

Developing SCA Based Wideband Networking Waveforms



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THIS INFORMATION WAS APPROVED FOR PUBLISHING PER THE ITAR AS 'BASIC MARKETING INFORMATION OF DEFENSE ARTICLES' OR AS 'ADVERTISING PRINTED MATTER' PER THE EAR

- 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.



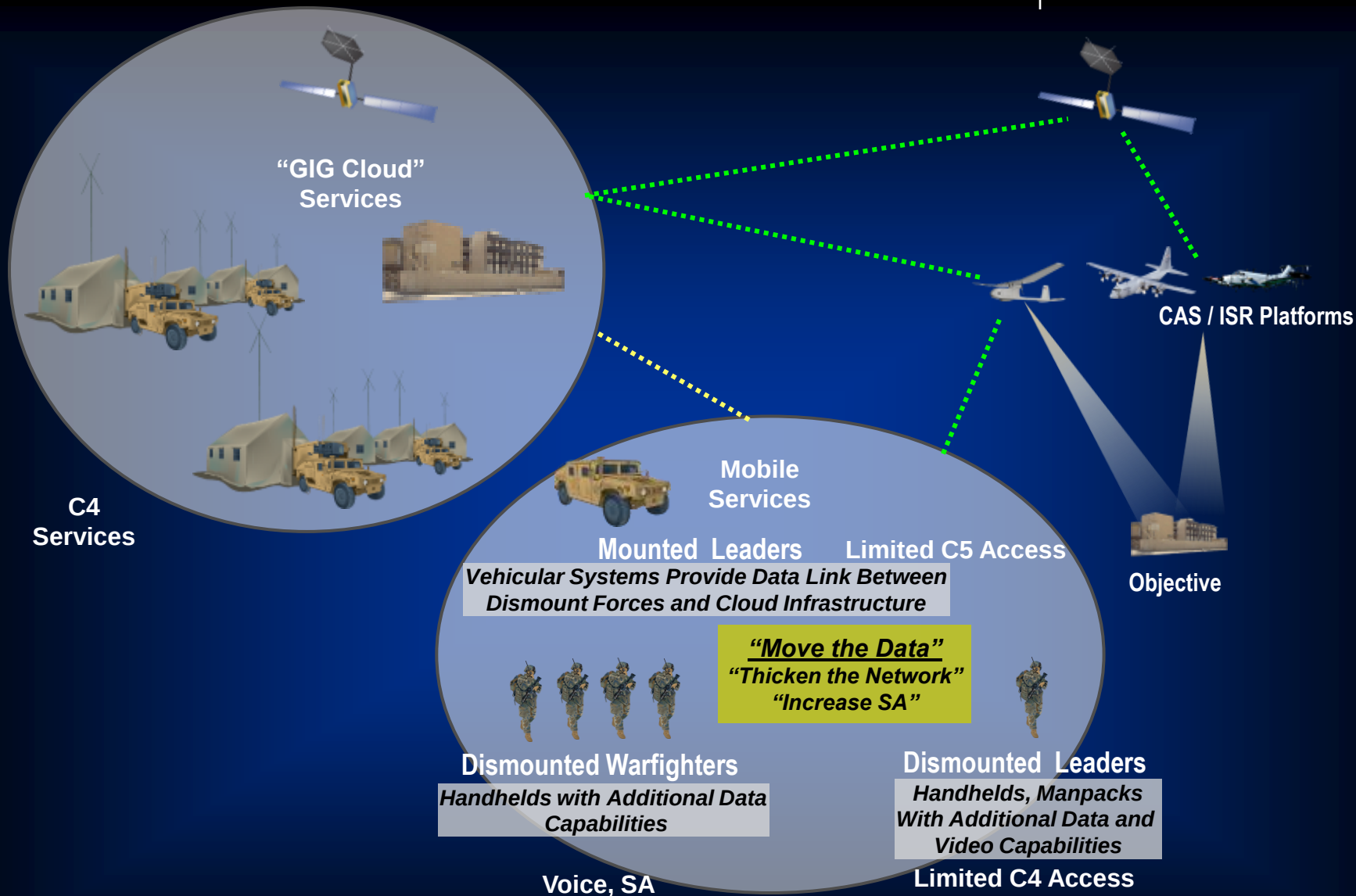


Military Tactical Networking

- 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.

