SOFTWARE DEFINED RADIO SOLUTIONS
Experience making JTRS work, from the SCA, to Waveforms, to Secure Radios

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ABSTRACT

The Joint Tactical Radio System (JTRS) Program is a key U.S. DoD transformational program with the purpose of supporting the U.S. DoD objective for information superiority on the battlefield. The JTRS Program is a driving force behind the advancement of U.S. Military Software Defined Radio (SDR) solutions and associated technology to meet today's and tomorrow's war-fighters' needs. Military SDR solutions are evolving towards JTRS compliance including the maturation of the JTRS Software Communications Architecture (SCA) with defined Application Programmer's Interfaces (APIs), the development and delivery of JTRS compliant waveform applications and the incorporation of key technologies, such as programmable security.

This paper discusses practical experience with the development, integration and JTeL certification of an SCA Operating Environment on a military Hand-held radio developed by Harris through private investment. This paper also describes the development, integration and porting of JTRS waveform applications across multiple JTRS hardware platforms and Operating Environments, and the development, integration, Security Verification and porting of JTRS Cryptographic Equipment Applications (CEAs) to multiple JTRS platforms. Summary results are supported by relevant metrics. This paper further provides a brief discussion of high assurance security solutions for military SDRs using the Harris Sierra™ II.

1. INTRODUCTION

"A unique combination of JTRS experience"

Harris Corporation is a highly active participant in multiple aspects of the overall JTRS Program, with experience across several U.S. Government contracts. The Harris JTRS Step 2B Program completed validation of the Software Communications Architecture (SCA) for battery-powered, Man-pack radio platforms in 2004 using Harris Sierra™ II security technology in accordance with the SCA Security Supplement. Harris Corporation is an integral member of the JTRS Cluster 1 Boeing Team, supporting development of the security architecture for the overall radio system, developing several key hardware Line Replaceable Units (LRUs) for the Cluster 1 JTR Set, developing the Cryptographic Subsystem (CSS) that uses Harris Sierra™ II security technology and also developing waveforms for the JTRS waveform repository. Harris Corporation is a major player on the Boeing AMF Team as the developer of elements of the Joint Tactical Radio (JTR) and RF distribution system for Maritime platforms. The JTRS CEA Program involves the development of software applications, which implement required modes of various cryptographic equipments. The Harris developed CEAs are targeted for Sierra™ II based cryptographic systems (i.e., the JTRS Cluster 1 radio set). As a participant of the SCA TAG, Harris is supporting the JTRS SCA through technical analysis and evaluation.

2. JTRS PROGRAM

"KEY tenants and challenges"

The objective of the Joint Tactical Radio System Program is to define and acquire a family of multi-mode, multi-band, programmable SDRs to increase operational flexibility, enhance Joint and Coalition interoperability, and reduce life cycle cost. These radio systems will provide network-centric capabilities and enable mission flexibility for the DoD Joint Vision 2020. As stated in the JTRS Operational Requirements Document (ORD), JTRS is required to provide interoperability across all geographical and organizational boundaries – horizontal and vertical, so as to create an interoperable information transfer capability for Joint and Coalition operations. JTRS will be capable of transmitting voice, data, and video while operating in frequency bands from 2 MHz up to 55 GHz, satisfying ground tactical, maritime, airborne and space based communications requirements.

To facilitate the building of the JTRS family of radios, the U.S. DoD tasked industry to develop and validate the SCA. The SCA consists of a set of rules and protocols, which define a Common Open Standards Architecture for SDR applications with the intent of making maximum use of commercial standards and APIs. This architecture supports implementation of SDR waveform applications and JTRS Set hardware that can be re-used or "ported" across multiple operational environments. Portability is an underlying tenet of JTRS and its development based on the SCA. Portability is intended to reduce the cost associated with development of JTRS (since each waveform is built only once), and to increase interoperability among JTRS radio sets built by different vendors. The SCA is also intended to facilitate

technology insertion into JTRS radio sets over the platform life cycle and leverage advances in commercial radio markets (i.e., cognitive radio technology). There are several challenges which need to be overcome for the SCA to meet this broad objective and acceptance beyond the military radio domain, including scalability, in particular for small battery powered platforms.

3. COMMERCIAL APPROACH TO JTRS

"Private investment leads to JTRS success"

The JTRS program is being implemented using an evolutionary acquisition approach, providing for multiple procurements with increasing capability and functionality during the life of the program. Through increasing degrees of interoperability, military communications will evolve from the current state of single-function legacy systems, to full integration of tactical radio communications across joint and coalition operations. Evolutionary acquisition is intended to allow the JTRS Program to keep pace with developing commercial technology and to maintain required interoperability with networks based on U.S. DoD Joint Tactical Architecture (JTA) and commercial standards. U.S. DoD Service acquisition requirements for JTRS have initially been grouped into common "clusters" or domain oriented product lines based on similarity of requirements and fielding schedules. The open architecture nature of the SCA facilitates the development of JTRS radios through commercial innovation and investment. Stimulation of commercial investment for the development of JTRS radios can save the Government System Design & Development (SD&D) costs, facilitates price competitiveness and continual technological advancement.

