Military Tactical Communications

HARRIS

Experiences and
Lessons Learned with

SCA Based Wideband Networking Waveforms

Mark Turner and Ken Dingman – Harris Corporation

Presentation Overview

- Military Tactical Networking: objectives, architectural vision and key characteristics.
- Software Communications Architecture provides a standardized foundation.
- SCA based wideband networking waveforms: where is the “state-of-the-art”?
- Harris wideband networking waveform experiences.
- Key lessons learned.
- Conclusions.

SCA Networking Waveforms

Military Tactical Networking

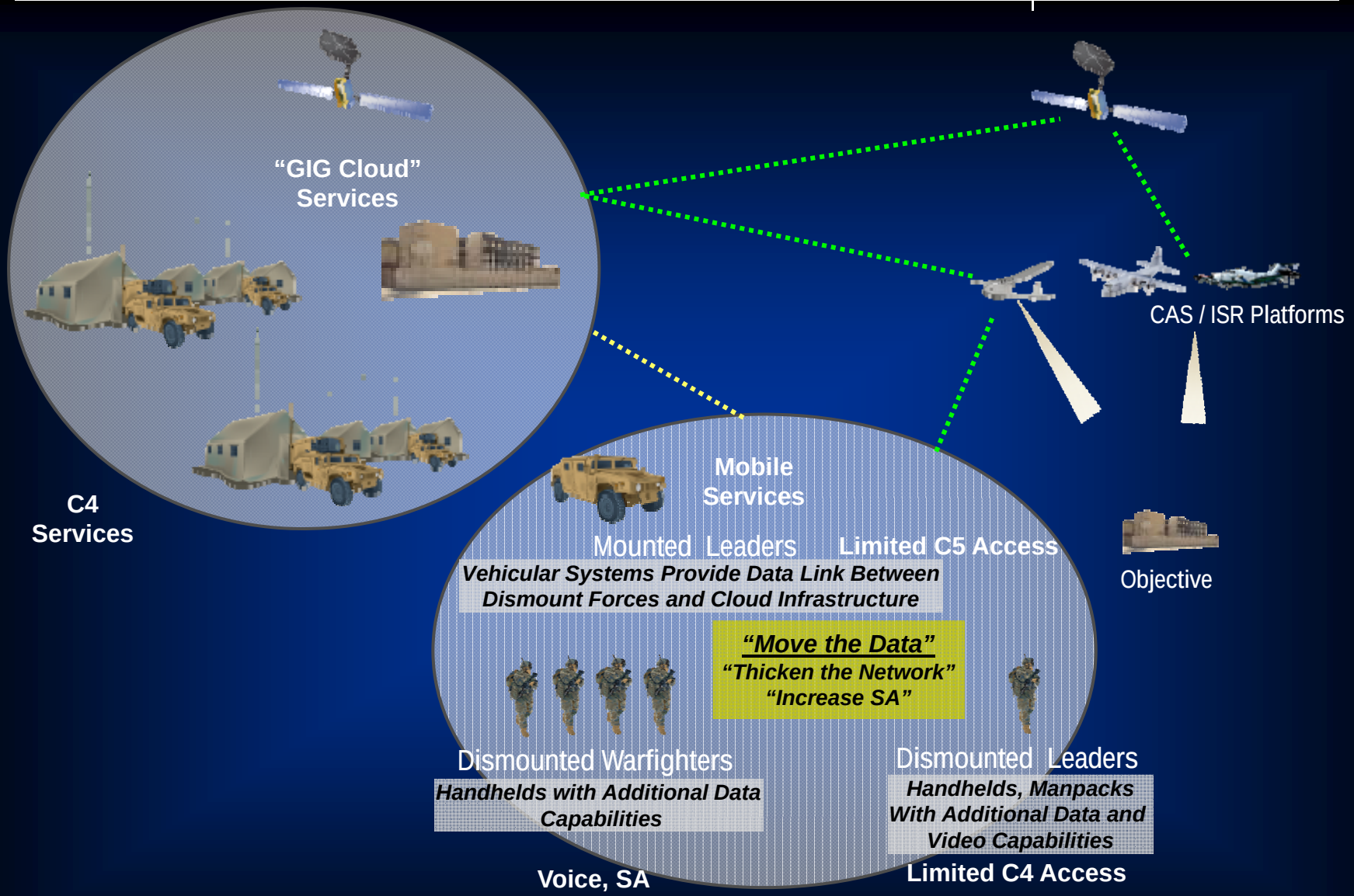
Tactical Networking Key Objectives

- Realization of information superiority on the battlefield through network extension deeper into the military enterprise, to forces operating at the “tactical edge”.
- Provide timely and accurate content delivery (voice, data and video).
  - Facilitate force self-synchronization, dynamic re-planning / redirection and speed of command.
- Facilitate “high reliability” communications in harsh RF environments (mobility, propagation, interference).
- Enabling use of collaboration applications such as ISR, SA and biometrics.

Architectural Vision

- Multiple interconnected network environments, i.e., air, ground, space, Global Information Grid (GiG) supporting variety of services.
  - "Stub networks" focused on end user applications (i.e., ISR, Situation Awareness).
  - "Transit networks" provide interconnection of stub networks within and between disparate network environments, including interconnection to the GiG.
- Internet Protocol (IP) serves as the common language foundation across the overall network architecture (convergence layer).

Example Network Architecture



Key Characteristics

- Mobile Ad Hoc Network (MANET)
  - Scalable, dynamic network operating without a static infrastructure (i.e., cell towers, fiber optic cables).
  - Fast self-forming and self-healing network where nodes dynamically enter and leave.
- Adaptation to varying RF channel conditions (i.e., interference, obstructions, node mobility)
  - Wideband channels with “signals-in-space” optimizations
  - Advanced routing algorithms.
- Security
  - High assurance data security across combination of secure (without intermediate decryption) and non-secure networks.
  - Encrypted traffic transfer at multiple security levels.

