Developing SCA Based Wideband Networking Waveforms

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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

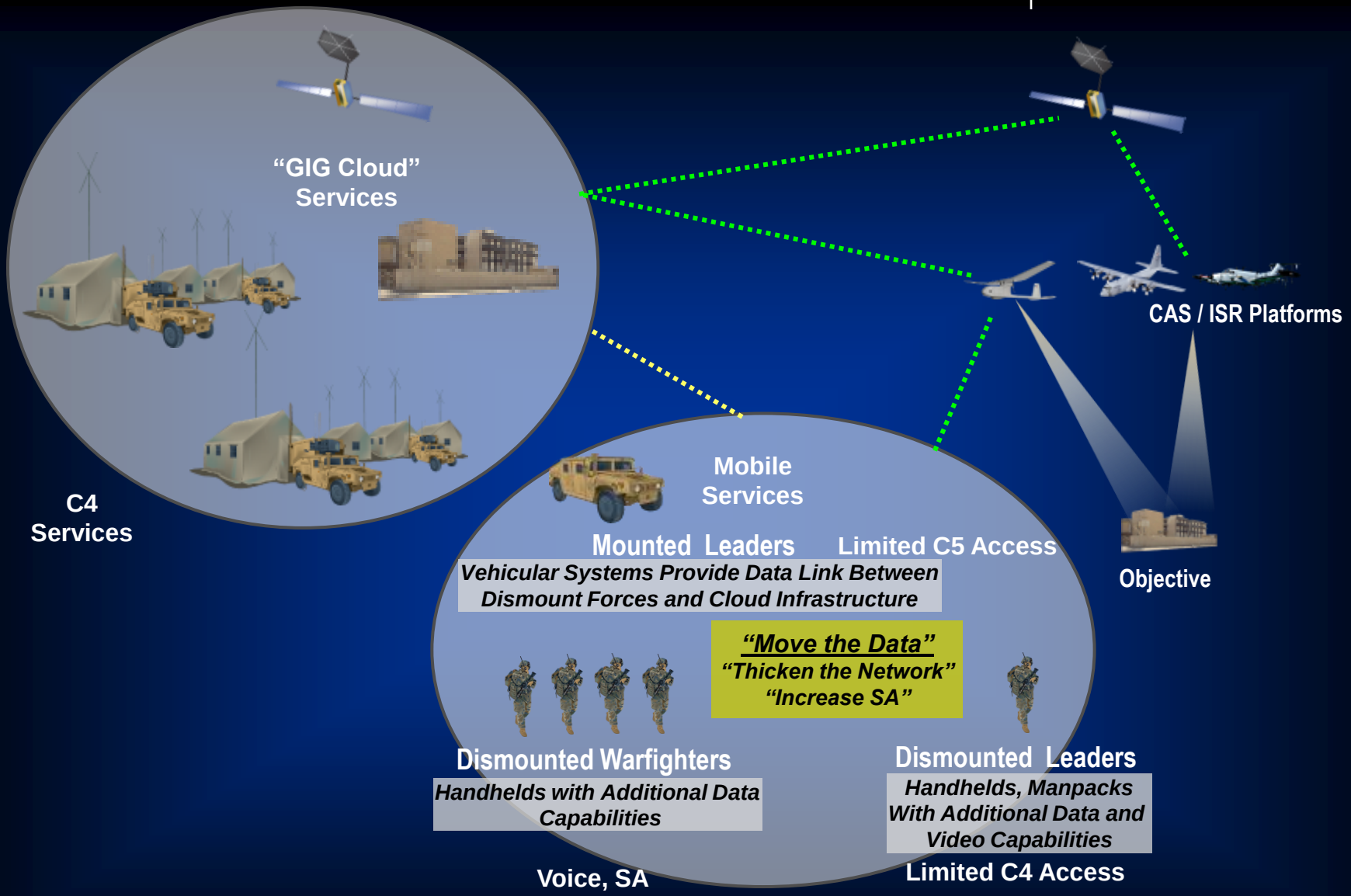
Tactical Networking Key Objectives

- 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



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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.