3.1. Harris funded JTRS Hand-held Radio

Harris has fully embraced the JTRS Program vision as demonstrated through significant investment in the development of highly capable and cost effective JTRS compliant military SDR solutions. The AN/PRC-152 (C) Hand-held radio depicted in figure 3.1-1 is a leading example of a commercially developed JTRS product through private investment. The AN/PRC-152 (C) radio has been developed by Harris as part of the Falcon® III radio family, a suite of JTRS tactical radio products. The AN/PRC-152 (C) is a Type 1 secure military radio that initially operates in the 30 – 512 MHz frequency range and has both 5W and 50W transmit power out configurations (refer to Figure 3.1-2 for a picture of a 50W vehicular configuration). The AN/PRC-152 (C) Hand-held radio supports several key JTRS waveform applications, including:

Figure 3.1-1
AN/PRC-152 (C)

- VHF/UHF LOS (AM/FM)
- HAVEQUICK
- SINCGARS ESIP
- MIL-STD-188-181B
- Others (in future product releases)

Figure 3.1-2 50W
Vehicle Configuration

The AN/PRC-152 (C) Hand-held radio has a fully capable JTRS hardware architecture, including a Harris Sierra™ II based Cryptographic Subsystem (CSS) that ensures the portability of JTRS repository waveforms. The AN/PRC-152 (C) Hand-held radio completed certification by the National Security Agency (NSA) in August 2005, executed through a Commercial COMSEC Evaluation Program (CCEP) agreement. All high assurance Type 1 security requirements specified by the NSA for JTRS were met by the AN/PRC-152 (C) Hand-held radio as well as the re-programmability security objectives of the NSA Cryptographic Modernization program.

Harris is also currently developing a Falcon® III Man-pack Radio on private investment which supports a similar set of capabilities and narrowband waveforms as described for the AN/PRC-152 (C) Hand-held radio, as well as hardware and software architectures that support high-speed, wideband data waveforms such as the JTRS Wideband Networking Waveform (WNW). The Falcon III Man-pack Radio wideband data waveform capability will be demonstrated in October 2005.

3.2. CF-Lite provides high performance operation

The AN/PRC-152 (C) Hand-held radio SCA Operating Environment has been developed utilizing an optimized version of the SCA V2.2 compliant Core Framework, referred to as CF-Lite. These optimizations conserve platform processing power and storage requirements, in order to reduce critical system power-up and application-switching times to field usable levels,

while maintaining the integrity of waveform application interfaces (and therefore ensuring waveform portability). Power-up and application switch times, as well as memory storage capacities are significantly impacted by the use and performance of the eXtensible Markup Language (XML) to describe system and software component characteristics. XML files are parsed both at system start-up time and during the waveform instantiation process. The CF-Lite pre-parses XML inside the radio set on waveform application installation (local or over-the-air) and stores the information in a significantly more concise and efficient format, improving the performance of platform power-up and application switch times. It should be noted that CF-Lite is one aspect of a power management and "fit-for-use" strategy that must be employed for the development of battery powered platforms.

Harris has submitted SCA Change Proposals (CPs) for consideration that cover all optimizations related to the CF-Lite. The AN/PRC-152 (C) Hand-held radio powers up to a usable state (able to communicate) within 30 seconds and is able to switch between installed waveform applications (i.e., VULOS to HAVEQUICK) within 5 seconds.

The AN/PRC-152 (C) Hand-held radio completed initial SCA Compliance testing by the JTeL in September 2005. This testing was performed against the defined requirements specified by the SCA and executed at JTeL facilities, through a combination of automated and manually executed tests. The AN/PRC-152 (C) Hand-held radio performed very well in this initial phase of SCA Compliance testing, failing compliance for less than 8% of the 735 defined SCA requirements. The final phase of SCA Compliance testing will be completed in the November 2005 timeframe.

4. JTRS WAVEFORM APPLICATIONS

JTRS waveform applications provide communications capabilities in accordance with established standards and specifications. JTRS waveform applications are installed on SCA compliant radio platforms, then instantiated for operation upon demand. The U.S. DoD is in the process of procuring a suite of waveform applications that will be stored in Government maintained Waveform Repository as reference implementations for porting to a variety of military radio platforms. Each developed waveform application will demonstrate compliance through Formal Qualification Testing and porting to a Government Representative Radio Set prior to approval and inclusion into the Waveform Repository.

4.1. JTRS waveform application porting constraints

Waveform porting complexity can vary dramatically, from minimal code changes to support unique platform capabilities, architectures and interfaces to almost complete re-writes of waveform application software. This can involve moving components designed and certified for execution on General Purpose Processors (GPPs) to Digital Signal Processors (DSPs) or Field Programmable Gate Arrays (FPGAs), or moving components across/within the Information Security (INFOSEC) boundary. As noted previously a key objective of JTRS is to use waveform porting to minimize development cost, but also as a means to ensure interoperability. The JTeL has developed plans to evaluate the portability and performance of waveform applications prior to acceptance into the JTRS waveform repository (refer to [1] and [2]).

There are however, no specific requirements or guidelines for the level of acceptable modification to JTRS repository waveforms when porting to JTRS radio sets. A radio set provider could conceivably re-write a significant portion of a JTRS repository waveform code, even removing most of the interfaces with a JTRS SCA compliant OE and potentially be regarded as JTRS compliant. Radio set providers could also develop JTRS SCA compliant radios with hardware architectures that are not capable of executing JTRS repository waveforms without significant code modification or hardware modification. It is incumbent on the JTRS JPEO to define criteria for acceptable porting levels to ensure that the key JTRS Program tenants of interoperability and low life cycle costs are achieved.

