Technology Trends, High Performance Radio Evolution and Smart Integration

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DRS Technologies

Company History

1960 Bethesda, Maryland

1973-2014 Gaithersburg, Maryland

1960 Communications Electronics Incorporated

1967 Watkins-Johnson

1999 Marconi North America

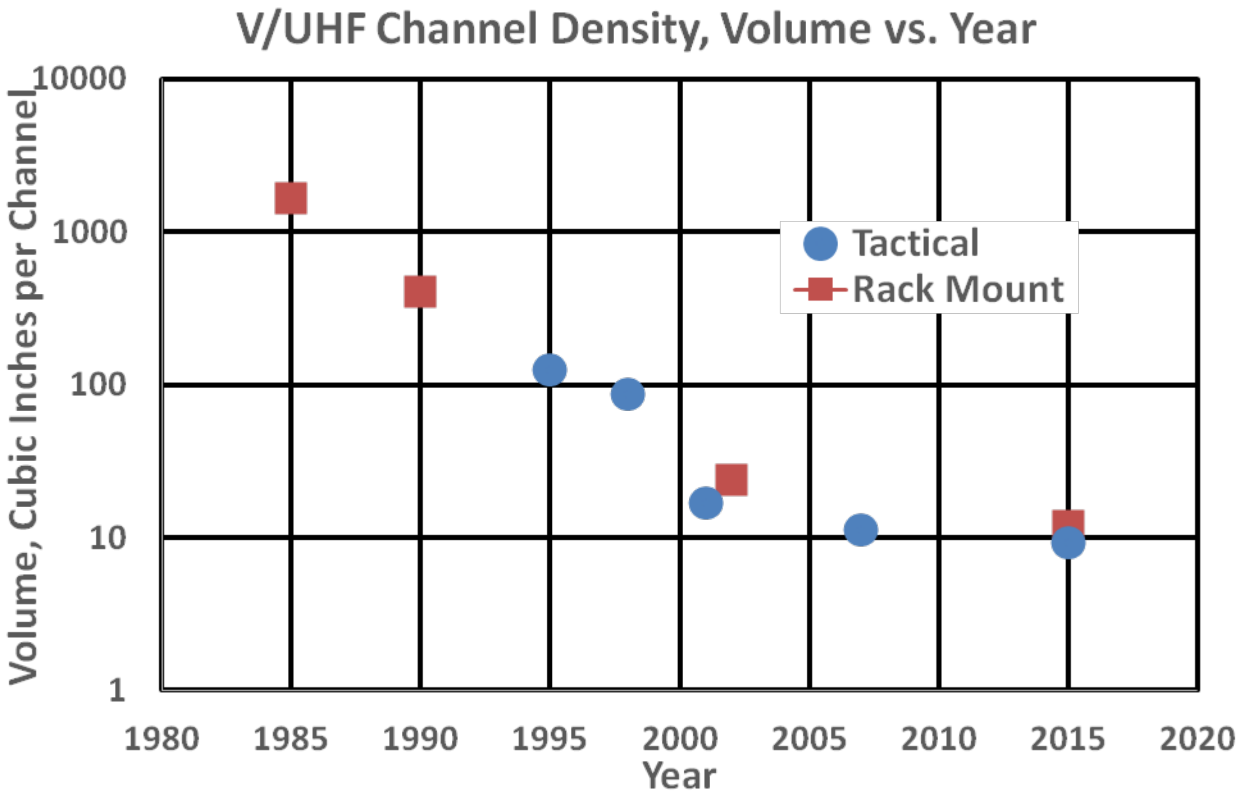
1999 BAE Systems

2002 Integrated Defense Technologies

2003 DRS Technologies

2015- Germantown, Maryland

Density vs. Time



RF Performance increases over time.
(Smaller *low performance* radios exist.)

SI-9170 Sparrow

NEXT GENERATION MICROWAVE

Sparrow: 3U VPX

QTY 2
SI-9158

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.

