Technology Trends, High Performance Radio Evolution and Smart Integration

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Company History

1960 Communications Electronics Incorporated
1967 Watkins-Johnson
1999 Marconi North America
1999 BAE Systems
2002 Integrated Defense Technologies
2003 DRS Technologies
2015- Germantown, Maryland
RF Performance increases over time.

(Smaller *low performance* radios exist.)
SI-9170 Sparrow

NEXT GENERATION MICROWAVE

IMPROVEMENTS

- Two channels in a single 3U VPX
  - Extended frequency range
  - Independent or coherent capability across 3U VPX cards
- Dynamic Range Performance **6 dB** improvement
- **55%** size reduction single version (**80%** dual)
- **35%** power reduction for single version (**55%** dual)
- **37%** reduction in weight
- Extended Temperature Range
- Modular approach allows 6U, Brick, or Rack mount

The Sparrow architecture is designed for high dynamic range with excellent Intercept Point, Image and IF Rejection, low Mixer Spurious, and very low internally generated spurs.
Consider Two Red Cars

One of these is not like the other.
Three Key RF Specifications

- Noise Figure
- Overload
- Spurious
Specifications:

MIL-STD-461

Intermodulation Sensitivity
Cross Modulation ENOB
Second Order Intercept
IF Rejection Compression
Third Order Intercept Reciprocal Mix
Spur Free Dynamic Range dB Noise Figure
Overload Recovery Instantaneous Dynamic Range Image Rejection Blocking
Some Specifications are Not Very Useful
The Radio Goal:

Get the signals you want and... reject the rest!
BIG Signal Interference

- **ADC full scale dB below full scale (dBfs)**
- **Small Signal**
- **Large Signal**
- **25 MHz BW**
- **Tuner gain reduced by large signal**

- **Tuner at full gain**
- **ADC full scale**
- **dB below full scale (dBfs)**
- **Small Signal in the noise**
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A Third Important Consideration:

SWAP

Performance

System Longevity
Life of a System

System design and funding

Acquisition

Training

Operation and Maintenance

Installation

End of Life
(Start Over)
System End of Life

- Does not meet new mission requirements
- Too expensive to operate
- Lack of parts
- No manufacturer support
System Upgrade Life Extension

Acquisition
Training

Operation and Maintenance

System design and funding
Installation

Upgrade – Extended Capability

Extended service
Rapidly Moving Technology

Cell Phone:

2 years!
Long Lifetime

Hammer
> 50 Years!
Anticipation of Future Needs

Support multi-mission capability.

- COMINT
- ELINT
- Electronic Support
- Electronic Attack
- COMMS
- IO & Cyber

This requires hardware architectures to be developed “scalable” and more “flexible”.
Goal – More with Less

- Multi-mission Capability – Rapidly Customized
  - Flexible, Extensible, Upgradeable
    - MOSA (Modular Open System Architecture)
    - Software configurable: “Mission Ware”
    - Service Oriented Architectures

- Plug in modularity requires appropriate interface partitions
Enabling Technologies

- Higher Density SMT
- Improved Semiconductor Parts
- Improved packaging
- Improved Interfaces and Standards
WAIT!!! – What About the Upgrade Impact Of WHIZ-BANG Technologies?
DRS has extensively evaluated a potential next generation laser optical RF converter in the lab.

The converter had a 4 GHz instantaneous bandwidth at microwave.

Unfortunately, current state-of-the-art optical converters have a spur free dynamic range of only about 56 dB.

Temperature and vibration of optical systems are also major technical challenges.

Don’t expect this technology for at least 5 years, probably longer.
This technology touts dramatic size and cost reductions.

The Zero IF direct I/Q conversion to baseband technique is over 60 years old.

Unfortunately, it still has the same major spurious signal problems.

This is a physical constraint of the analog elements.

Don’t expect this to replace wide bandwidth, broad coverage high performance receivers.
Performance Comparison of Superheterodyne Vs. Zero IF (I/Q) Radio

**DRS SI-9150 “POLARIS”**

**Best-In-Class Zero IF Radio**

**TEST SIGNAL**

**NOISE FLOOR**

**SPURS**

Test Conditions:
Equal level test signals, receiver gains set for equal sensitivity.
State-of-the-art A/Ds can directly digitize HF, but acceptable performance above 100 MHz is not currently available.