The JTRS SCA utilizes Component Based Development (CBD) technology, which promotes the advent of interchangeable software parts, built to predefined specifications. With respect to SDR solutions, the ability to reuse existing software components across multiple radio applications in an open framework, and the encapsulation of hardware specific capabilities and platform services through well-defined APIs are the lynchpins for facilitating true waveform portability, both from practical application and affordability perspectives.

The standardization of SCA APIs is essential in order to meet this objective. Today the path to universal adoption of standard APIs for the JTRS SCA is unclear. The SCA API supplement as it exists today provides a framework for the development of APIs, but does not provide detailed API definitions required to ensure waveform application interoperability. The latest version of the JTRS SCA Specification [3] has expanded the

interface framework to support the abstraction of software elements in both the DSP and FPGA domains. While this framework sets the stage for increasing the portability of lower level software elements, it also does not define specific interfaces for broad usage. The result is that waveform portability continues to be at risk, as the level of software modifications required to port waveforms across radio sets will be significantly higher than if all radio sets were being developed to a set of standard API definitions.

4.2. JTRS waveform porting becomes a reality

Harris Corporation is responsible for the development of the VULOS and HAVEQUICK waveform applications targeted for the JTRS Waveform Repository. These waveform applications were designed and developed by Harris in accordance with the waveform and radio platform requirements established as part of the Cluster 1 Program. In addition, Harris employed a "right size" waveform design concept to target the performance and memory footprint requirements of the smallest, and most processing disadvantaged platform (in this case a Hand-held radio platform). The concept is intended to ensure that the waveform application will be readily portable to the smallest common denominator platform and can be easily "scaled up" to more capable platforms. Without the use a "right size" waveform application design concept it could be extremely difficult and costly to port a developed waveform application to a small platform ("scaling down").

Harris recently completed Formal Qualification Testing (FQT) for the VULOS waveform, the first waveform application FQT to be completed as part of the Cluster 1 Program. The VULOS waveform FQT was performed on a Harris JTRS Step 2B radio platform (demonstrating the portability of the waveform to a battery powered platform).

Harris has also successfully ported the VULOS and HAVEQUICK waveform applications developed as part of the Cluster 1 Program to the AN/PRC-152 (C) Hand-held radio. The result is that the first deployment of a JTRS waveform application destined for the Waveform Repository will occur with delivery of AN/PRC-152 (C) Hand-held radios in October 2005. Table 4.2-1 provides a summary of the scope in terms of thousands of source lines of code (KSLOC) and approximate porting costs (in U.S. dollars) for these waveform applications.

Table 4.2-1 Summary Waveform Porting Costs

Porting Characteristic	**HQ to AN/PRC-152**	**VULOS to AN/PRC-152**
Developed KSLOC	54	56
KSLOC Reused	39	48
KSLOC Modified	15 (28%)	8 (14%)
KSLOC Added	0	8 (14%)
Total KSLOC	54	64
Porting Cost	$ 300K	$ 400K

It should be noted that this porting example represents a real, but single porting data point for JTRS waveform applications. The following represents a list of important aspects of this particular waveform porting example:

- Harris is a domain expert regarding these waveform applications (significant past experience).
- Harris was the radio platform and SCA OE developer. AN/PRC-152 (C) Hand-held radio platform is fully capable including an SCA Cryptographic Subsystem using NSA verified Cryptographic Equipment Applications.
- Harris was the original waveform application developer.
- Waveform applications were developed using a "right size" waveform development concept.
- Most of the scope of work to port the waveform applications to the AN/PRC-152 (C) Hand-held radio was due to the use of somewhat different APIs since APIs have yet to be standardized (AN/PRC-152 Hand-held radio APIs were optimized to support platform performance requirements, i.e., battery life).

The SINCGARS ESIP waveform application is not yet available from the JTRS Waveform Repository, so Harris developed an SCA based SINCGARS ESIP waveform application through private investment and has ported this waveform to the AN/PRC-152 (C) Hand-held radio. This version of the SINCGARS ESIP waveform application will be deployed with AN/PRC-152 (C) Hand-held radio deliveries in October 2005.

As part of the JTRS AMF Program, Harris successfully ported the VULOS and HAVEQUICK waveform applications to a demonstration JTRS radio platform targeted for a significantly different domain than the JTRS Cluster 1 radio. The Cluster 1 Operating Environment (including SCA services and devices) was used as the basis for this demonstration platform, including provision of all APIs required by these

waveform applications. The approximate cost of porting these waveform applications to the AMF demonstration platform was less than $ 150K for both waveforms, including use of U.S. DoD Type 1 security. This example further amplifies the importance of API standardization in achieving the JTRS vision of cost effective and timely waveform application porting.

5. MILITARY SDR SECURITY SOLUTIONS

"Programmable security for SDRs"

Information Assurance (IA) is a key component to the success of the JTRS Program, including the development and deployment of a programmable Information Security (INFOSEC) module. Without a programmable INFOSEC module the flexibility and growth capability of a JTRS-compliant system will be limited by legacy cryptographic equipment or require expensive hardware upgrades. In addition, the rapid evolution of the Internet and advent of wireless networking is dictating the development of next-generation cryptography. The development and integration of programmable cryptographic modules will allow JTRS compliant radio sets to download new cryptographic algorithms and functions in conjunction with new or updated waveform capabilities. These requirements for programmable security are fully aligned with objectives of the NSA Cryptographic Modernization program.