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Three Key RF Specifications

- Noise Figure
- Overload
- Spurious

Specifications:

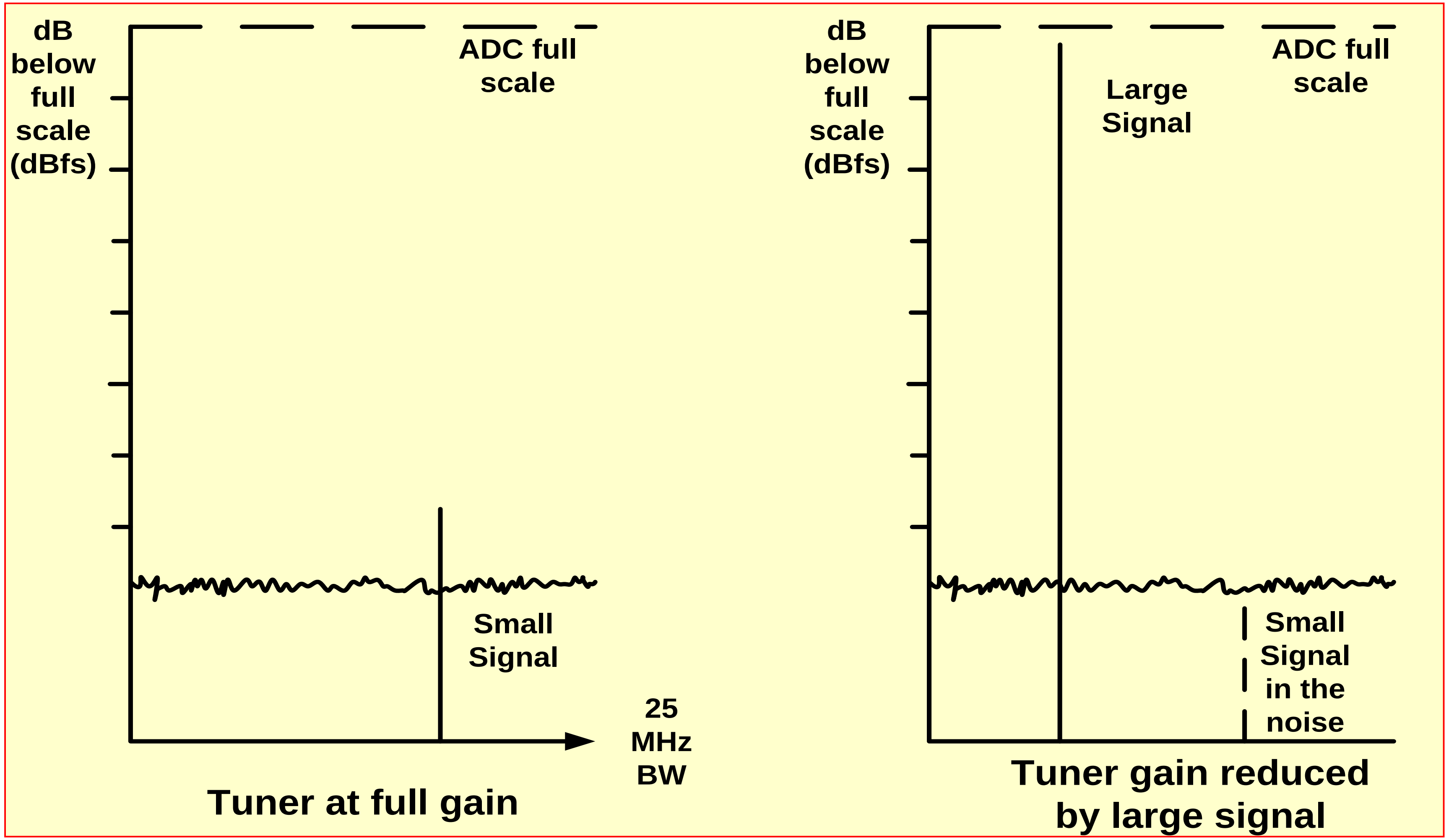
- MIL-STD-461
- Intermodulation
- Sensitivity
- Second Order Intercept
- ENOB
- Cross Modulation
- Noise Figure
- Spur Free Dynamic Range
- 1dB Compression
- Blocking
- IF Rejection
- Third Order Intercept
- Overload Recovery
- Reciprocal Mix
- Instantaneous Dynamic Range
- Image Rejection

Some Specifications are Not Very Useful

The Radio Goal:

Get the signals you want and… reject the rest!

