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Military Wireless Interoperability and Spectrum Use

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Outline

- Changing operational picture
- Spectrum challenge
- Military demand for wireless
- Where next

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Changing Operational Picture

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NATO Summit

- NATO Readiness
- The Ukraine
- Middle East and North Africa (MENA)
- Afghanistan
- NATO's Open Door Policy
- The Transatlantic Bond
- Increased cooperation: NATO, EU, European Defence
- At least 2% GDP on Defence

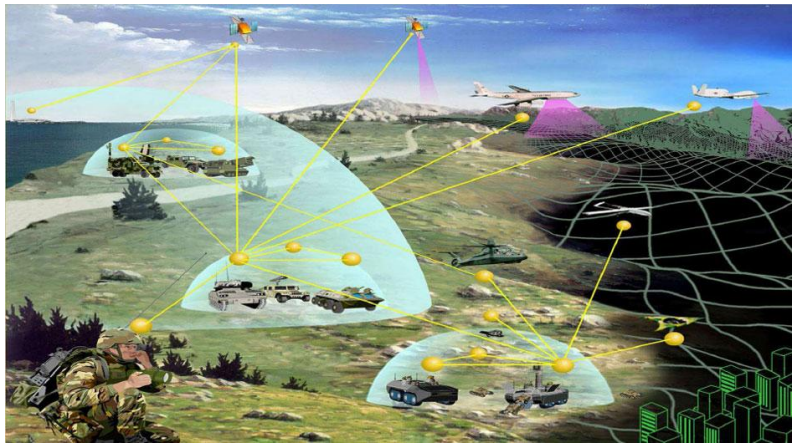
Operational Trends

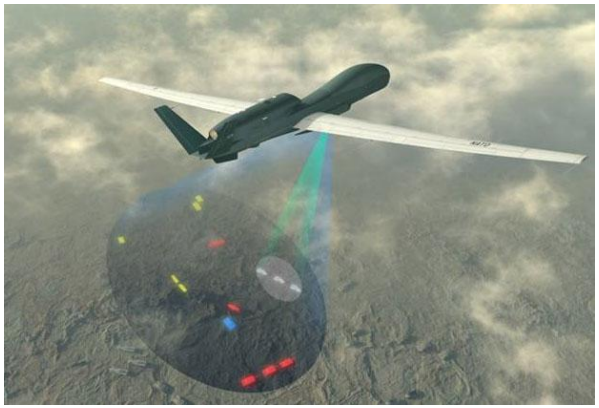
- Need operational ability to deal with spectrum of conflicts: low to high intensity
- Involving a range of communities: not just military also political, economic, humanitarian, media (Comprehensive Approach)
- Operating in or out of NATO area
- Responsiveness, transportability and mobility key capabilities
- With robust and capable C4ISR*
- Increased use of technology

* Command, Control, Communications, Computers, intelligence, Surveillance, Reconnaissance

Responses

- Readiness Action Plan:
  - More and higher readiness forces
  - Very High Readiness Joint Task Force (VJTF),
  - More transportability and mobility
- Experience from Afghanistan leading to more surveillance capability and greater use of UAS/UAV
- Connected Forces Initiative