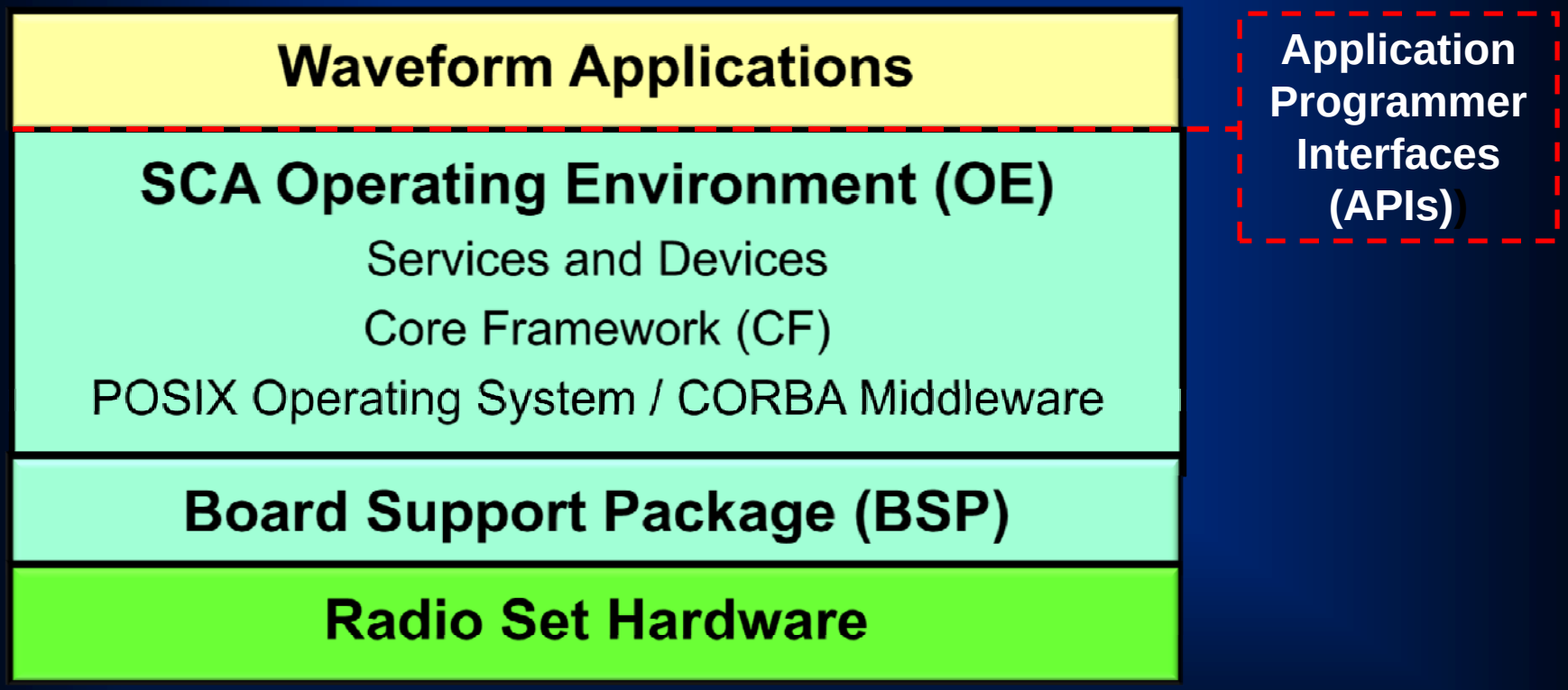
SCA Networking Waveforms

SCA Provides a Standardized Foundation

Software Communications Architecture

HARRIS

- Set of rules and protocols for SDR applications.
- Component Based Design (CBD) technology.
- Independence of Platform and Applications software.



The SCA Today

- **Standardization is the key!**
- Developed as part of U.S. DoD JTRS Program.
  - Specification (v2.2.2) & suite of APIs published by U.S. DoD.
  - Evolution continues (SCA "next" rolled out Dec-2010).
  - Change Management controlled by US DoD today.
- Growing international acceptance
  - EDA "Three Category Approach" for API standardization.
  - ESSOR program adoption of SCA v2.2.2 baseline.
  - Commercial tool suite emergence.
- Wireless Innovation Forum "Coordinating Committee for International SCA Standards"
  - Coordination Model defined for harmonization of standards portfolio.

Three Category API Approach

Category 1 International Open Standard Recognized ISO(s)	Category 2 Multi-National Interests Coalition PMOs	Category 3 Specific National Interest National Authorities