BIG Signal Interference



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A Third Important Consideration:

SWAP

Performance

System Longevity

Life of a System

System design and funding

Acquisition

Installation

Training

Operation and Maintenance

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

System design and funding

Acquisition

Installation

Training

Operation and
Maintenance

Upgrade –
Extended Capability

Extended
service

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Rapidly Moving Technology

Cell Phone:

2 years!

Long Lifetime

Hammer
> 50 Years!

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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

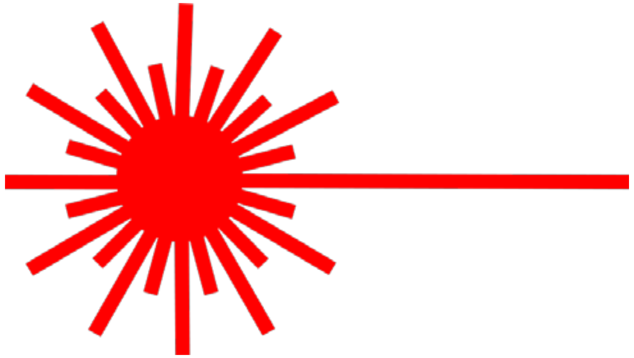
- Multi-mission Capability – Rapidly Customized
  - Flexible, Extensible, Upgradeable
    - MOSA (Modular Open System Architecture)
    - Software configurable: “Mission Ware”
    - Service Oriented Architectures
- Plug in modularity requires appropriate interface partitions

Enabling Technologies

- Higher Density SMT
- Improved Semiconductor Parts
- Improved packaging
- Improved Interfaces and Standards

WAIT!!! – What About the Upgrade Impact Of WHIZ-BANG Technologies?

Laser Optical RF Converters



- 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.

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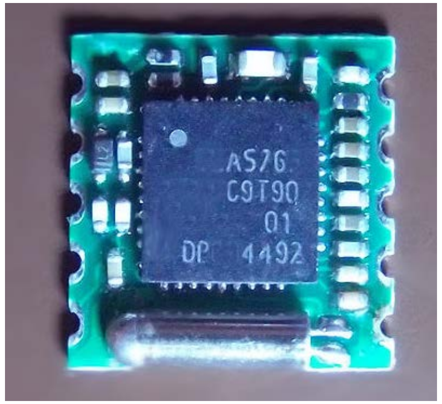
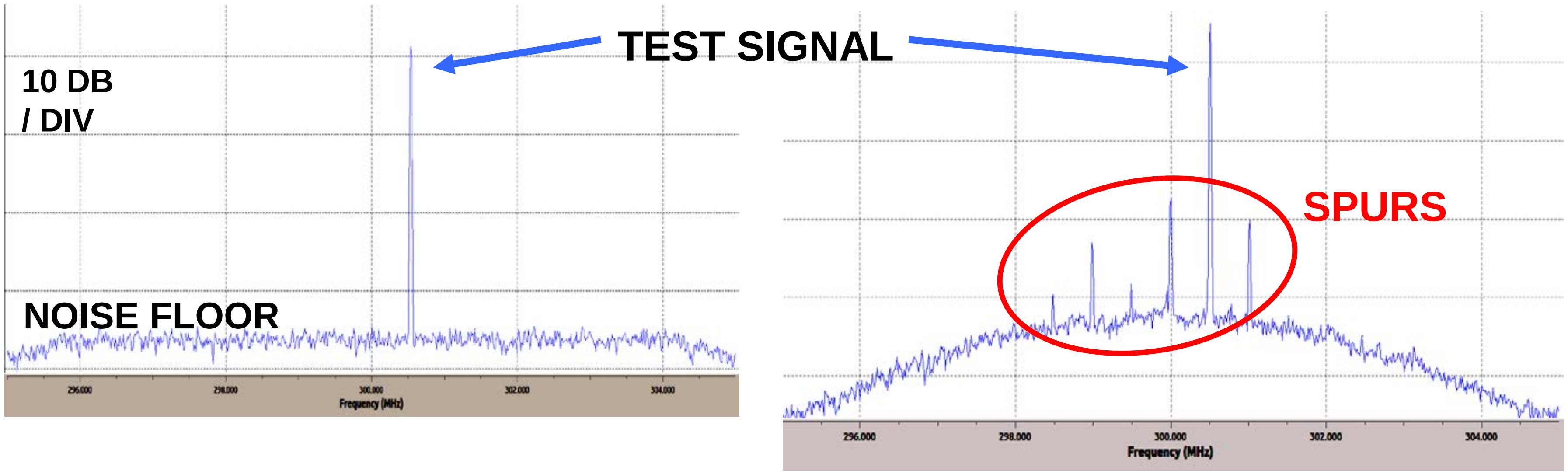
Zero-IF (I/Q) Receiver On A Chip



- **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 Conditions:

Equal level test signals, receiver gains set for equal sensitivity.