5.1. Sierra™ II SDR INFOSEC Solutions

Harris Sierra™ II security devices are fully NSA certified for Type 1 operation (TS/SCI) and provide advanced INFOSEC solutions across all JTRS radio domains and for other applications. Harris Sierra™ II devices are small in size and are designed with a scalable architecture based on the latest System-on-a-Chip (SoC) ASIC technology (refer to figure 6.1-1). This scalable architecture facilitates a combination of cryptographic and key management functions into a single chip or allocation of these functions across multiple chips for solutions, which require multiple channels and/or multiple levels of security (i.e., JTRS Cluster 1 radio). The Sierra™ II cryptographic functions include a broad set of capabilities, including: encryption and decryption, transmission security, authentication and integrity, certificate and policy management.

Figure 6.1-1
Sierra™ II
ASIC

Sierra™ II devices provide an optimized combination of hardware and software components to maximize performance: including throughput and power utilization. The Sierra™ II device fully supports the demanding throughput performance and high assurance requirements of the JTRS Wideband Networking Waveform (WNW) as well as for high-band satellite data links. Sierra™ II devices employ chip level power management, automatically disabling unused internal circuitry dependent on security channel configuration to minimize power consumption (not possible with software only security device implementations). The unique scalability of the Harris Sierra™ II architecture, make it the only INFOSEC solution able to meet the broad requirements across the diverse set of JTRS domains.

Sierra™ II meets the cryptographic requirements for U.S. DoD Type 1 IP network system solutions (such as the JTRS WNW noted previously). This includes support for systems that employ High Assurance Internet Protocol Interoperability Specification (HAIPIS) V1.3.5 and V3.0 capabilities. The next generation HAIPIS is evolving to meet additional needs including: bandwidth efficient requirements, error tolerant requirements, and foreign releasable requirements. Sierra™ II can be updated through software to support these advancing capabilities.

5.2. Cryptographic Equipment Applications

A Cryptographic Equipment Applications (CEA) is Software Product Configuration Item that implements one or more operational modes of cryptographic equipment. CEAs are developed uniquely for a particular cryptographic hardware device (i.e., Sierra™ II). Although architecturally part of the radio Operating Environment, CEA implementations can be thought of in a context similar to waveform applications, where there is an approved reference implementation maintained in a CEA library repository which is then ported to a particular radio platform. Typically there will very little porting effort required, since CEA reference implementations are targeted for a specific cryptographic hardware device and associated software environment. Examples of potential CEA porting tasks include: OE command stream processing optimizations and throughput performance allocation.

5.3. Sierra™ II CEAs

Harris has developed a suite of CEAs under contract with the JTRS JPEO. The Harris Sierra™ II software utilizes a modular, building block architecture, which facilitates the porting of CEAs across all JTRS radio domains and specific hardware platforms with minimal porting cost and time (refer to Figure 5.1-1).

The lowest layer of the Sierra™ II software architecture consists of the essential software burned into

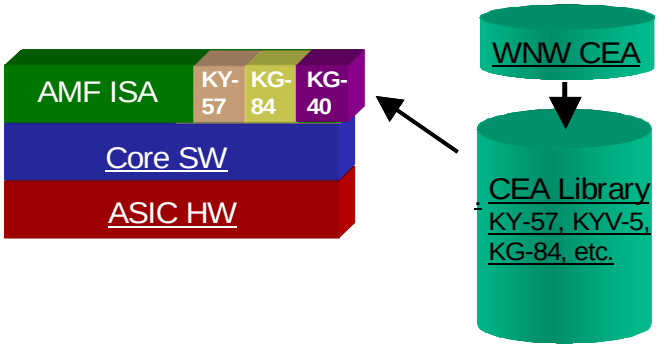


Figure 5.1-1 Sierra™ II Software Architecture

the ASIC hardware. The next layer is the Core Software Application, which provides a set of essential services (operating environment) for CEAs, such as file services and key management. These first two layers of the Sierra™ II software architecture are certified by the NSA, in conjunction with the Sierra™ II ASIC hardware as basis for each individual host embedment to build upon. The Independent Software Application (ISA) layer supports platform specific hardware/software interfaces, which are unique for each host embedment. The CEAs required to support a waveform application and other radio platform functions are extracted from the JTRS JPO CEA Library and integrated with the platform specific ISA. The integrated ISA/CEA executable image is signed by NSA following the certification process and upon installation, is stored within a Sierra™ II based Cryptographic Subsystem (CSS) following signature authentication.

Harris has completed the software development and NSA security verification of multiple CEAs, including: KG-84, KY57/58, KYV-5, KGV-8 (for the Link-16 waveform) and KGV-13 (for the EPLRS waveform) and WNW COMSEC / TRANSEC. Harris has ported the KY-57/58 CEA to the Cluster 1 radio platform and completed initial integration with the HAVEQUICK waveform application (demonstrated at Ft. Huachuca in May 2005). Harris has also ported the KY-57/58, KG-84 and KYV-5 CEAs to the AN/PRC-152 (C) Hand-held radio and integrated with the VULOS, HAVEQUICK and SINCGARS waveform applications which will be deployed in October 2005.