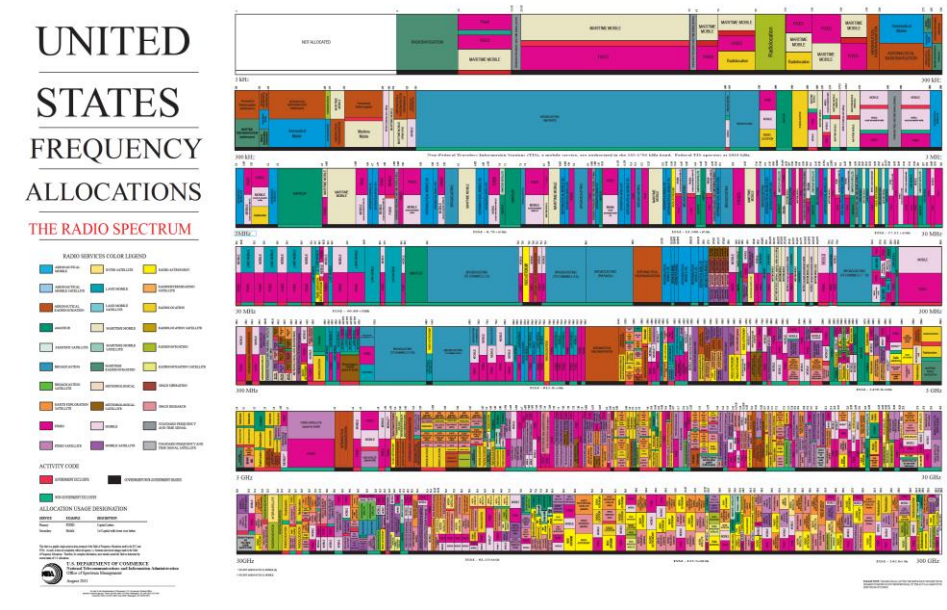


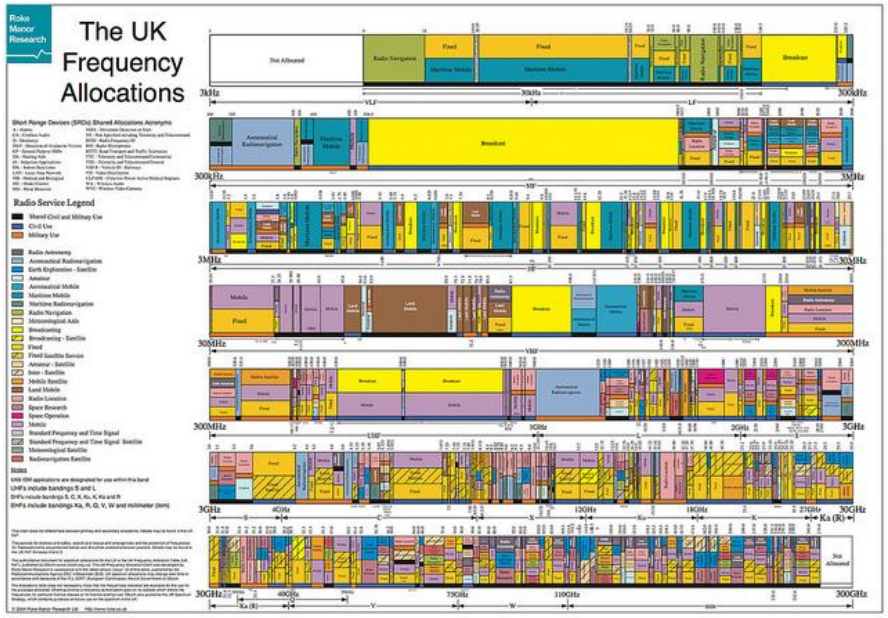


Spectrum Challenge

Spectrum Challenges (1)