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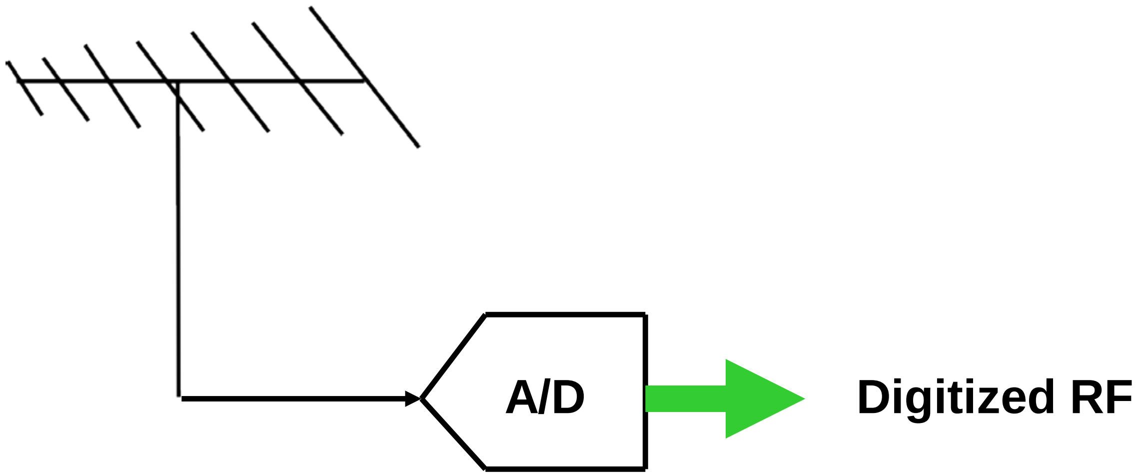
High-Speed ADCs for Direct RF Digitization



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.