~~Unclassified~~ Unlimited distribution Examples: SCA v2.2.2 APIs (profiles in future)	~~Unclassified~~ Controlled and limited distribution Examples: Coalition Waveforms (COALWNW, HDR) Security APIs	~~Classified~~ Controlled and nationally limited distribution Examples: Crypto Algorithms

SCA Networking Waveforms

Where is the "State of the Art"?

Soldier Radio Waveform (SRW) Characteristics

- Objective: Battery powered stub network applications.
- Operating Modes (SiS):
  - Combat Communications (CC - wideband)
  - Electronic Warfare (EW – wideband AJ)
  - LPI/LPD (Low Probability of Intercept/Detection - spread).
- Each SiS supports a discrete set of bandwidths.
- Frequency Range:
  - 225 MHz to 420 MHz; 1.350 to 2.500 GHZ
- Maximum data rate: 2 Mbps (CC mode)
- MAC: Hybrid CSMA/TDMA

Wideband Networking Waveform (WNW) Characteristics

- Objective: High capacity transit network applications.
- Operating Modes (SiS):
  - Orthogonal Frequency Domain Multiple Access (OFDM-WB)
  - Anti-jam (WB)
  - BEAM (NB)
  - LPI/LPD (Low Probability of Intercept/Detection--spread).
- Each SiS has a variety of bandwidths, data rates.
- Frequency Ranges:
  - 225 to 420 MHz; 1.350 to 1.390 GHZ 1.755 to 1.850 GHz
- Maximum data rate: 5 Mbps
- MAC: USAP / TDMA