- 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

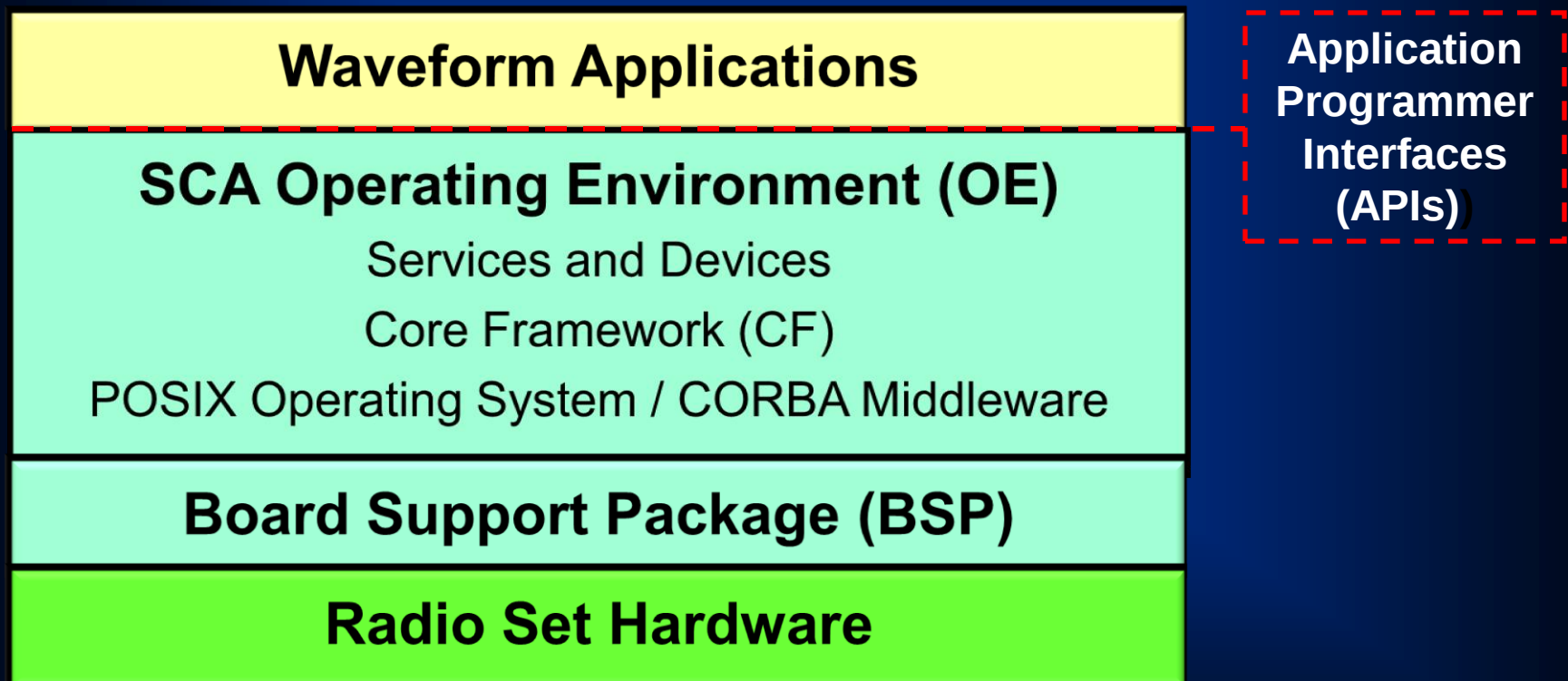


- Mobile Ad Hoc Network (MANET)
 - Scalable, dynamic network operating without a static infrastructure (i.e., cell towers, fiber optic cables).
 - Fast self-forming and self-healing network where nodes dynamically enter and leave.
- Adaptation to varying RF channel conditions (i.e., interference, obstructions, 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 Provides a Standardized Foundation

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



- **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)

Unclassified

Unlimited distribution

Examples:

SCA v2.2.2

APIs

(profiles in future)

Category 2
Multi-National
Interests

Coalition PMOs

Unclassified

Controlled and limited
distribution

Examples:

Coalition Waveforms
(COALWNW, HDR)

Security APIs

Category 3
Specific National
Interest

National Authorities

Classified

Controlled and
nationally limited
distribution

Examples:

