1998 International Symposium on Advanced Radio Technologies

SPEAKeasy Military Software Defined Radio

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SPEAKeasy System

- The “PC of the Communications World”
- Fully Programmable Waveform and COMSEC for Voice, Multimedia and Networking Use
- Multiband ... continuous from 2MHz to 400MHz
- Open Modular HW Architecture
- Open SW Architecture
- Commercially Successful HW and SW
- Legacy Systems Compatibility
SPEAKeasy Phases

FY95

PHASE I
ADM

MMI

SPARC 10

19" RACK

FY96 - FY99

PHASE II
ADM

FY00+

[Images of military equipment and various diagrams]
PARTICIPANTS

• DARPA

• AIR FORCE/AFRL

• ARMY/CECOM

• NAVY/NRaD/SPAWAR

• NSA
Military Benefits

- Interoperability
  - Emulates Legacy Systems
  - Bridges Diverse Non-interoperable Systems
  - Provides Data Gateways

- Flexibility/Adaptability
  - Reconfigurable, Modular, Scaleable to Platform Requirements

- Responsiveness
  - Reprogrammable - In-situ and Over-The-Air
  - Enables P3I

- Mobility & Sustainability
  - Reduces Logistics - SWAP - Spares
  - Reduces # of Terminals and Ancillary Boxes

- Reductions in Cost
  - Initial Production is Competitive
  - LCC Savings: Common Equip, Volume Buy, COTS
Communications Revolution

- Adaptive Antenna Technology
- Dynamic Power Control
- LPI & AJ Techniques
- Optimization Techniques
- Media Resource Allocation

- Navigation
- Identification
- Surveillance
- Mission Planning

Small → Growing → Commercialize → Mass Commercialization

Speakeasy Phase-1
SPEAKeasy Phase-2
JTRS
Speakeasy Phase-1

Objective:
- Demonstrate the feasibility of a Multiband, Multimode Radio
- Develop technologies that facilitate programmability and implementation of MBMMR

Accomplishments:
- Demonstrate multiband, multimode operation at JWID95
- Operation of HF, SINCGARS, Have Quick
- Bridging between voice networks

Lessons Learned:
- INFOSEC is paramount to acceptable architecture
- All areas (HW/SW, subassemblies) need open system
- Beware of growing requirements
- Requires cutting-edge technology

Phase-1 Equipment Rack
SPEAKeasy Phase 1

• A proof of concept, research and development program
• Awarded in 1990 to Hazeltine, TRW, Lockheed-Martin, Motorola, and Rockwell-Collins
• 2 programmable channels
  – VME bus architecture
  – Texas Instrument quad-TMS320C40 multi-chip module for digital signal processing
  – SUN Sparc 10 workstation as man-machine interface.
Initial SPEAKeasy Phase 1 Architecture

- SUN SPARC station
- Ethernet Link
- Terminal Controller Subsystem
- RS-232
- Microprocessor Subsystem
- I/O Subsystem (Voice, Data)
- Clock/Time Reference Subsystem
- FFT Subsystem
- Waveform Generator Subsystem
- IF/RF and Frequency Synthesizer Subsystem
- Baseband Converter Subsystem
- BUS Interface
- ANCP Subsystem
- Power Supply Subsystem
- Bus Interface
- Power Amps and Multiband Antenna
- To Power Amps and Multiband Antenna
- Main Power On/Off
- Chassis Power On/Off
- Standby On/Off
- Distribution

- VME Bus
- High-Speed Bus
- Clock/Timing/Reference (CTR) Lines
- RS-232
- Ethernet Taps
- RS-232
- Kov-5
- Speaker
- Microphone
- Power Supply Subsystem

Note: The diagram illustrates the architecture and connections between various subsystems and components within the Initial SPEAKeasy Phase 1 system.
Revised SPEAKeasy Phase 1 Architecture

- Revised SPEAKeasy Phase 1 Architecture
- SUN SPARC Station
- Ethernet Link
- Ethernet Taps
- RS-232
- I/O Subsystem
  - Data
  - Voice
- Quad C40 µP Subsystem
- Preprocessor Subsystem
- Waveform Generator Subsystem
- Clock/Time Reference Subsystem
- Interference Suppression Subsystem
- Baseband Converter Subsystem
- IF/RF Interface
- Power Supply Subsystem
- Distribution
- Main Power On/Off
- Chassis Power On/Off
- Standby On/Off
- To Power Amps and Multiband Antenna
- VME Bus
- High-Speed Bus
- Clock/Timing/Reference (CTR) Lines
SPEAKeasy Phase 1
Lessons Learned

• OVER DESIGNED
• PERFORMANCE/COST TRADE-OFFS
• SECURITY AT CORE
• OPENNESS IN ALL AREAS
• REQUIREMENTS CREEP
## SPEAKeasy EVOLUTION TOWARDS MBMMR