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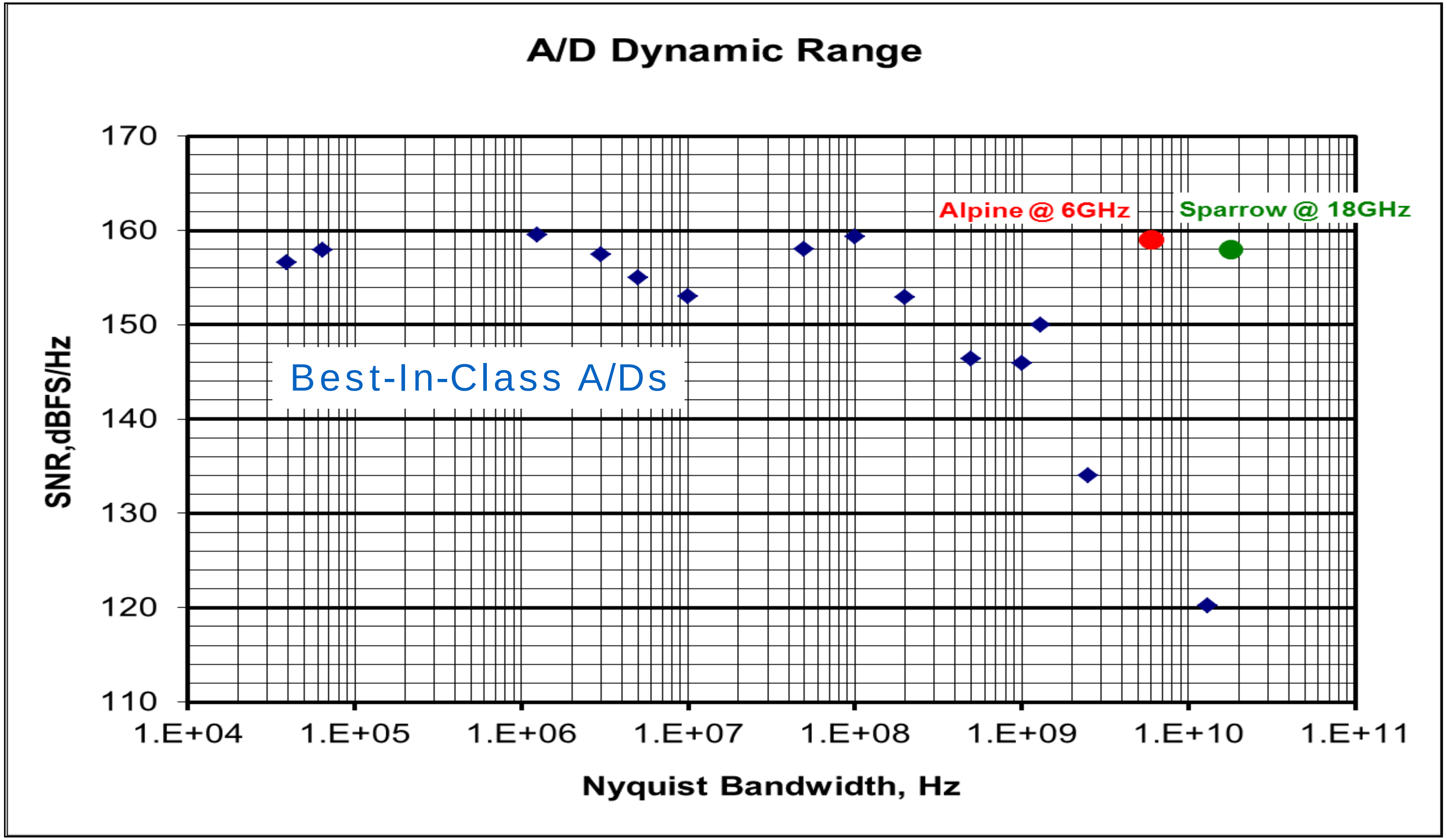
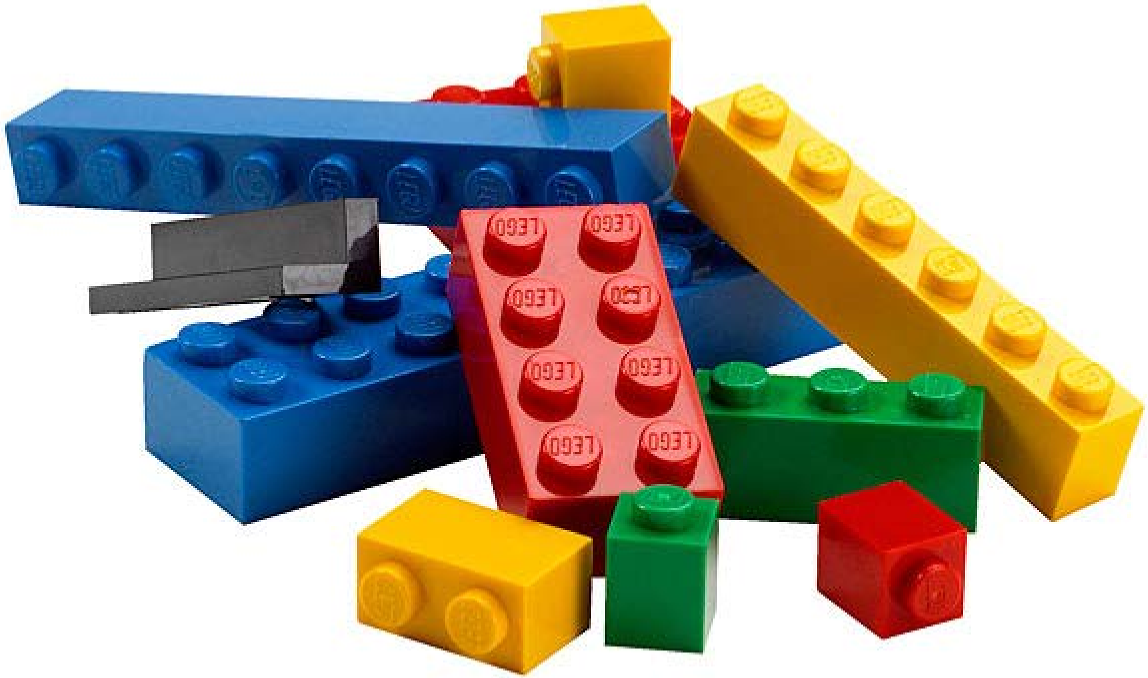
High-Speed ADCs Dynamic Range