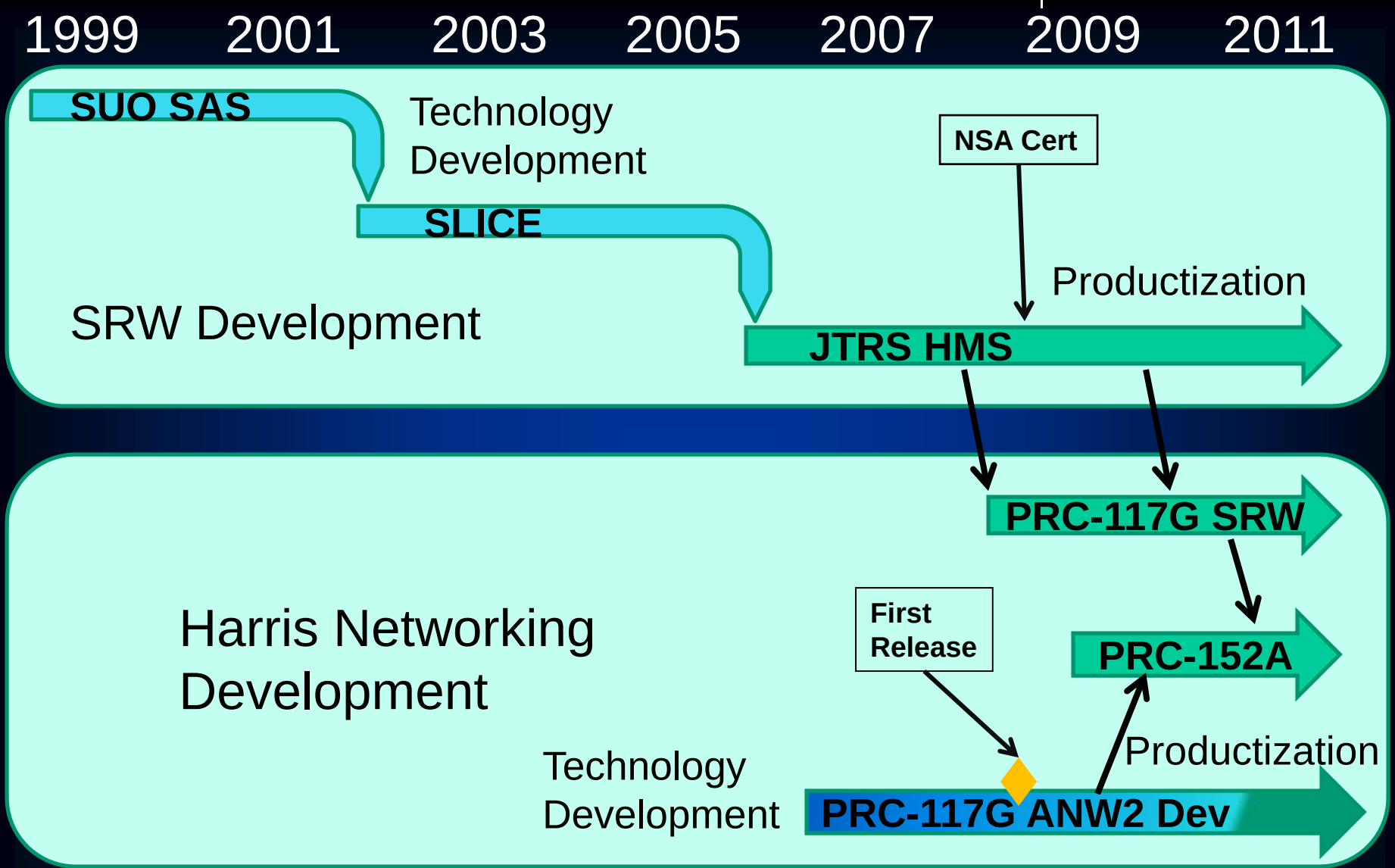
Harris Networking Waveform (ANW2) Characteristics (1 of 2)

- Objective: Scalable to support either stub or transit network configurations.
- Adaptive SiS optimizes channel performance
  - Suite of bandwidths from 500 KHz to 5 MHz.
  - Range of on-air data rates: 22 Kbps to ~ 10 Mbps.
  - Extremely robust vs. fading and multi-path conditions
  - Tolerant to interference with partial RX spectrum loss.
  - Same waveform can be demodulated in different ways to facilitate different platform implementations.
- Network formation
  - Subnet formation and synchronization < 30 secs.
  - Subnet healing time < 5 secs; Joining time < 5 secs.