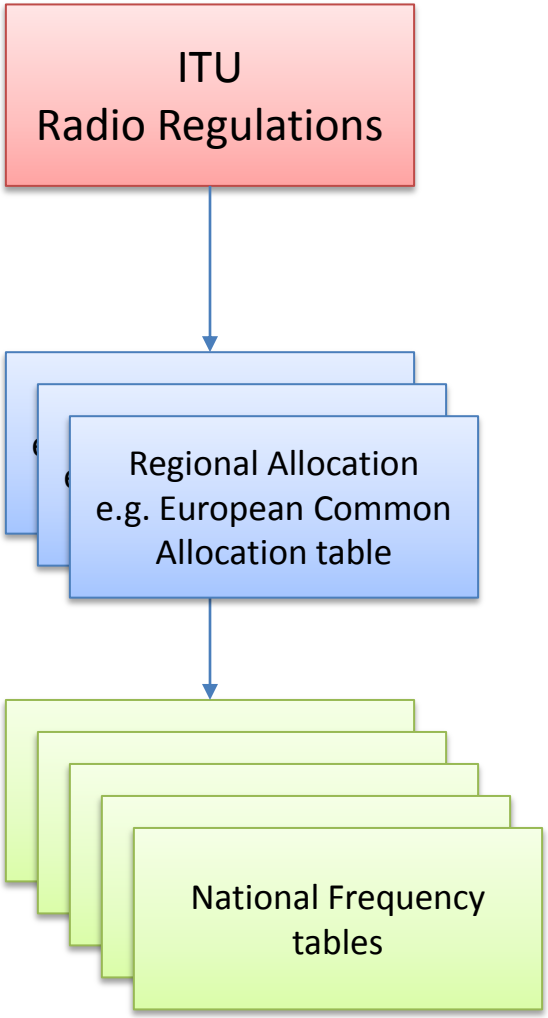
- Most if not all spectrum is allocated
- Great demand for the sweet spots:
  - balance between capacity and propagation range
- But allocated spectrum is not necessarily highly utilized
  - Spectrum for commercial benefit:
    - Mobile networks, wi-fi, broadcast
  - Spectrum for “societal” benefit:
    - Military, emergency services, utilities, transport, broadcast





Spectrum Challenges (2)

- Spectrum is a national asset
- But regulations and allocations are there to minimise interference

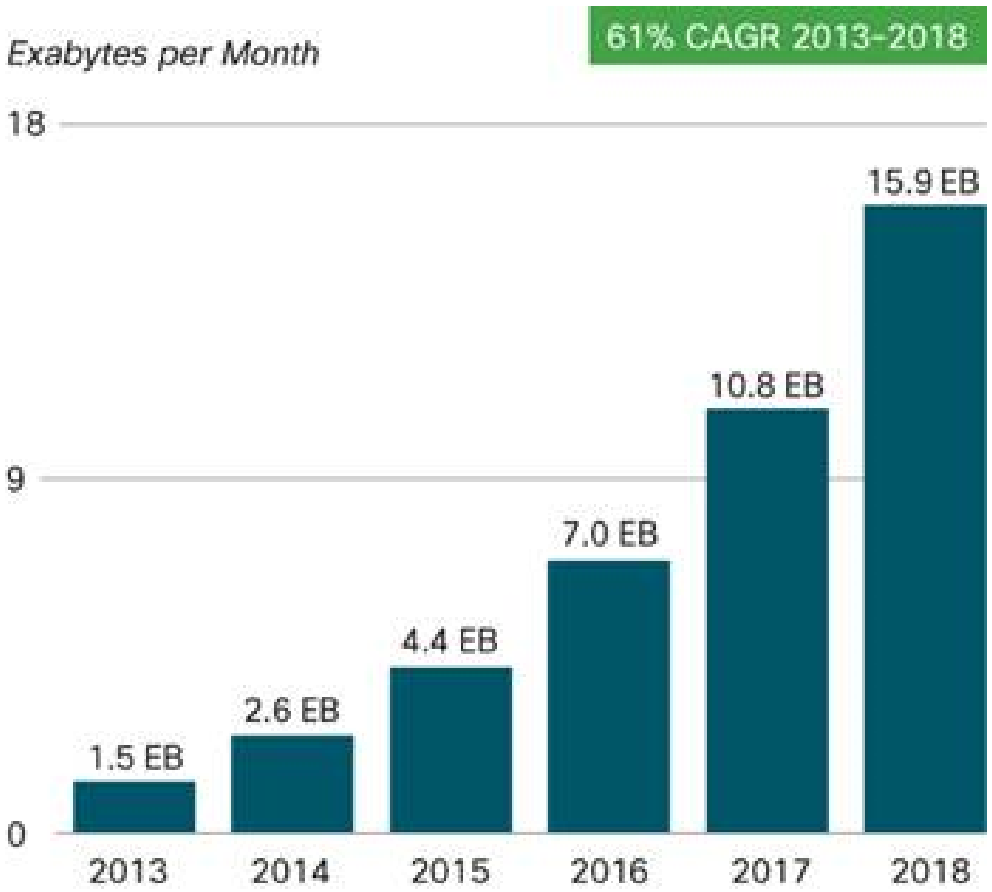


NATO Civil/Military Joint Frequency Agreement (NJFA)