6. CONCLUSIONS

"Take Away Messages"

- Harris continues to be a prominent player in the military SDR industry, and significant contributor to the development of JTRS radio sets across multiple domains.
- The Harris Falcon® III AN/PRC-152 (C) Hand-held radio product begins shipping in October 2005 as the ONLY JTRS radio to date to have completed full NSA certification, gone through formal SCA Compliance testing conducted by the JTeL and is being deployed with ported JTRS waveform applications destined for the Waveform Repository
- Harris Sierra™ II provides fully capable, NSA certified, security solutions optimized for an unmatched combination of small size, high performance throughput (i.e., WNW) and power management.
- Harris Corporation is committed to working with the U.S. DoD to ensure the ultimate success of the JTRS Program and achievement of the JTRS vision for military SDRs and war-fighter communications.

7. REFERENCES

[1] JTRS Technology Laboratory, "Waveform Portability Assessment Plan", Version 1.0, 17-September-2003.

[2] JTRS Technology Laboratory, "Waveform Performance Assessment Plan", Version 1.0, 17-September-2003.

[3] JTRS Joint Program Office, "Software Communications Architecture Specification", Version 3.0, 27-August-2004

Software Defined Radio Solutions

Experience making JTRS Work

from the SCA, to waveforms, to secure radios

Mark R. Turner – Director Software & Secure Products Engineering

Presentation Overview

- Domain knowledge, JTRS experience and private investment leads to commercial solutions.
- JTRS SCA and Scalability – Contributions and limitations from many elements.
- Waveform porting experience with the SCA, its not just the waveform applications.
- Networking – Keystone application for JTRS.
- Sierra™ II solutions - Information Assurance and security permeate military SDR architectures.
- Conclusions.

Joint Tactical Radio System (JTRS)

Domain knowledge, JTRS Experience, and Private investment lead to commercial solutions

Harris JTRS Program Experience

- **Step 1** - Architecture definition competition phase.
  - Harris on Boeing Team.
- **Step 2** - Architecture development & validation phase.
  - Step 2A - Harris provides domain management software.
  - Step 2B - Harris awarded two man-portable radio contracts.
  - Step 2C - Harris provides Sierra programmable crypto.
- **Production and deployment phase**
  - JTRS Cluster 1 Program.
  - JTRS AMF Program.
  - JPO Crypto Equipment Application (CEA) Program
  - JPO SCA Technical Advisory Group (TAG).
  - JTRS Technical Lab (JTeL) Harris provides COTS CF.

Commercial Model for JTRS Radios

- Involves private investment for JTRS radio development (including waveform porting).
- Benefits
  - Private investment directly reduces Gov't SD&D costs.
  - Potential reduction in product "Time-to-Market".
  - Preserves price competitiveness.
  - Stimulates continual technological advancement.
- Model supported by U.S. DoD.
  - AN/PRC-152 Hand-held Radio
- Further definition of evolutionary acquisition approach is needed to ensure product availability.

AN/PRC-152 Hand-held Radio

Shipping October 2005

- **Developed through Harris investment.**
  - Initial release of Harris Falcon III Radio family
- Single channel; 30 - 512 MHz; 5W Tx
- Weight: 2.4 lbs (with battery)
- JTRS SCA V2.2 OE (Type 1 security)
  - Completed 1st phase JTeL testing Sept 2005
- Waveforms:
  - VHF/UHF Line-of-Sight (VULOS)
  - HAVEQUICK I/II
  - SINCGARS
  - MIL-STD-188-181B; HPW
  - COBRA, APCO25 (future)
- Programmable encryption (Sierra™ II)
  - Platform fully NSA certified August 2005

AN/PRC-152 Vehicular Configuration

- AN/PRC-152 Hand-held Radio provides waveform processing, base-band interfaces and power amplifier control.
  - "Jerk and Run" configuration with integrated battery charger keeps HH Radio in "ready-to-use" state.
- Single channel; 30 – 512 MHz; Selectable Tx to 50W in VHF.
- Two 50W systems fit into legacy SINCGARS mount configuration.

Initial shipments January 2006

Falcon III Man-Pack Radio

- **Being developed through Harris investment.**
- Single channel; 30- 2000 MHz; 20W output power.
- Weight: 9.0 lbs (with battery).
- Technology transfer (reuse) from AN/PRC/152:
  - OE (SCA V2.2); Programmable encryption (Sierra™ II).
  - Waveforms: VULOS, HAVEQUICK I/II, SINCGARS, MIL-STD-188-181B, HPW.
  - Human/Machine Interface (HMI).
- Additional waveforms
  - BLOS: Integrated Waveform (IW).
  - "Ready to accept" WNW, SRW. Harris wideband waveform demonstrates platform capabilities.

Available January 2007

Falcon III vs. JTRS Characteristics

- 2 MHz – 55 GHz frequency range.
- Multiple, simultaneous channel operations.
  - Re-transmission across bands and waveforms.
- Backwards-compatible: legacy radios/waveforms. √
- Programmable Information Security (INFOSEC). √
- Portability of Waveform Applications software. √
- Network connectivity across RF spectrum to meet demands of network-centric warfare. √
- Scaleable, enables additional future capacity. √
- Modular, “pluggable” technology insertion. √

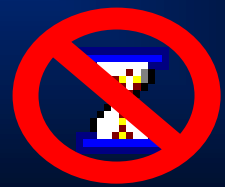
JTRS SCA and Scalability

Contributions and limitations from many elements…

Lightweight Core Framework (CF-Lite)

