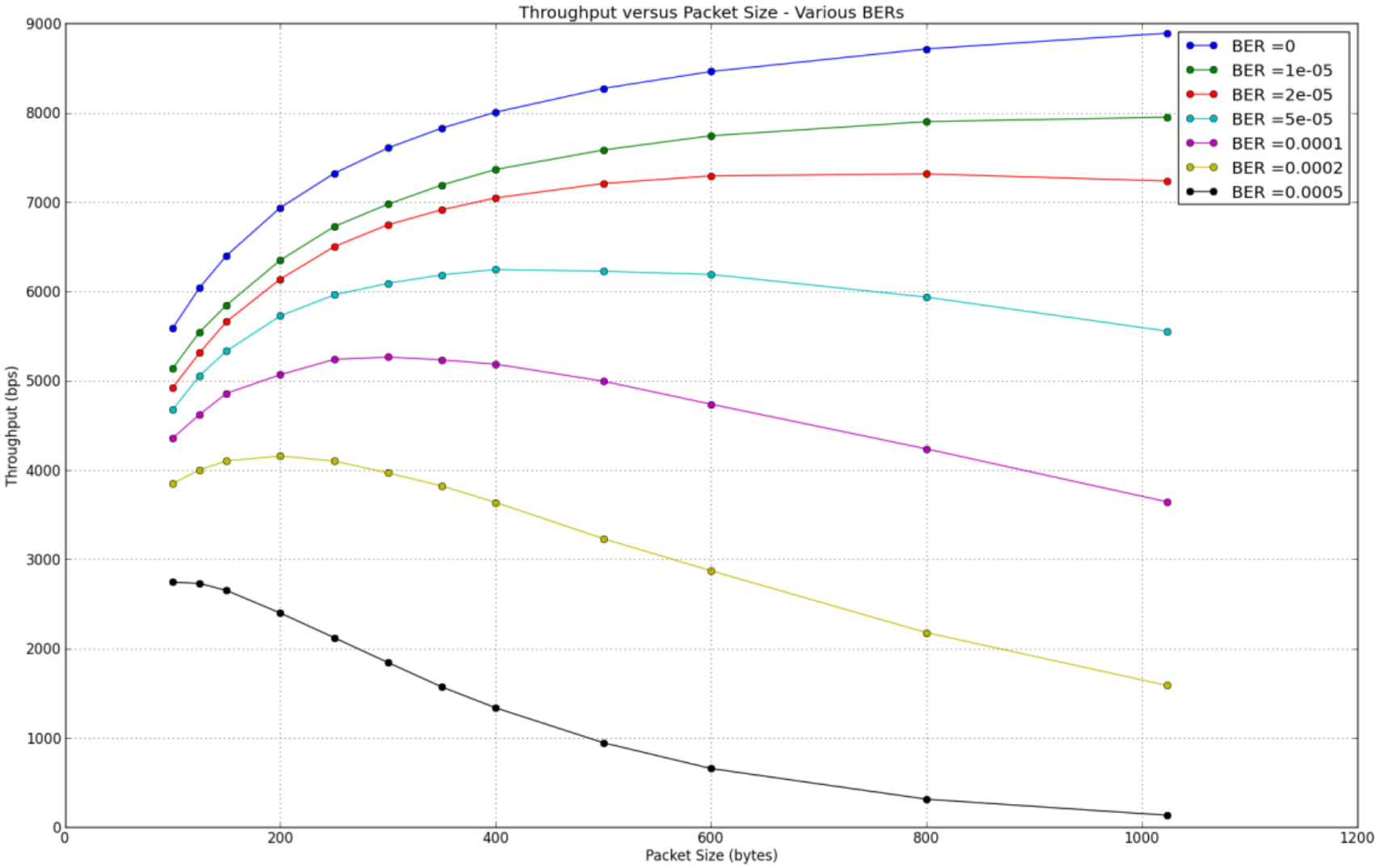
They also may need to be dynamically linked to the control of equipment parameters such as AGC, filter bandwidths, radio sensitivity, tuning, *TX power* - which also need to be considered from a wider integration perspective

- ..(depending on the specific HF system implementation)

The more complex the ALE process the more complex the integration task

THALES

Packet size- No simple Optimum - Optimum packet size varies with Channel BER – Specify in ALE Traffic set-up ?



THALES

Extra Info - Over The AIR (OTA) Specification required for Interoperability - ref. HFIA Jan 2006 (n.b example only 2G)

Extract of Content list of the OTA

AFCEA West HF ICMV HF INDUSTRY JAN 2006

ALE – Some Wider integration issues (2)

- The use of wider and variable bandwidths with W/B HF will pose additional challenges for of collocational interference i.e. where multiple HF circuits are simultaneously in use (UK QEC Aircraft Carriers has ~ thirty HF ccts. and destroyer /frigate : typically six to eight)
- Improved integration with on-board frequency planning and control systems will therefore be of increasing importance for large platforms with multiple HF circuits
- Must use all available knowledge - typically held in the platform comms management system - of on-going HF transmissions to assist the HF Automatic Channel Selection (ACS) process
  - in selecting the right waveform characteristics to minimise collocational interference
  - While also choosing a suitable channel/waveform/initial parameters to support required traffic type
- Additionally must provide, dynamically, details of the (wideband) HF channels in use back to the platform comms management systems to facilitate overall traffic management
  - Use of Automatic Link Maintence (ALM) processes i.e. altering in-use channel characteristics and /or re-invoking ALE to maintain required QOS make this a dynamic process

THALES

Summary

- ALE is a key part of any modern, networked HF system with performance linked to(& of course many other aspects of the system)
  - the implementation of a reliable and efficient LBT scheme
  - the ability of the ACS process to match channels to traffic needs and external constraints and the ALM process to maintain QoS
- None of above are standardisation issues per se. but setting credible minimum reliability for LBT performance in future w/b standards needs consideration.
  - Must allow vendors users and purchasers the freedom to specify and design HF systems to meet specific user/market needs
  - Need to avoid over stringent LBT performance leading to costly systems for scenarios where LBT less of an issue e.g. less waveforms in use, shorter ranges, the near /far problems not so significant
- Reuse of existing ALE elements from 3G ALE e.g. FLSU process and waveforms could have major benefits
  - Reduces costs of implementation for vendors & avoids increasing unnecessarily number of waveforms and the knock on impact on LBT
- The inherent complexity resulting from moving to variable bandwidth waveforms is likely to require more sophisticated systems and better integration with wider platform comms management and control systems
- Without proper consideration of these issues (.. cognitive radio concept) the full potential of wideband HF unlikely to be fully realised

THALES