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<th>Development Emphasis</th>
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<td>Modem Only</td>
<td>Entire Radio</td>
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<td>Modular by function for modem</td>
<td>Modular by function for radio (Publish &quot;Open&quot; Interface Standards)</td>
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<td>Emphasis</td>
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<td>Form Factor</td>
<td>Packaged for lab use</td>
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Speakeasy Phase-2

Objective:
- Develop and Demonstrate
  - Open Architecture
  - Software Reprogrammability
  - Package in near ”field ready” enclosure

Accomplishments:
- Successful demo at TF-XXI AWE
  Ft. Irwin, March 97
- Interoperation with HF, VHF, UHF
- Bridging between any diverse radios
- In-Field Reprogramming
- In-Field Repair w/ COTS Components

Lessons Learned:
- Composing Lessons Learned Report
  - RF
  - INFOSEC
  - Control
  - Software
  - Modem
  - Man-Machine Interface
  - Internetworking
  - General Comments

Phase-2 TF-XXI Model
SPEAKeasy Objective
Interconnectivity

**NB Terrestrial Communications**
- SINCgars
- SINCgars SIP
- Have Quick I
- Have Quick II
- SATURN (goal)
- HF & HF Modem 110A
- HF & HF ALE 141A
- HFAJ
- FM
- ATC & Civil Aviation
- Law Enforce. & Public Safety (goal)
- Have Quick II/IDM (goal)
- Cellular

**WB Terrestrial Communications**
- EPLRS
- Packet Radio
- T1
- LPI
- Link-16 (goal+)

**WB Satellite Communications**
- EHF MDR (Extended Cap)
- INMARSAT M (Extended Cap)
- MILStar (Extended Cap)

**NB Satellite Communications**
- UHF SATCOM
- UHF SATCOM DAMA
- SHF DAMA (Extended Cap)
- EHF LDR (Extended Cap)

**Broadcasts**
- GPS
- Commercial FM
- TRAP (goal)
- TADIX-B (goal)
- TADIL-A (goal)
- TIBS (goal)

**Local Data**
- Voice
- Modular Phone Jack

**Local Control**
- RS-232
- RS-422
- RS-449
- MIL STD-1553
- MIL-188-114A/EIA-423

**Internetworking**
- Ethernet
- FDDI
- ATM (goal+)

**Accomplished**
- By Addition of Software (Only)
- By addition of Software; possibly some HW
- Requires additional HW & SW
STANDARDS BASED
SPEAKeasy SOFTWARE Open Architecture

Complete flexibility in choice of operating systems, processes, tasking model, language, and application code.
STANDARDS BASED SPEAKeasy Open Systems

- Alternate Suppliers of Modules
- Upgradeable via Commercial Technology
- Customizable System Configurations
- Lower Maintenance and Life Cycle Costs
SPEAKEasy Phase 2
Modular-by-Function
Architecture

SPEAKEASY MULTIBAND, MULTIMODE COMMUNICATIONS TERMINAL

Capabilities at a Glance
• Frequency Range: 2 MHz - 2 GHz Initial Capability, Extendable Through 45.5 GHz
• Data Rate: 75 bps - 10 Mbps
• Initial Capability Includes 22 Programmable Waveforms, Plus GPS and Cellular
• Four Simultaneous, Programmable Channels, Plus GPS and Cellular (Available PCI Bus Margin Can Support Additional Simultaneous Channels)

Open Architecture “Wireless Communications PC”
• Modular by Function - “Library of Common Modules”
• Bus/Form Factor Independent Design Provides Multimission/Multiplatform Utility
• Minimizes Technological Obsolescence; Allows Periodic Insertion of State-of-the-Art Technology

Programmable Waveforms and INFOSEC
• Update/Add New Capability Without Hardware Modifications
• Reprogrammed via Over-the-Air Download

Networking
• Voice/Data Bridging Between Disparate Networks
• Tactical Internetworking (MIL-STD-188-220)
SPEAKeasy Phase 2
Hardware Architecture

- 4 Simultaneous Channels
- Over-the-Air Capability
- > 6 Simultaneous I/O Capability

**Front Panel MMI**
- Laptop MMI
- Waveform Controller
- Amps / Bridging
- GPS
- Cellular Reference Osc
- Program I/O
- Ethernet
- Smart Radio Processor
- Program
- Internetworking
- FDDI
- Modem
- Internetworking
- I/O*

**Power Supply**
- CSE
- Control Interface Unit
- RF Control
- RF Selector
- Pre-Selector
- T/R
- Data Conv
- Waveform Processor
- Data
- Reference Osc
- Interfer Cancel
- Antenna Coupler
- RF

**RF Control**
- Pre-Selector
- T/R
- Data Conv
- Waveform Processor
- Data
- Reference Osc
- Interfer Cancel
- Antenna Coupler
- RF

**Black PCI**
- CSE
- Waveform Controller
- Mem
- Hard Drive
- Control Processor
- Laptop MMI

**Red PCI**
- Red PCI
- Router Processor

*I/O* simultaneous, types vary
Established a SPEAKeasy Voice “Bridge” at Brigade Tactical Operations Center That Allowed Air Force Tactical Air Control Party (TACP) Personnel, Using a VHF/AM Radio to Communicate With an F-16 Operating on a UHF Radio
Integrated SPEAKeasy into Army tactical vehicles (HMMWVs with SICPS shelters).