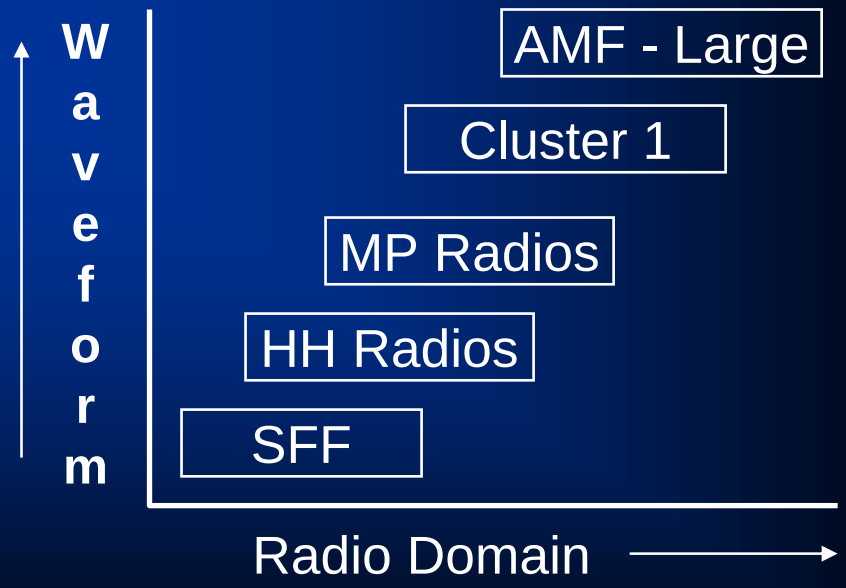
- Optimized SCA V2.2 CF for improved radio startup performance on small (potentially all) platforms.
- Waveform XML parsed at install time in radio.
- File interface extended for efficient “local file access”.
- Maintains waveform application portability.
- Tight implementation (~ 62 KSLOC), plus COTS.
- 1st phase JTeL SCA Compliance test failed < 8% of 735 requirements; 2nd phase testing Nov-05.
- AN/PRC-152 HH Radio starts up in < 30 seconds.

Radio Set startup time counts!



Devices and Services

- Devices and Services provide radio platform capabilities to support applications through APIs.
- Robust set of Devices and Services required for many waveform applications and radio domains.
  - **Large amount of associated software (MSLOC).**
- Scalability related to both specific waveform requirements and radio domain requirements.



SCA V3.0 and Scalability

- Defines standards for DSP / FPGA environments.
- Specialized Hardware Supplement (SHS)
  - Non-CORBA components running on specialized hardware.
- HW Abstraction Layer Connectivity (HAL-C)
  - Communications between non-CORBA components using services provided by a HAL.
  - Defines interfaces, not how they get connected together (XML is approach for CORBA components).
- Several issues / limitations need to be addressed:
  - IP core usage, performance impact, development cost.
- Validation prior to procurement recommended.
- **Work currently on "strategic pause" by JPEO.**