Crypto Algorithms



**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)



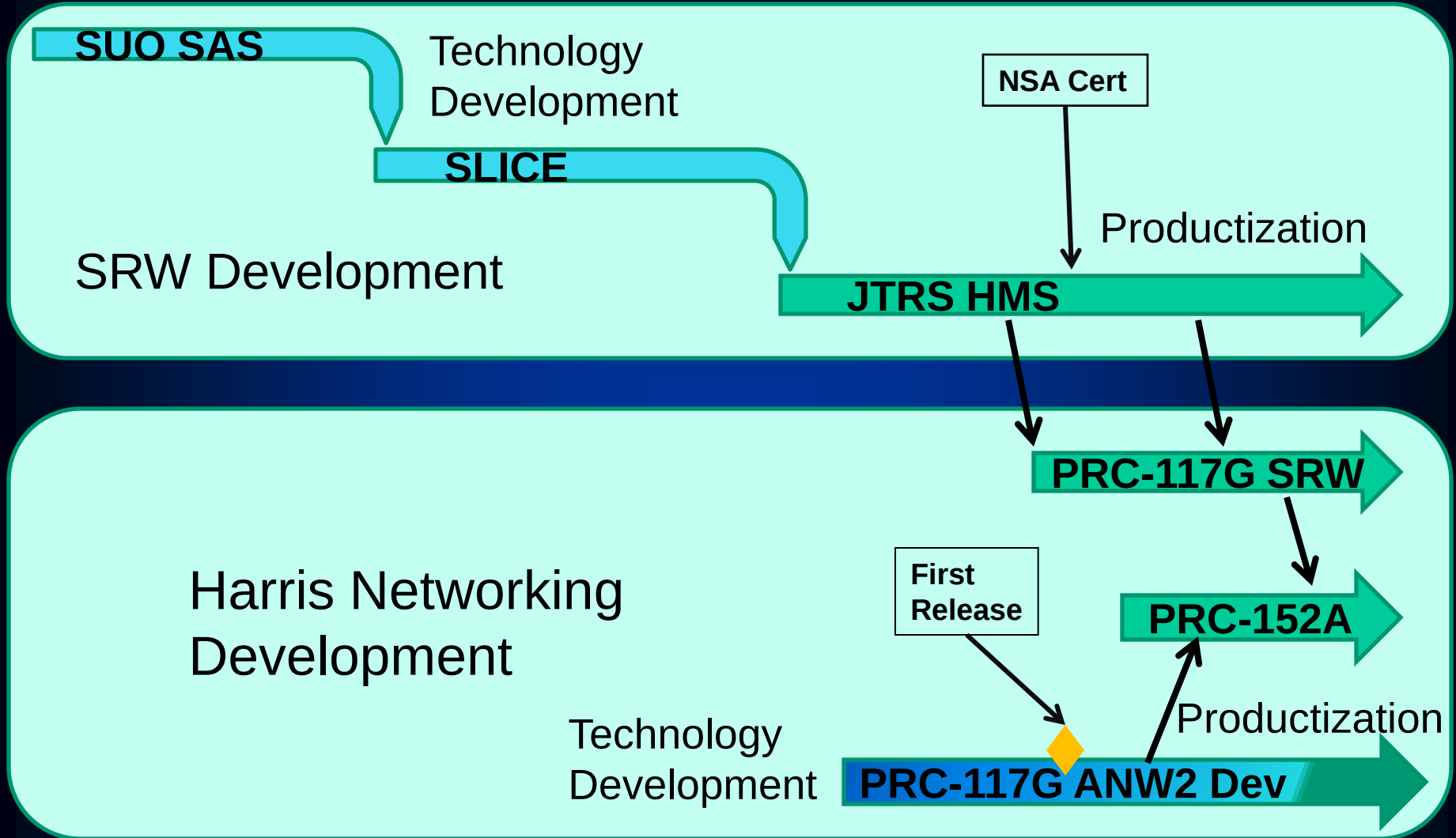
- Self-Synchronizing scheme, no GPS required.
- MANET Protocols (passive, pro-active and reactive) with zone routing to optimize performance.
- Black IP Routing and HAIPE for secure data transport.
- **Dedicated Digital Voice interval for traditional CNR and multi-talker voice capability (true party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