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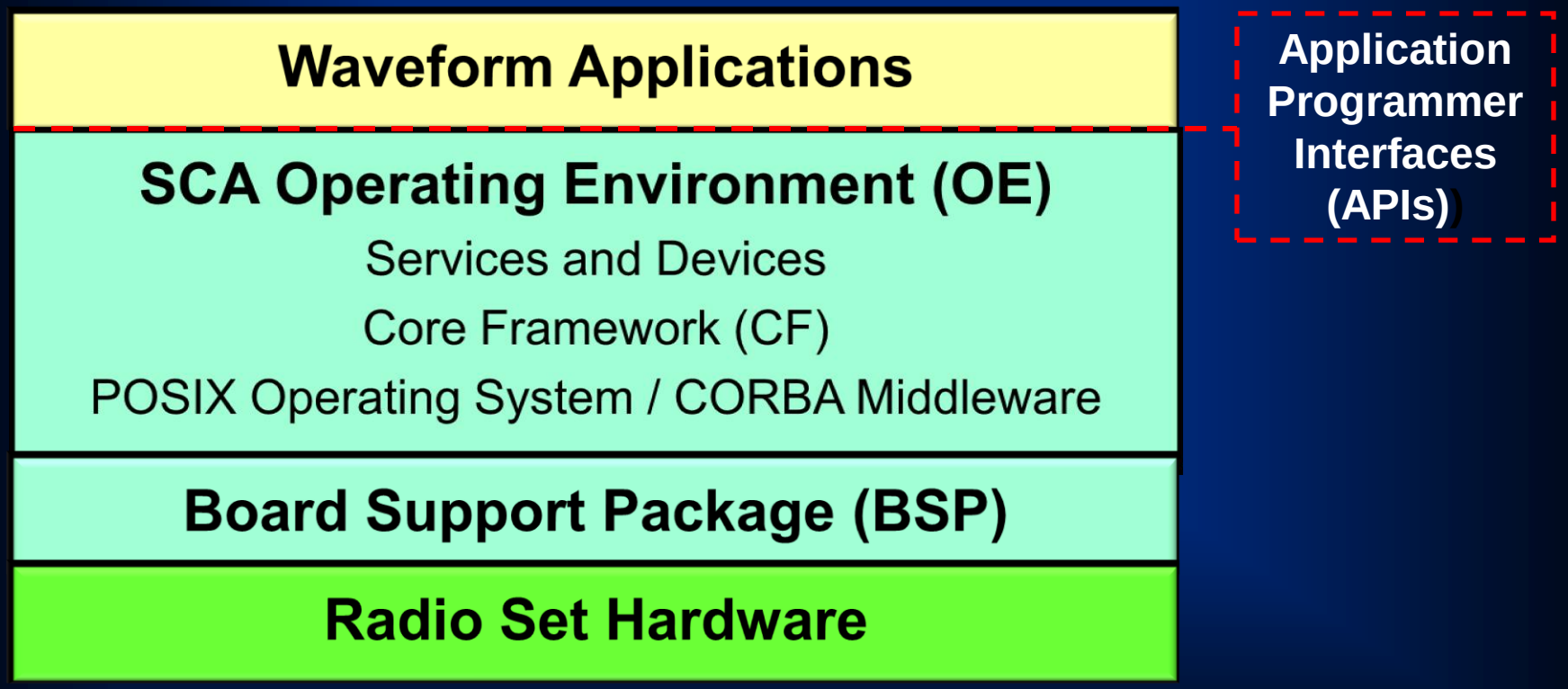
SCA Provides a Standardized Foundation

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

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- 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