Deployed and operated SPEAKeasy in the Ft. Irwin National Training Center’s field environment.

**Repaired SPEAKeasy on-site using parts from a **commercial** computer (an IBM-clone).**

Demonstrated single channel operation of: **HF/SSB, VHF/AM, VHF/FM, VHF/FM-SINCGARS, UHF/FM, UHF/AM and UHF/AM Have Quick hopping.**

While deployed at Ft. Irwin: **received & installed software upgrades and new waveform capabilities for SPEAKeasy; using laptop computer and commercial phone line.**

**Controlled A-10 and F-16 aircraft,** performing close air support (CAS) mission, using a standard military UHF radio waveform.

Colocated SPEAKeasy and existing TACP communications suite (GRC-206) at Division Tactical (TAC) for comparative evaluation.
SPEAKeasy ACCOMPLISHMENTS

- Developed an Open, Modular, COTS-based Architecture
- Model-1 Demonstrated TF-XXI
  - Modular Repair w/COTS
  - Software Re-programmability
  - HF, VHF, UHF (Voice/ECCM) Waveforms
  - Voice Bridging
  - Secure Voice (CYPRIS Crypto) 1998
- Provided Baseline Documents to the Programmable Modular Comm System IPT and the Joint Tactical Radio System’s Joint Program Office (JTRS-JPO)
- Future Multiband Multiwaveform Modular Tactical Radio (FM3TR)
  - Allied (4 Power) ECCM waveform created
  - Software Radio Interoperability Demo Planning
  - SPEAKeasy Phase-1 used in US/UK Demo June 98

- Facilitated Formation of Modular Multifunction Information Transfer System (MMITS) Industry/Government Forum
  - International Participation (>35 members)
  - Service Providers, Component Mfgs, System Integrators & Regulators
  - Publications: Architecture/APIs/Download

- R&D Not Completed Under SPEAKeasy
  Advanced INFOSEC (Context Sw) Data Modes
  Wideband Waveforms
  Data-Gateways
Summary of Benefits

• Open Architecture
  - Eliminates Stovepipe Solutions
  - Reduces Cost (Purchase and Life-Cycle)
  - Allows for Keeping Pace with the Technology Revolution

• Reprogrammability
  - Provides a Flexibility to Support Doctrinal and Mission Changes
  - Modifications and Upgrades in the Field
  - Gracefully Degrades

• Simultaneity
  - Multiband, Multimode Operation
  - Enables a Broadcast Mode

• Internetworking and Bridging
  - Seamless Connection - Interconnects Diverse Radios
  - Enables Incremental Fielding Benefit
SPEAKeasy Transition to JTRS

- Modular Functionally-Partitioned System
- COTS-based Hardware Interfaces
- Application Programming Interfaces
- Message-passing Protocols
- Linear RF (HF/VHF/UHF)
- ECCM Capability
- Military Radio Compatibility
- Voice Bridging Of Diverse Legacy Systems

COTS-based DSP Modem
Programmable, CYPRIS-based:
TRANSEC & COMSEC

Re-programmability:
Field Addition of New Waveform

WINDOWS-based Radio Control

Future Enhancements:
A/J and LPI Waveforms
Interference Mitigation
Adaptive Control
Smart Radio Techniques

Navy
Air Force
Army
Smart Networked Radio

- Develop Wideband Waveforms [LPI, ECCM, High Capacity, Packet-Switched]
- Adaptive Radio Control
  - Power
  - Data Rate
  - Coding
  - Bandwidth
  - AJ/LPI
  - ACE/BER
- Develop Adaptive Antennas
  - Receive Interference Cancellation
  - Tracking
  - Power Control
  - Bandwidth
  - Tuning
  - Enemy Emitter Location
  - Automatic Dynamic Matching
Smart Networked Radio (cont.)

- Media Resource Control
  - Routing/Switching
  - Packet control
  - Multiplexing
  - Priority/Preemption
  - Media/Channel selection
- Information Warfare
  - Info Gathering Analysis
  - Active ECM
A Software Defined System IS what you make it!

Smart Networked Radio

Adaptive Antenna Technology
Dynamic Power Control
LPI & AJ Techniques
Optimization Techniques
Media Resource Allocation

TRAP
TIBS
TADIX-B

Have Quick
SINCGARS
JTIDS

Navigation
Identification
Surveillance
Mission Planning

Smart Tech.
INTEL
COMM

A Software Defined System IS what you make it!