- NJFA harmonises frequency ranges, identifies:
  - Those that are essential/ very important for military use
  - Plus future requirements

Spectrum Challenges (3)

- Relentless growth in demand
- Military cannot assume to have full freedom of action – especially in area (e.g. Europe)

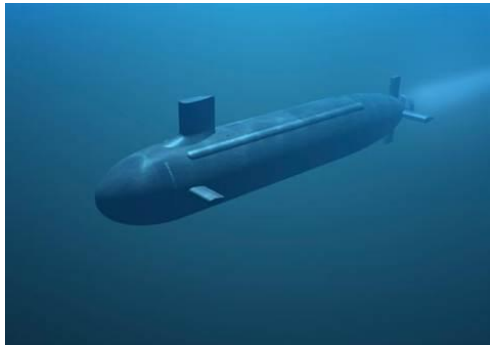


Source: Cisco VNI Mobile, 2014

Spectrum Challenges (4)

- Spectrum pricing and trading perhaps not continuing with previously anticipated success
- More pressure to share: geographically/ temporally
- Sharing challenges:
  - Primary user will want some guarantee that they can use the spectrum when needed
  - Predictability of that need and likely warning time
  - Impact of returning spectrum
- Comprehensive Approach (many actors engaged in an operation) and use of existing telecommunications infrastructure may limit who military can sensibly share with

Military Demand for Spectrum



- ELF to EHF
- Also increasing demand: e.g. ISR, network centric, unmanned systems
- Harmonisation: important for Alliance
  - Same band for same use across nations
  - Support mobility/ transportability
  - Spectrum supportability
  - Even if nations doesn't have a certain military asset may need to accommodate another nation:
    - Particularly for strategy assets such as strategic UAV/UAS

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Wireless Communications and Interoperability

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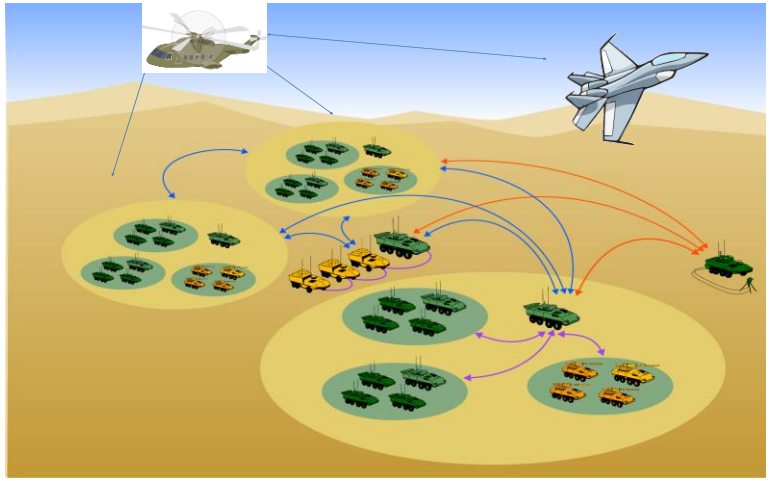
Requirements for Modern Battlefield Communications



- Robust, highly reliable communications among multinational forces
- Wired multinational connectivity suitable for elements that operate at the halt but wireless is required for operating on the move
- Unpredictable EW and physical threats

- Networked communications with dynamic relay
- Modern voice CODECS
- Radio-Based Combat Identification
- No special nodes, no base stations, no preplanned relays
- COMSEC + Electronic Protection Measures
- Efficient use of spectrum.