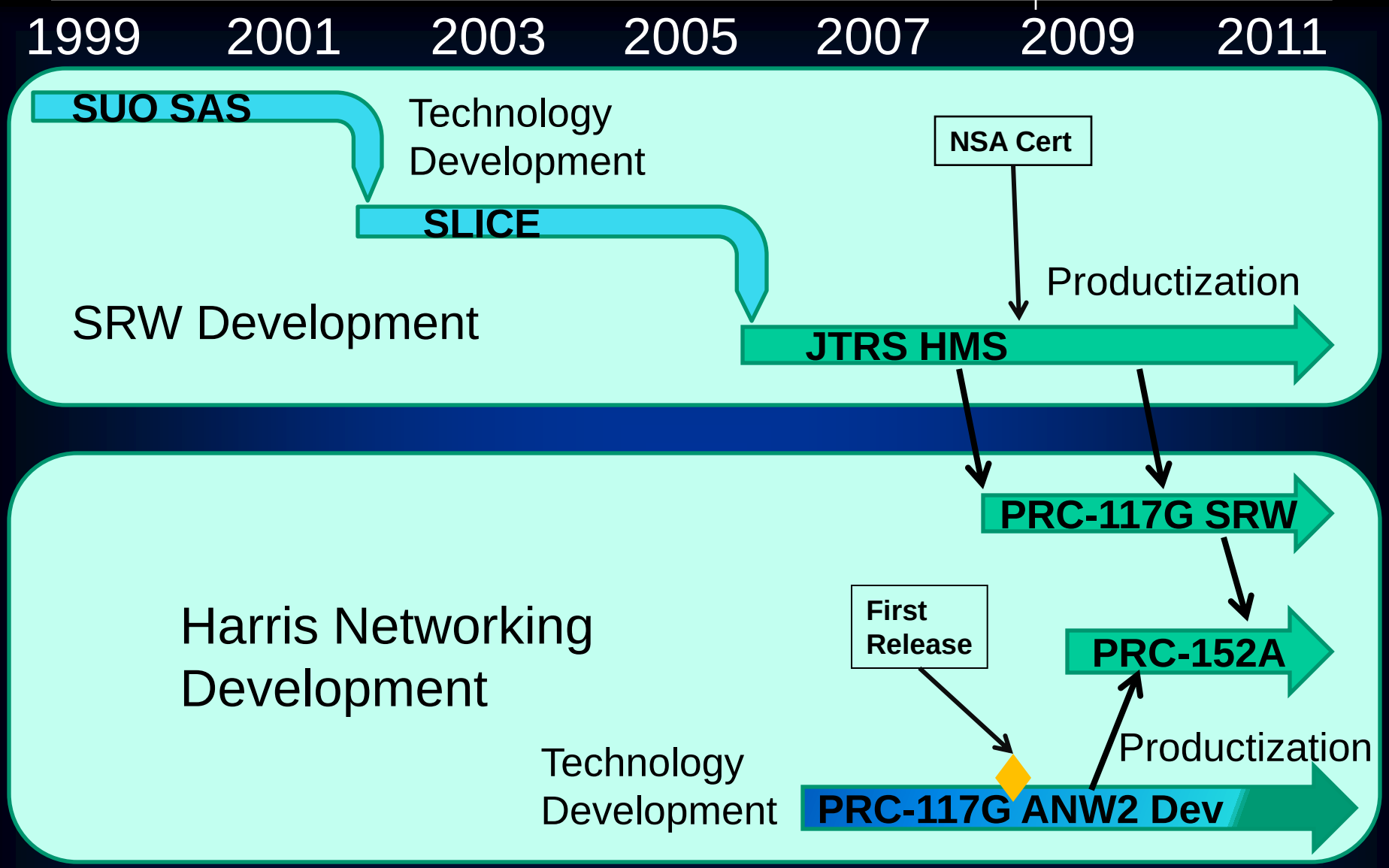
Harris Networking Waveform (ANW2) Characteristics (1 of 2)