Networking Waveform Development



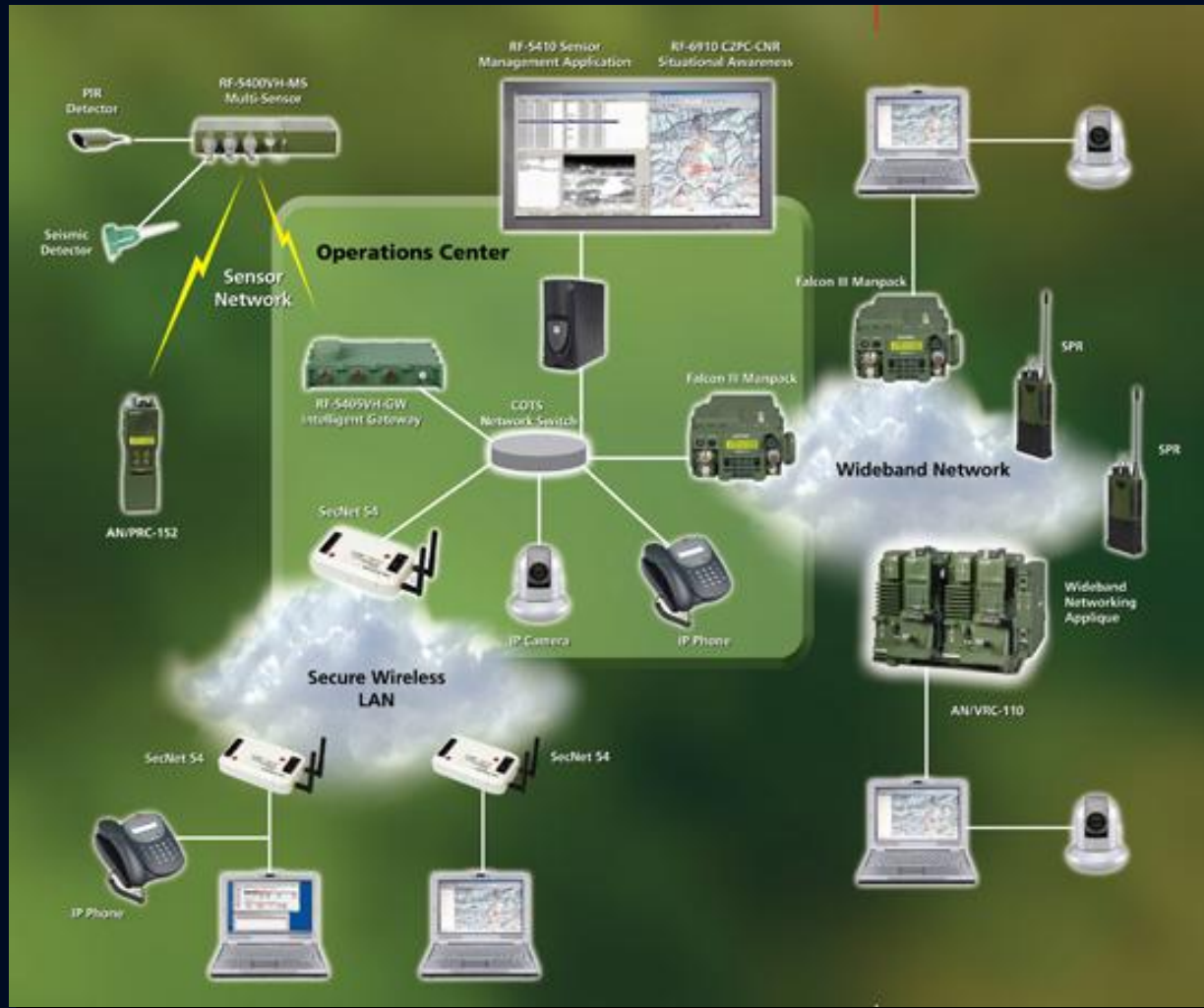
1999 2001 2003 2005 2007 2009 2011



- 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



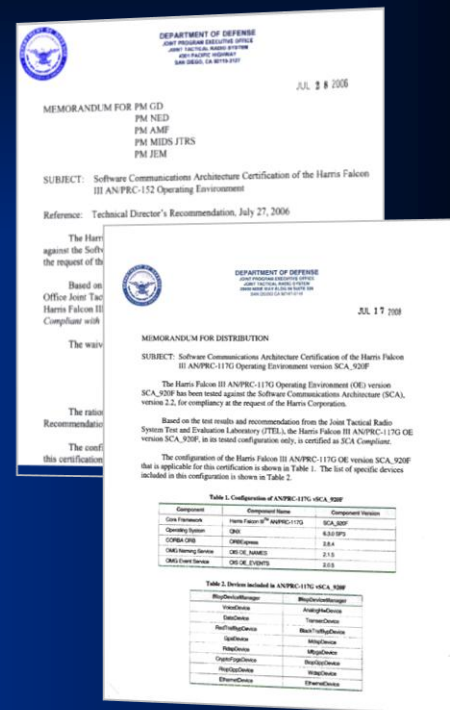
**Harris
Experience**

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.

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

- 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 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]



- 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.

- 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.



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.

- 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.

- 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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