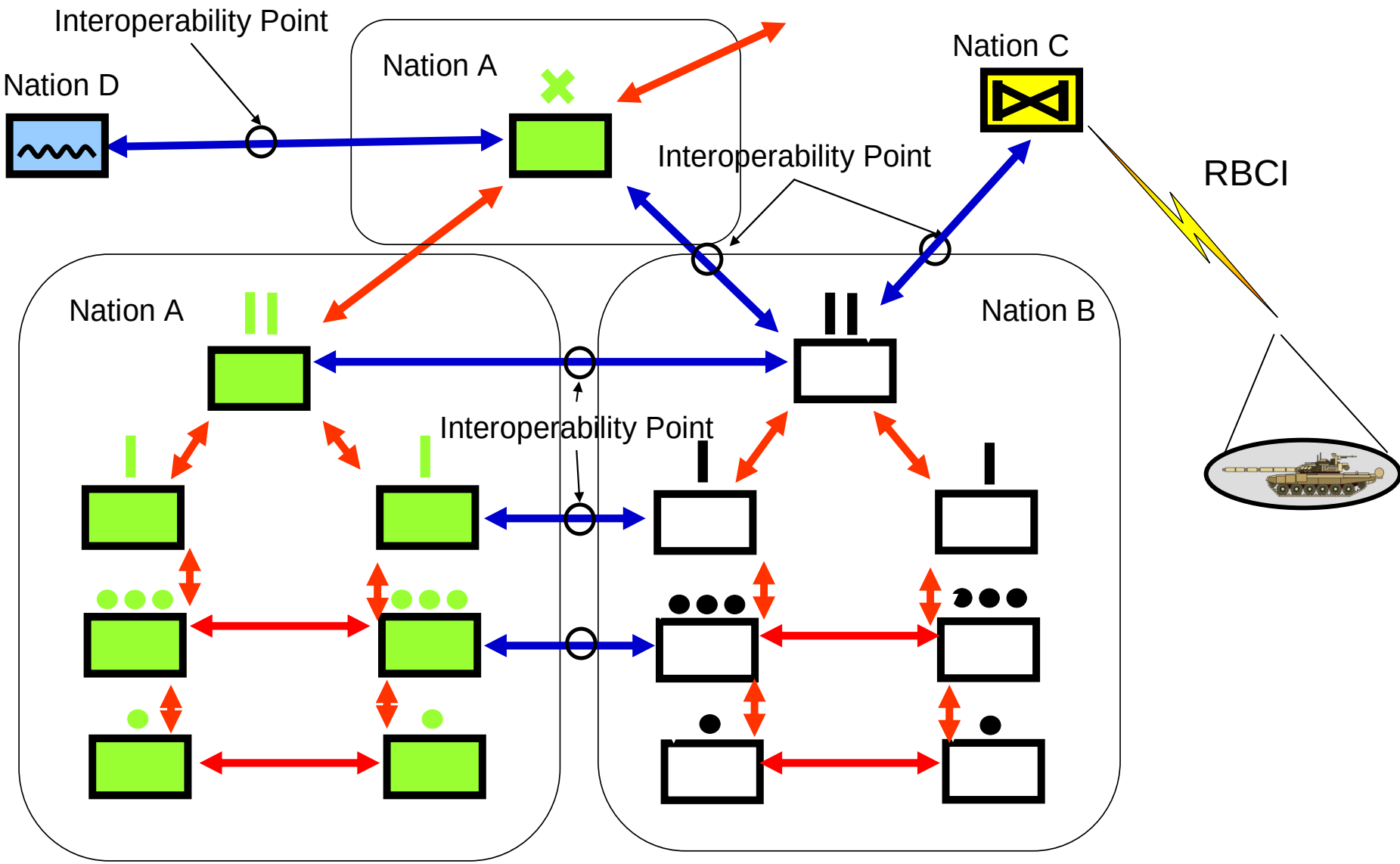
Categories of Radio Systems

- "Soldier" or Personal UHF Systems:
  - Good throughput, modest range (a few miles) due to small antennas mounted on the soldier and low power.
- Wideband UHF Systems:
  - Excellent throughput, modest range; few miles terrestrial- more with elevated antennas, and significantly more with air platforms, large amplifiers.
- Combat-Net Radio VHF Systems:
  - Excellent range (can be up to 40 miles) with high power amplifiers, full mobility, limited throughput- conventionally a "voice+" radio.
- Air-Ground-Air Systems:
  - Highly robust EPM, excellent range (hundreds of miles), modest throughput "voice+" with aeronautical platforms
- These are all complementary systems.