- 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

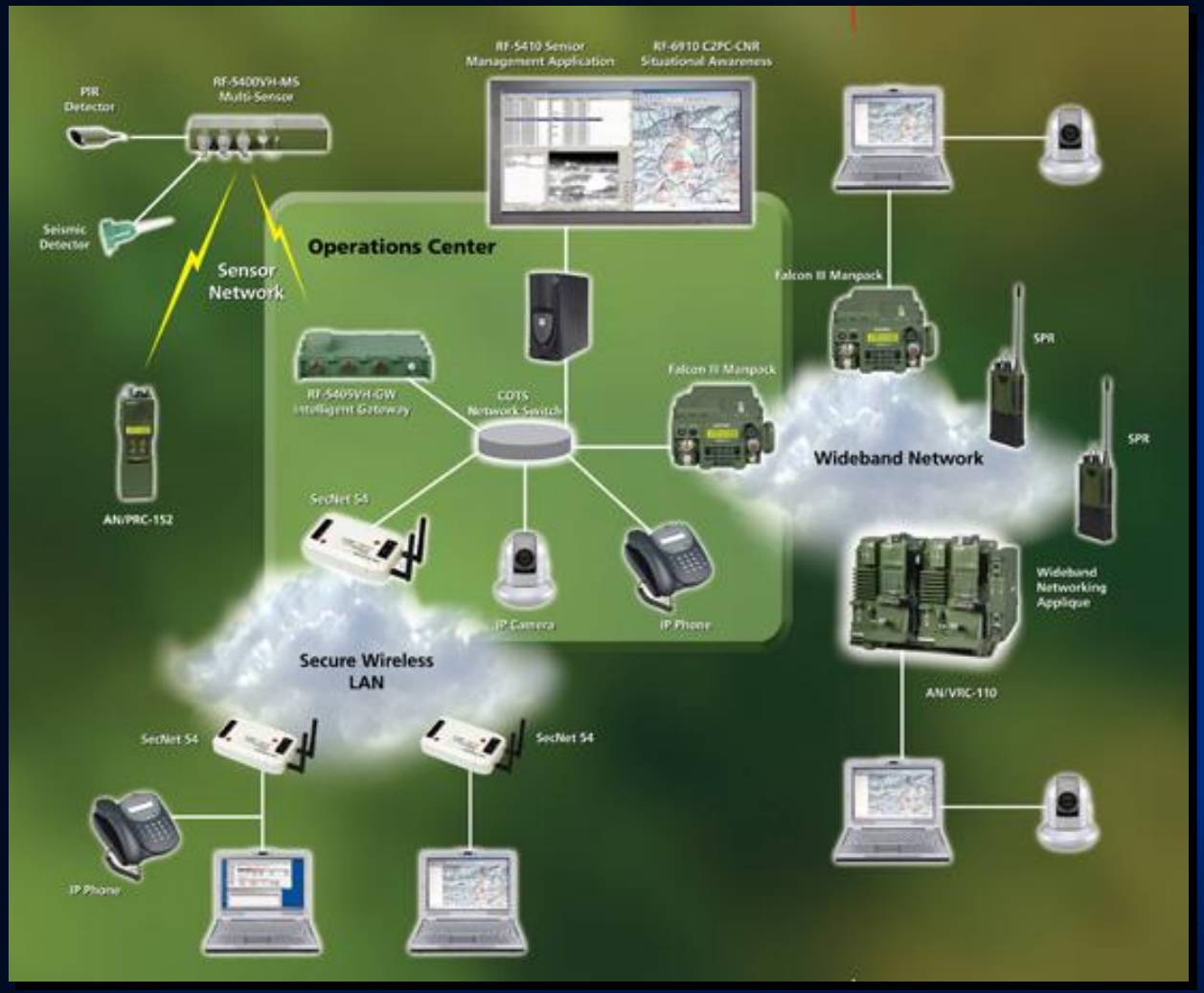


Future SCA Networking Waveforms

- 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.

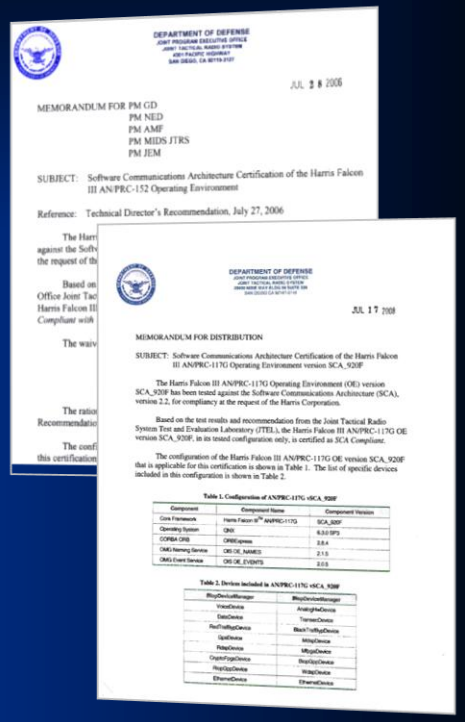
SCA Networking Waveforms



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.
- Completed SRW NSA Type1 Certification
- Ported and demonstrated WNW WF from JTRS IR.


DEPARTMENT OF DEFENSE

JUL 28 2006

MEMORANDUM FOR PM GD
PM NED
PM AMF
PM MIDS JTRS
PM JEM

SUBJECT: Software Communications Architecture Certification of the Harris Falcon III AN/PRC-152 Operating Environment

Reference: Technical Director's Recommendation, July 27, 2006

DEPARTMENT OF DEFENSE

JUL 17 2008

MEMORANDUM FOR DISTRIBUTION

SUBJECT: Software Communications Architecture Certification of the Harris Falcon III AN/PRC-117G Operating Environment version SCA_920F

The Harris Falcon III AN/PRC-117G Operating Environment (OE) version SCA_920F has been tested against the Software Communications Architecture (SCA), version 2.2, for compliancy at the request of the Harris Corporation.

Based on the test results and recommendation from the Joint Tactical Radio System Test and Evaluation Laboratory (JTEL), the Harris Falcon III AN/PRC-117G OE version SCA_920F, in its tested configuration only, is certified as *SCA Compliant*.

The configuration of the Harris Falcon III AN/PRC-117G OE version SCA_920F that is applicable for this certification is shown in Table 1. The list of specific devices included in this configuration is shown in Table 2.

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).

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