Harris Networking Waveform (ANW2) Characteristics (2 of 2)

- Self-Synchronizing scheme, no GPS required.
- MANET Protocols (passive, pro-active and reactive) with zone routing to optimize performance.
- Black IP Routing and HAIPE for secure data transport.
- **Dedicated Digital Voice interval for traditional CNR and multi-talker voice capability (true party line).**

Networking Waveform Development

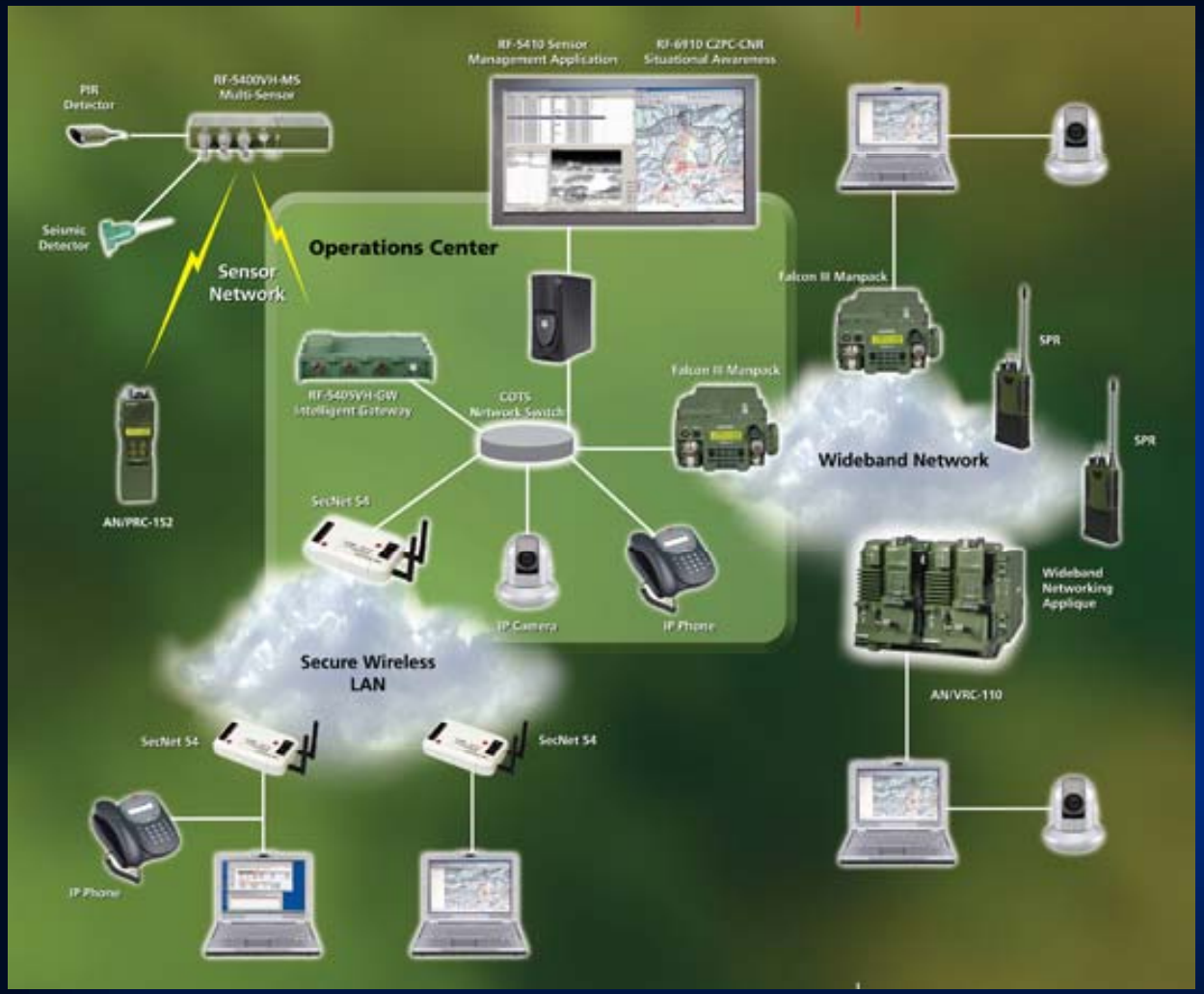


Future SCA Networking Waveforms

- Coalition WB Networking Waveform (COALWNW)
  - Multi-national effort to realize an IP-based WB networking waveform for tactical interoperability among coalition partners.
    - Australia, Finland, France, Germany, Italy, Spain, Sweden, United Kingdom, United States.
  - Phase 1: Consolidated and prioritized operational requirements (ORD approved January 2011).
  - Phase 2: Waveform design and development.
  - Phase 3: Interoperability testing.