Multinational Challenge

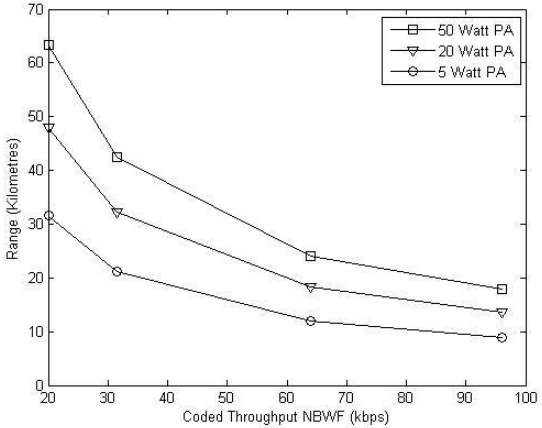
- Modern radio technology means that are millions of ways to be non-interoperable
  - 1940s radio: just needed the right (frequency) crystals
- Waveforms have been unique selling points for military radios
- Each nation wants its own encryption
- Maritime and air have fixed this to a larger extent
- Land tactical environment is the challenge
- Developments that could enhance multinational wireless interoperability:
  - Narrow Band Waveform (NBWF) – NATO development
  - Wide Band Waveform (WBWF) – multinational development may provide solution
  - Enhancements to SATURN – NATO development

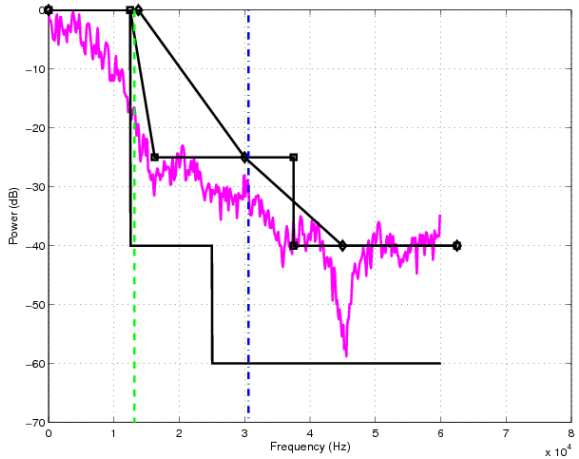
NBWF Requirements

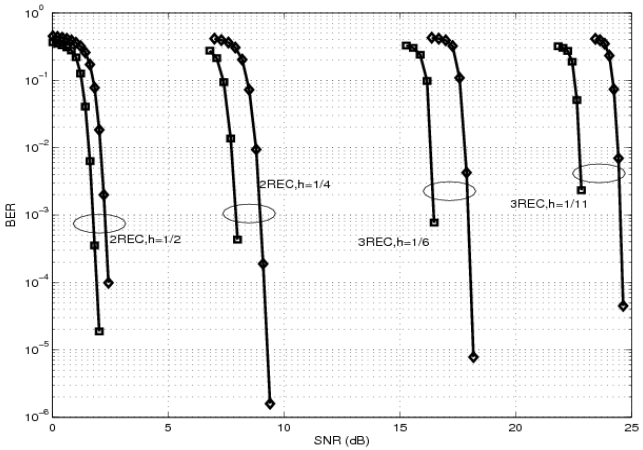


NBWF

- Narrowband- 25KHz for up to ~64kbps
- Continuous Phase Modulation, range of coding rates
- Time division media access, supporting simultaneous voice and data, with relay capability
- Routable network layer
- Layer 1 and layer 3 encryption