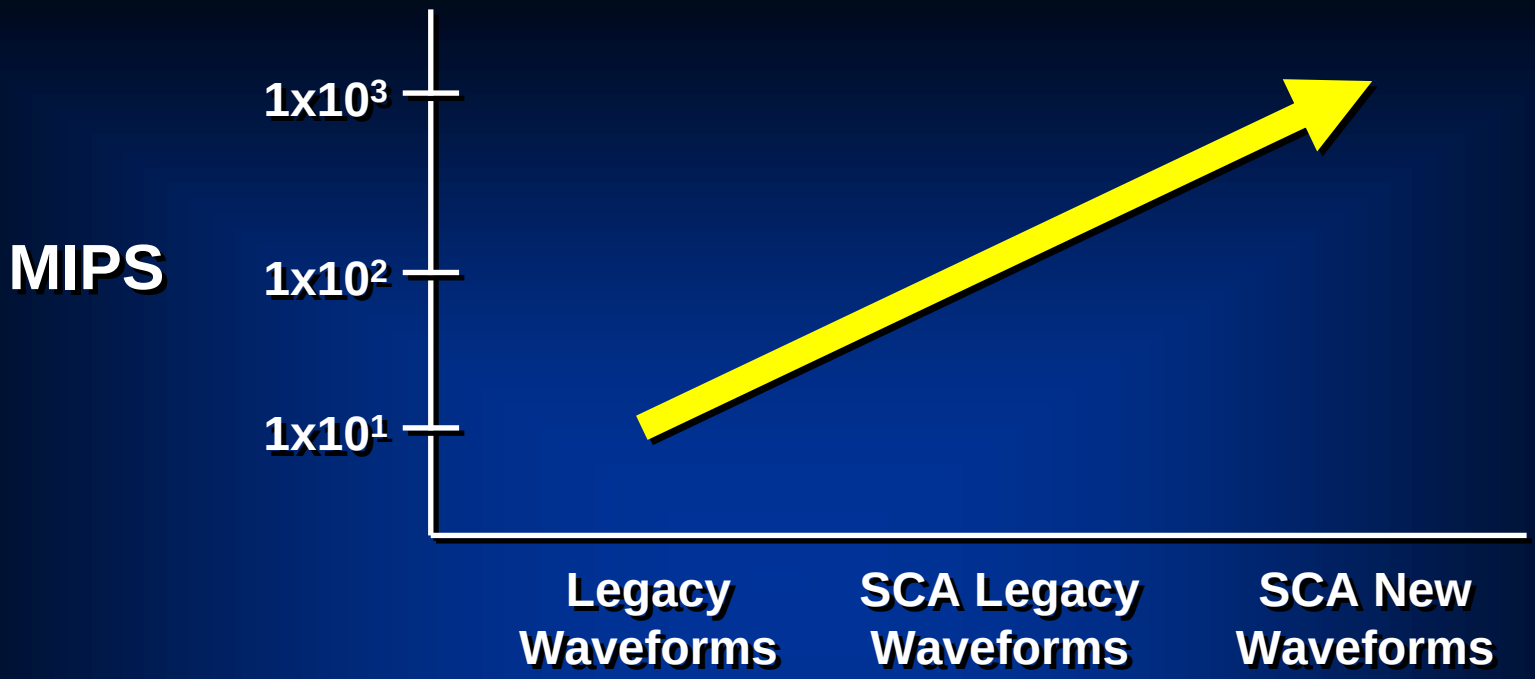
Waveform Porting with the SCA

Its not just about the Waveform Applications

API Standardization

- Use of standard APIs to encapsulate hardware specific capabilities and radio platform services essential for JTRS waveform porting success.
- **APIs not standardized as part of SCA V2.2.**
- Export restrictions limiting broad industry participation in API definition and publication.
- JPEO API working group addressing issues:
  - Evaluating Cluster 1 API applicability to broad set of radio domains (i.e., HH Radios, SFFs).
  - How to handle inevitable need for API extensibility?
- How do the OMG SBC DTF definitions apply?

Waveform Resource Requirements



- Moore's Law helps meet MIPS requirements, exacerbates thermal dissipation challenges.
- **"Right size" waveform application design** for most disadvantaged platform (MIPS and memory).

Waveform Porting Sequences

HARRIS

HAVEQUICK Waveform

Port

F Q T

Port

GFE SDR 3000

Waveform Development

Port

Port

JTeL Waveform Repository

VULOS Waveform

Port

F Q T

Port

GFE SDR 3000

First Cluster 1 developed Waveform to complete FQT

Waveform Porting Metrics

Porting Characteristic	HQ I/II to JITR	VULOS to JITR
Developed KSLOC	54	56
KSLOC Reused	39	48
KSLOC Modified	15 (28%)	8 (14%)
KSLOC Added	0	8 (14%)
Total KSLOC	54	64
Porting Cost (approximate)	$ 300K	$ 400K

- "Right size" waveform design (targeted for HH domain).
- Waveforms developed and ported by Team with strong domain knowledge; platform, SCA OE, CSS developer.

Waveform Porting Recommendations

- Unified path to adoption of standardized APIs.
  - Must be broadly applicable and extensible.
  - Need to be exportable to support Joint and Coalition interoperability.
- Establish waveform porting criteria.
  - Hardware architecture framework.
  - SLOC modification limits.
- Validate JTRS Repository Waveforms on most disadvantaged platform to ensure portability.
  - **Ensure "right size" waveform design.**

RF Networking

Keystone Application for JTRS.

RF Networking Uses

- Foundational element for Network-Centric Warfare.
- Situational Awareness (SA).
- Global Information Grid (GIG) connectivity.
- Multi-service coordination without borders.

Advanced Networking Wideband Waveform (ANW2)

- Purpose:
  - Validate Falcon III hardware/software architecture for wideband networking (future use of WNW and SRW).
  - Potential interim solution until WNW and SRW are available.
  - Solution for NATO and international market.
- Characteristics:
  - Self-Synchronizing TDMA Scheme, No GPS required.
  - AdHoc Network formation using passive, pro-active, and reactive protocols.
  - Dedicated Digital Voice Interval for traditional CNR and multi-talker voice capability.
  - Robust Burst Signals in space
    - 500 KHz to 10 MHz
    - 22 Kbps to 15 Mbps on-air rate

AUSA Networking Demonstration

Video Streams:

90 Kbps Throughput

2.7 Mbps PSK On-Air Rate

Demonstrated:

28 Sec SCA Boot and WF Load

2 Sec WF sync time and AdHoc Net formation

A to B Video and Voice

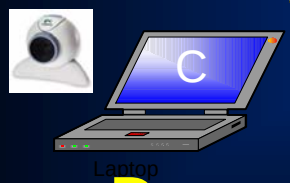
C to D Video

Voice

Voice

Audio Streams:

1.35 Mbps OGMSK On-Air Rate



Demonstrated operation in October @ AUSA 2005

Sierra ™ II Security Solutions

Information Assurance and security permeate the Military SDR architecture.

Information Assurance and Security

- SCA portability concepts establish new paradigms for IA and security.
  - Use of COTS software (ie., OS).
  - Software re-programmability.
  - Policy based re-configurability.
  - Connection to open networks I.e., GIG).
- Solutions will require combinations of:
  - Architectural guidance
  - IA standards & protocols
  - Technical requirements
  - Policy

Sierra™ II Technology

- Military-grade security / commercial technology.
- Low cost solutions
  - Small size, scalable, building block architecture.
  - Procurement model provides lower per-channel cost.
  - Proven incremental NSA certification model.
- High Performance
  - Programmability supports security capability expansion and new cryptographic algorithm insertion.
  - Optimal combination of Hardware and Software components to maximize speed and flexibility.
- Low power consumption
  - Chip level power management.