- ESSOR High Data Rate Waveform (HDR)
  - Program effort to define and develop IP based WB networking waveform to support European coalition partners.
  - User traffic (voice, video, data); AJ features; LPI/LPD.

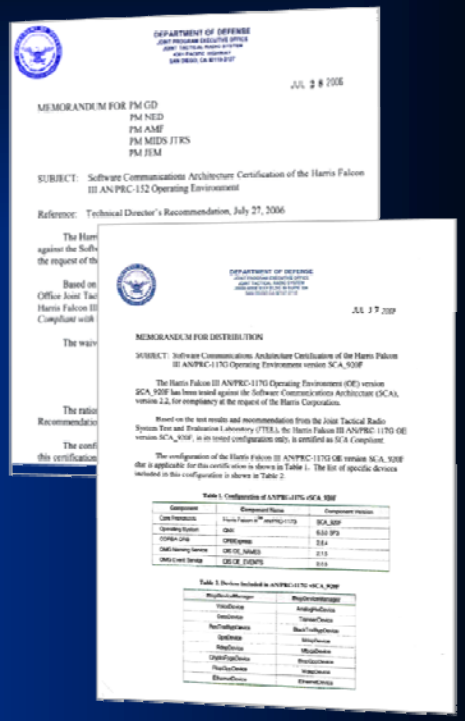
SCA Networking Waveforms



Harris Experience

Harris SCA Pedigree

- 1st radio provider with JTEL SCA certification.
- 1st radio provider to put completed SCA waveform into JTRS Information Repository.
- 1st & only radio provider with JTEL SCA certified radios without waivers – AN/PRC-152 HH and AN/PRC-117G MP radios
- 1st & only JTRS fielded SCA waveforms.
- 1st & only fielded SCA 30-2000 MHz radio with NSA certified wideband networking.
- Official "JTRS Approved" status from JPEO.
- Ported and demonstrated SRW and WNW waveforms from JTRS IR.



Delivered > 150,000 SCA compliant radios

Harris Falcon III Networking Radios

	AN/PRC-117G 	AN/PRC-152A 	RF-7800M 
Size	7.4W x 3.7 H x 8.8 D in	2.0 W x 9.6 H x 2.5 D in (w/batt)	7.4W x 3.4 H x 8.8 D in
Weight	8 lbs	2.6 lbs w/ batt	8 lbs
Crypto Algs	KY-57, KYV-5, KG-84, HAIPE™, AES	KY-57, KYV-5, KG-84, HAIPE™, AES	AES, Citadel I and II
Power Output	NB: 10W; WB: 20W peak/5 W ave; SAT: 20W	NB: 5W; WB:5W peak/2.5W ave SAT: 10W Burst Mode	NB: 10W; WB: 20W peak/5 W ave;
SW Environment	SCA 2.2	SCA 2.2	SCA 2.2
NB Waveforms	VHF/UHF LOS, SINCGARS, HQ I and II, DAMA, IW, HPW	VHF/UHF LOS, SINCGARS, HQ I and II, HPW	VHF/UHF LOS, QuickLook I and II
WB Waveforms	ANW2, Rover (opt)	ANW2	ANW2, Rover (opt)
WB Channel Spacing	500kHz, 1.2MHz, 2.5MHz, 5MHz	500kHz, 1.2MHz, 2.5MHz, 5MHz	500kHz, 1.2MHz, 2.5MHz, 5MHz