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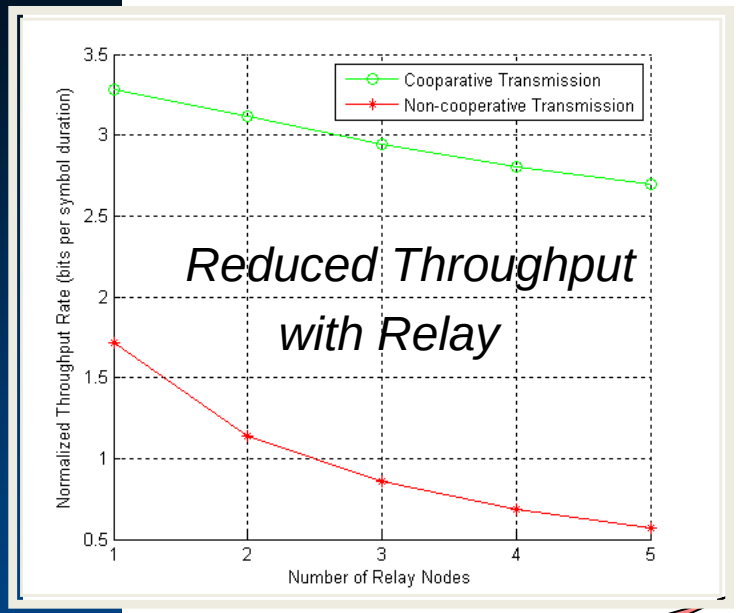
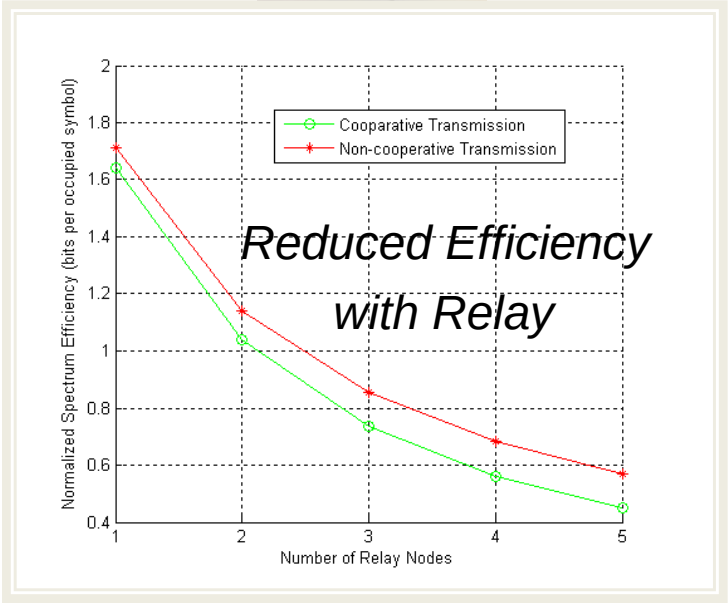
Range and Network Resources

Single hop





Multiple hops use up more network time and throughput resources

Chronology of UHF Jam Resistant Communications

Coronet Clear Study

* *

1973
Arab/Israeli Conflict

SEEK TALK
- DSSS/AA

STOP

Too expensive

EJS
- DSSS/FH

STOP

HQ I
- 400 radios
- Limited frequencies
- SFH

HQ II
- Lots of frequencies
- SFH
- Cosite Solution
- 2.4 kbps D w/ IDM

- 30 year old Waveform
- Known performance gaps
- Limited data capability

HQ IIa / SATURN
- Lots of frequencies
- FFH
- Cosite Solution
- 16 kbps V or 2.4k D