SMART INTEGRATION

Defining Breakpoints and Interfaces



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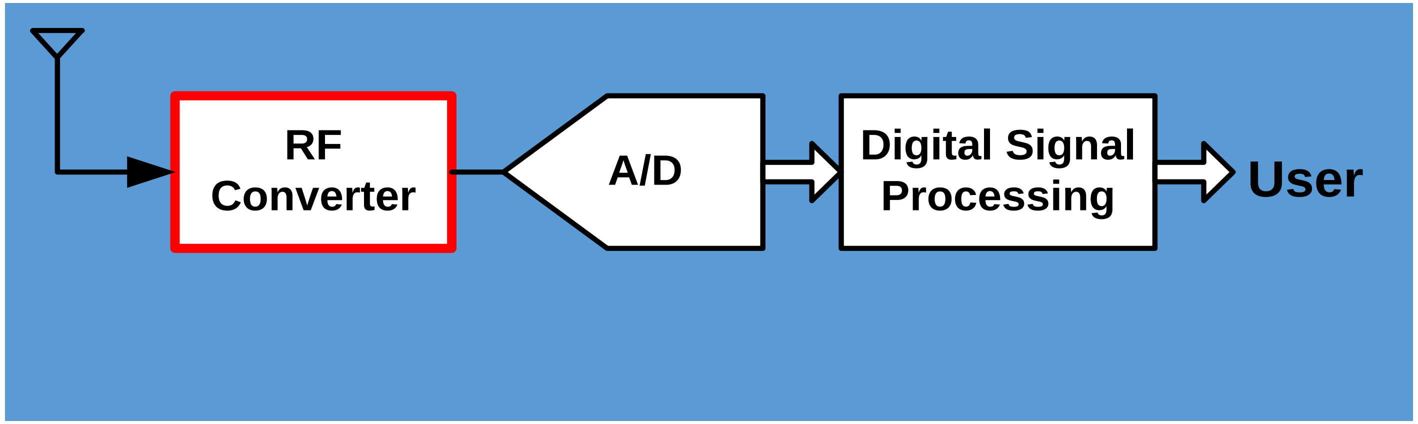
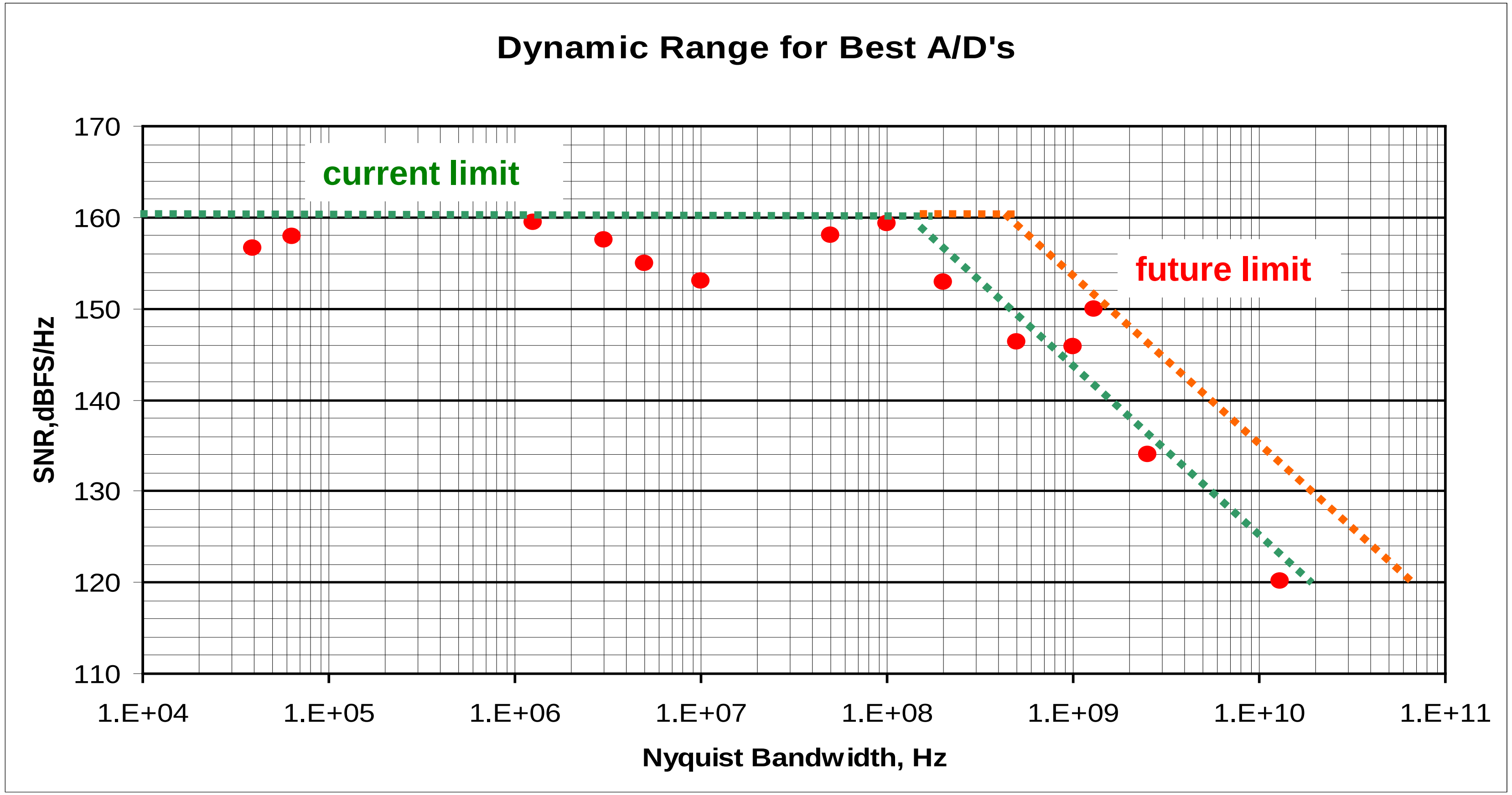
RF Converter