ANW2 Development Experience

- Incremental development approach
  - Initial focus on key CONOPS; frequent user feedback.
  - Started with basic functionality (i.e. node counts, ranges, net formation, modem performance).
  - Significant investment to develop extensible network simulation capabilities.
  - Evolved domain knowledge along with waveform maturity.
- Key waveform design concepts
  - "Right size" waveform design (scale up vs. scale down).
    - Same waveform demodulated in different ways to facilitate scaling across platforms with varying capabilities.
    - Exportable security services; Disadvantaged platforms
  - Architectural choices to multiple wideband networking waveforms on a single platform.
  - Ensure voice communications even in the presence of overwhelming data traffic

ANW2 Networking Experience

- ANW2 initially released on AN/PRC-117G MP Radio.
- Deployed in field down to company and platoon levels supporting multiple missions & applications.
  - Missions: En route strategic air communications and communications on-the-move.
  - Applications: Chat, e-mail, data (sharepoint portal access) and full motion video over the SIPRNet.
  - "…first time in the history of Airborne Operations where commanders, while in flight, were able to receive and share SIPRNet data prior to exiting the aircraft". [82nd Airborne]

Harris SRW Porting Experience

- Ported version 1.01.1c to AN/PRC-117G MP radio
  - Multiple drops taken from JTRS IR as waveform matured.
  - Significant analysis and prototyping.
- Key Software Modifications
  - PHY implementation used as reference design only.
  - Used radio supplied platform networking functions
    - Leveraged ANW2 DSP & FPGA components (i.e., sequencer).
    - Utilized OE MHAL
  - GPP largely reusable. Worked stubs and code that wouldn't build, throughput optimizations, update exception handling.
  - Secure traffic data handling
    - Maintain consistency with existing networking data flows.
    - API updates to optimize data copies, secure memory handling.

Harris SRW Networking Experience

- Applications: voice, data, low rate video.
- Validated implementation/models (or gold standard radios) not available to verify interoperability in-house
  - Required early and frequent joint interoperability testing with other SRW developers
- Challenge to gain understanding of “anticipated” SRW profiles/use case models.
  - SRW working group facilitated knowledge exchange, significant focus on configuration parameters.

SCA Networking Waveforms

Key Lessons Learned

SRW Key Lessons Learned

- Quality, completeness of reference implementations and design artifacts directly impacts porting efficiency.
- Waveform application modifications driven by:
  - Functional allocation to HW and SW processing frameworks.
  - SW threading model and real-time analysis.
  - Memory footprints and security architecture.
- Philosophical differences in exception handling.
  - Exceptions used to handle status conditions and lack of pre-condition testing, conflicting with standard C++ classes.
- Configurability
  - Can provide value, but can also impact interoperability.
- Configuration management strategy/plan essential
  - Isolate changes; Move large components en-masse.
  - Wrap ported functionality to minimize interface changes.

ANW2 Key Lessons Learned

- MANET waveforms offer almost limitless use cases.
  - Bound use cases through categorization and profiles where possible, especially for disadvantaged platforms.
  - Test and verification of wideband networking waveforms requires significant scale, including applications validation.
- Wideband networking waveforms DSP and FPGA implementations heavily dependent on RF hardware.
  - Standardization of transceiver interface is opportunity minimize porting effort and ensure consistent performance.
- "Right size" waveform definition and design facilitates application across multiple platform domains.
  - Identify least capable platform and define functionality for it.
  - "Scale up" capabilities to less disadvantaged platforms.

Conclusions

- Military tactical communications being shaped through wideband networking waveform technology.
  - Voice, data and video connectivity down to “tactical edge”.
  - Facilitates speed of command, force self-synchronization, dynamic re-planning & redirection, collaboration applications.
- **AN/PRC-117G (C) only fielded SCA 30 – 2000 MHz radio with NSA certified wideband networking.**
  - ANW2 Waveform deployed today; SRW testing & demos.
  - Significant scale required to test and verify wideband networking waveforms, including associated applications.
  - Porting complex networking waveform from JTRS IR successful (requires coherent architectural, testing, CM strategies).

Contact Information

Mark R. Turner
Harris Corporation

Director of Software and Information Assurance Engineering

mark.turner@harris.com

Ken Dingman
Harris Corporation

Sr. Engineering Manager Waveform Applications

ken.dingman@harris.com