NSA certified September 2004

Sierra™ II Provides Broad Solutions

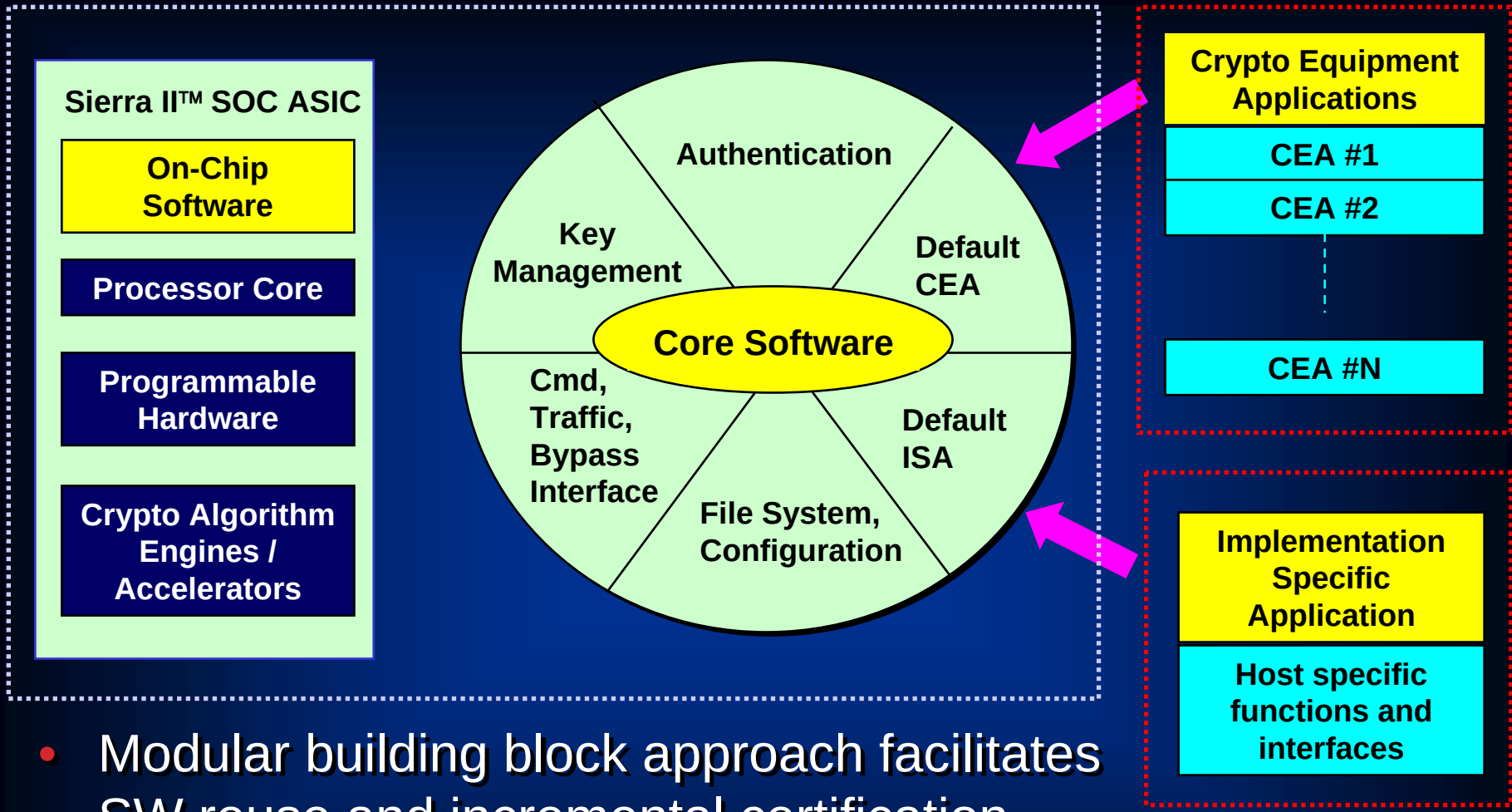
- Supports classifications to TS/SCI (high-grade).
- High speed data applications (up to 1Gbps).
  - IP Crypto (HAIPIS V1.3.5 / 3.0), ATM, other applications.
- Rich suite of cryptographic algorithms.
- Advanced key management functions.
- **Can support Coalition and Sovereign high assurance solutions, i.e., UK CHIM(P) Program.**
- Standard modules, developer's kits and training.
- Used in multiple applications and platforms
  - JTRS Cluster 1, AN/PRC-152, UREM, ADI, INE

Sierra™ II Technical Description

- Next generation SoC ASIC
  - Multiple packages provide flexibility in configuration.
- Cryptographic Software
  - On-Chip Software
  - Core Software (Control, File services, Key Mgt, etc.)
  - Implementation Specific Application (ISA)
  - Cryptographic Equipment Application (CEA)
- Certified Sierra II Modules
  - Sierra™ II ASIC
  - Cryptographic SW
  - Misc. HW components.

Two package sizes for broad applicability

Sierra™ II Software Architecture



- Modular building block approach facilitates SW reuse and incremental certification.
- **Reduces embedment cost and schedule.**

Conclusions

- **JTRS being delivered to war-fighters through private investment model supported by DoD.**
  - Harris AN/PRC-152 first fully NSA certified JTRS radio.
  - Harris Sierra™ II meets ALL JTRS requirements including legacy interoperability, networking, key management.
- Harris has unique JTRS Program experience.
  - Step 2B (Focus on SCA, small platforms, security).
  - Cluster 1 (LRU / waveform developer, CSS provider).
  - AMF (Maritime system lead; JTR Secure Network Processor).
  - CEA Program (SV done on six CEAs).
  - TAG (supporting SCA evolution).

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