# **On Software Defined Radio Issues**



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### **Future Combat System –** 18 manned and unmanned systems (started 2003- cancelled Oct 2011)

FCS was the largest program in the history of the Department of Defense.



### **Communication network - FCS basis**

- Software Defined Radio Joint Tactical Radio System (JTRS); started in 1997 cancelled Oct 2011 (after 15 years), JTRS core element of the FCS. JTRS to replace 25 30 military radio systems.
- Battlefield Information System Warfighter Tactical Information Network (WIN-T) satellite communications
- A new operating system SOSCOE. The network-centric operating system integrates separate FCS communications software packages.

The cost of JTRS and WIN-T - one-third to the cost of the FCS itself (\$34 and \$108 billion), 2011-2003=8 years (\$13,5 billions yearly).

Latvijas budžets 2011 – 4,5 mljd latu, 2021 – 10 mljd doll. 2021. gadā zinātnes bāzes finansējums 23,5 mlj eiro.

**FCS's Requirements** 

Operational system SOSCOE planned to be ready only by 2011.



### **FCS software overview**



FCS Software (in 1000s of code), 63.8 mlj SLOC in 2005

Almost all of FCS's functionality is controlled by software (>95%);

Operating system – SOSCOE: for integration with the FCS >100 software interfaces;

The core SDR software architecture and the "waveforms" contain 4 mlj SLOC.

### WIN-T Networking At-the-Halt

Network-Centric Waveform (NCW) modem to optimize satellite bandwidth



### **WIN-T Networking At-the-Halt**



Tactical Hub Node - the central element



WIN-T Transportable Terminal

### **SDR** = **computer**+**router**+**phone**



4 mlj SLOC

19 waveforms - military radio protocols for **mobile ad hoc SDR** 

Operating Environment - between applications and radio platform

Radio platform: digital signal processor (DSP), application-specific integrated circuit (ASIC), field programmable gate array (FPGA), general purpose processor (GPP).

#### Uses OFDM physical layer.

Demodulation in OFDM - fast Fourier transform algorithms.

OFDM requires very accurate frequency synchronization.

# **SDR transceiver structure**



SDR signal processing: channel selection, modulation, demodulation, etc. executed programmatically.

*Smart antenna*. Each waveform called for different frequencies;

different frequencies required divergent antenna properties.

Building a radio receiver that works would require breaking some fundamental laws of physics.

### Lessons from the FCS Program (RAND, 2012)

*SDR is an immature technology*. Combat Systems of the Future was the largest and most ambitious planned modernization program in US Army history. In 2011, the FCS program was cancelled.

*Software critics.* The main purpose of JTRS is the organization of flexible and easily reconfigurable communications. Software communications architecture CORBA.

CORBA was introduced in the 1990s. Originally designed for RPC (remote procedure call) applications within distributed systems. The RPC model is built on the false idea that there is a reliable, homogeneous, secure network with zero latency and infinite bandwidth that never changes topology and always has only one administrator. In practice, RPC solutions have been replaced by application server-based solutions.

### What is left of the ambitious JTRS project?



The AN/PRC-154A Rifleman Radio is designed to be carried by leaders needing secret access to the platoon. Weigh less than a kilogram (with a 10hour battery and antenna) that can create self-forming ad hoc networks for voice and data transmissions. Securely transmit voice and data using and Soldier Radio cryptography Waveform. Three antennas accordingly to frequency ranges 225-450 MHz, 1250-1390 MHz, 1755-1850 MHz; but not just a single smart antenna.



JTRS HMS' AN/PRC-155 Manpack is a larger (6+ kilogram) – for battlefield commanders. This JTRS radio to successfully demonstrate 3 waveforms: Soldier Radio Waveform, Wideband Networking Waveform, and Mobile User Objective System (MUOS) satellite-communications waveform.

### **WIN-T on-the-move**



# **Soldier Network Extension:** Combat vehicle planned by 2012, but the 2011 failure exchanged plans (till 2018).

## **Russian SDR**



#### RADIO R-187P1 AZART:

- voice transmission both in analog form (FM) and in digital form (TETRA, frequency hopping);

 voice transmission in duplex negotiation mode (if TETRA infrastructure is available);

- data transfer at speeds up to 7.2 kbit/s;

- pseudo-random frequency hopping at a rate of 20,000 hops per second;

determination of coordinates using GLONASS/GPS space radio navigation systems;

- R-187P1 were also used as repeaters (wireless mesh network mode).

### **Cyber war - on the rise**

In October 2018, the US Government Accounting Office (GAO) sensationally reported that all software-based weapons systems that were tested between 2012 and 2017, including those created over the past ten years, have cyber vulnerabilities and can be hacked.



Embedded software and information technology systems in weapon systems.

Fighter F-35 seems the biggest DOD failure today.

### **Government network DRSN and "Red phone"**



Defense Red Switch Network (DRSN) uses 40 years old ISDN technology (at a speed of 128 kbps). Global secure communications for the command and control of the US Army and NATO.

"Red Phone": note the slot at the bottom right serves for a crypto-card and four buttons at the top - to select the priority of communications.

# **Summary: A Cautionary Tale For Today**

Future Combat System – 18 manned and unmanned systems (started 2003 – cancelled Oct 2011). FCS was **the largest program in the history of Pentagon**.

Software Defined Radio – core element of the FCS – to replace 25 - 30 military radio systems; started in 1997 – cancelled Oct 2011 (after 15 years). **SDR is an immature technology**. SDR = computer+router+phone.

FCS Software 63.8 milj SLOC in 2005. The core SDR software architecture and the "waveforms" contain 4 milj SLOC.

Software communications architecture **CORBA** – introduced in the 1990s; designed for RPC (remote procedure call), now replaced by server-based solutions.

**Cyber war** – on the rise. Fighter F-35 seems the biggest DOD failure today.

Defense Red Switch Network (DRSN) uses 40 years old ISDN technology.

What will be **future military radio** technology?