Performance above 1 GHz is orders of magnitude worse than superheterodyne based converters.

High performance direct digitization of most RF is not in the foreseeable future.
High-Speed ADCs Dynamic Range

A/D Dynamic Range

Best-In-Class A/Ds

Nyquist Bandwidth, Hz

SNR, dBFS/Hz

Alpine @ 6GHz
Sparrow @ 18GHz
SMART INTEGRATION
Defining Breakpoints and Interfaces
Due to physics constraints, the analog portions of the RF converter change more slowly than the rest of the system.
Analog to Digital Converter

Bandwidth is increasing, but maximum dynamic range is not.
Digital Processing is Improving Rapidly
Moore’s Law
The Fifth Paradigm

Calculations per Second per $1,000

10^10
10^8
10^6
10^4
10^2
10
1
10^-2
10^-4
10^-6

Electromechanical
Relay
Vacuum Tube
Transistor
Integrated Circuit

Computer Servers are a Commodity Item
The Logical System Breakpoint

Relatively stable technology

Quickly changing technology

Breakpoint
Standardizing the Interface For Rapid Integration

- Data Formats
- Electrical Interface
- Mechanical Interface
Basic System Detail

- RF Converter
- A/D
- Digital Signal Processing
- VITA 49 Formatting
- I/O
- Additional Processing
- Storage
- GPS Timebase
- Controller
- Time Tag
- User

Breakpoint
VITA 49 is the ANSI approved, industry adopted standard for digitally formatting RF signal data.
VITA Radio Transport (VRT)

**RF Converter**

**Digital IF** Signal Data Packets

**Context Data Packets**
- Frequency
- Precision time tags
- Geo-location data
- Gain
- Etc.
Connecting the Modules:

Physical Data Transport
Physical Data Transport

Ethernet

- Well established industry standard (IEEE 802.3)
- Standard speeds up to 10 Gbps
- 100 Gbps now available
- TCP/IP for crowded links
- UDP for high throughput (>90% of nominal rate)
- Wire Ethernet suitable for short distance
- Fiber optic for long distance, 80km and more
Connecting the RF
Standard connectors simplify long term integration

A few standard coax types are widely used.

There are adapters for most types.
Common Plug-in Module Standards:

- VME
- VXI
- VPX
3U VPX or 6U VPX

- Relatively compact
- Conduction cooled
- High speed back plane
- Coax plugability using Vita 67.3
VITA 67.3 Backplane RF Connector Insert
VITA 67.3 Benefits

- Supports high performance RF to beyond 20 GHz
- Provides plug-in module servicing
- Allows simple functional upgrades using an RF insert
- Easy to implement without high cost
- Does not constrain RF innovation with rigid packaging rules.
Problems with Over-Constrained Standards

RF integration needs to be defined at an appropriate break-point.

RF technology is very different from digital technology, particularly with regard to spurs.

Rigidly specifying the details of the RF integration within the VPX module is technically dangerous.

With VITA 67.3 plugability, this sort of constraint is unnecessary.

A well designed break-point allows the maximum of flexibility and innovation.

DRS is now offering RF tuners with higher the density than what is possible with some proposed internal module standards.

Future cost reductions could also be imperiled with rigid standards.
Vesper SI-9173x Multi-Channel 6U VPX Tuner

- 2 MHz to 6000 MHz Frequency Range
- 6U, 1” Pitch, VPX UHF/VHF Tuner Module
- 100 MHz Digitized Bandwidth
- 10 Channels
- Independent Tuning or Phase Coherent
Upgrade Planning in Advance

- Identify core system elements:
  - Antenna
  - Tuner
  - Processor

- Identify easy to upgrade parameters:
  - Bandwidth (anticipate)
  - Frequency range (anticipate)
  - Number of channels
  - Signal processing

- Choose good system interface “break points”
  - RF
  - Data
Choose Carefully for the Future

You may be living with your choice for a long time.