Socialize w/ NATO

NATO fielding SATURN
- FR, GE, UK, IT, …

NATO Path

1970's | 1980's | 1990's | 2000's | 2010's

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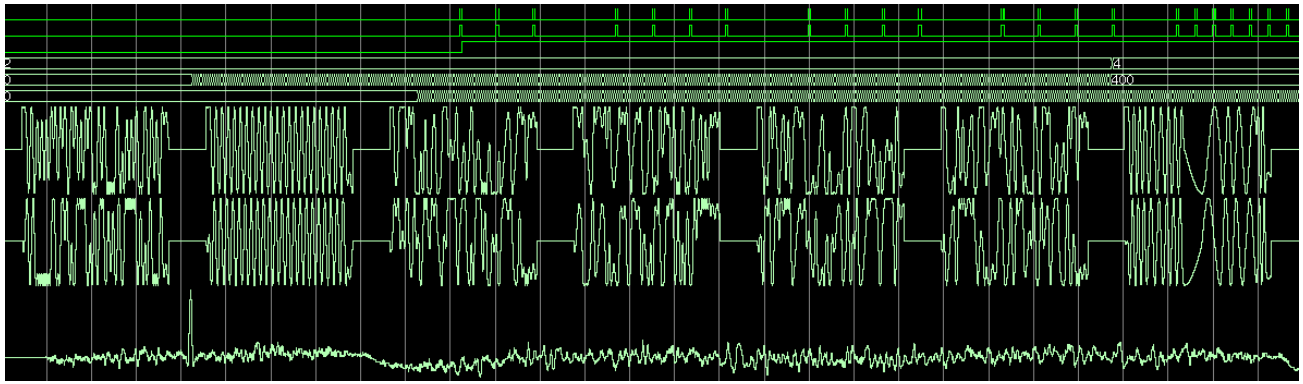
SATURN Enhanced Data Rate (SEDR)

- Enhancements:
  - higher data throughput, simultaneous voice and data
  - no change to existing ‘inner core’ anti-jam functionality
  - more efficient use of assigned spectrum within existing spectrum allocation
  - ‘adaptive’ data rate to optimise performance in the face of interference or jamming
  - extend data transfer capability by use of modern techniques:
    - introduce networking with addressing and dynamic routing capability
    - reduce unnecessary on-aircraft processing of unwanted messages
    - allow SATURN nets to extend beyond ‘line of sight’ (LOS) through relay of data between net members which are in LOS of each other



SEDR - Implementation Approach

- Create additional, orthogonal nets to SATURN
  - Same frequency allocation
  - Identical frequency selection algorithm (TRANSEC)
  - Extend net #'s
- Increase instantaneous bandwidth by using 7 contiguous channels (175 kHz)
  - Allocations offers many opportunities for contiguous frequency groupings (i.e., < 7 channels, or more)
- Signaling constellation size can be made adaptable (i.e., 4-ary, 8-ary & 16-ary) to increase throughput under changing channel conditions

Information Throughput (kbps)

Modulation (_-ary)	FEC Code 7/12	2/3	Rate 3/4	5/6
4	89.6	102.4	115.2	128.0
8	134.4	153.6	172.8	192.0
16	179.2	204.8	230.4	256.0

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Where Next

Software Defined Radio (SDR)

- NATO standardisation process is for multinational interface
- How this is implemented is national choice
- However SDR can offer:
  - Flexibility and evolutionary path
  - Re-use of solutions across different platforms and nations - given standardised architecture and interfaces
- But, there are challenges:
  - Implementation of security mechanisms
  - Radio performance, power consumption
  - Cost?

Cognitive Radio

- Some of the NATO standards are adaptive – for example to HF propagation conditions
- However the growing challenge is access to a crowded spectrum when it is needed:
  - Shared spectrum: warning times, rapid reassignment
  - Who shares with who: correlation between different "lines of business"
    - commercial mobile, broadcast, emergency services, military, science, aviation, rail, utilities, amateur radio…
  - Impact of suppressing (secondary?) users:
    - Comprehensive Approach may mean a wide range of users are key to the military mission
- Today spectrum management requires lawyers, economists, politicians as well as (instead of?) engineers
- How much can we get into a cognitive radio?

Questions