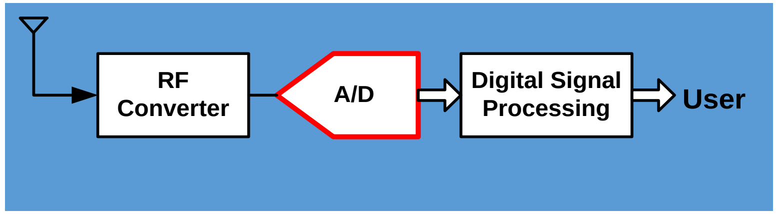
Due to physics constraints, the analog portions of the RF converter change more slowly than the rest of the system.



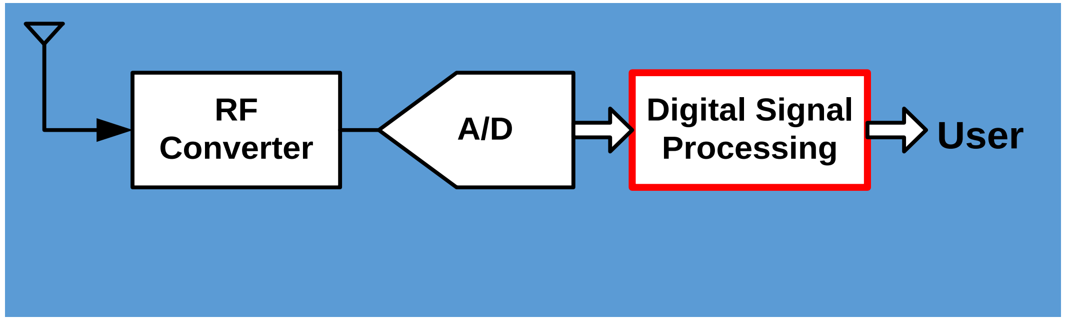
Analog to Digital Converter

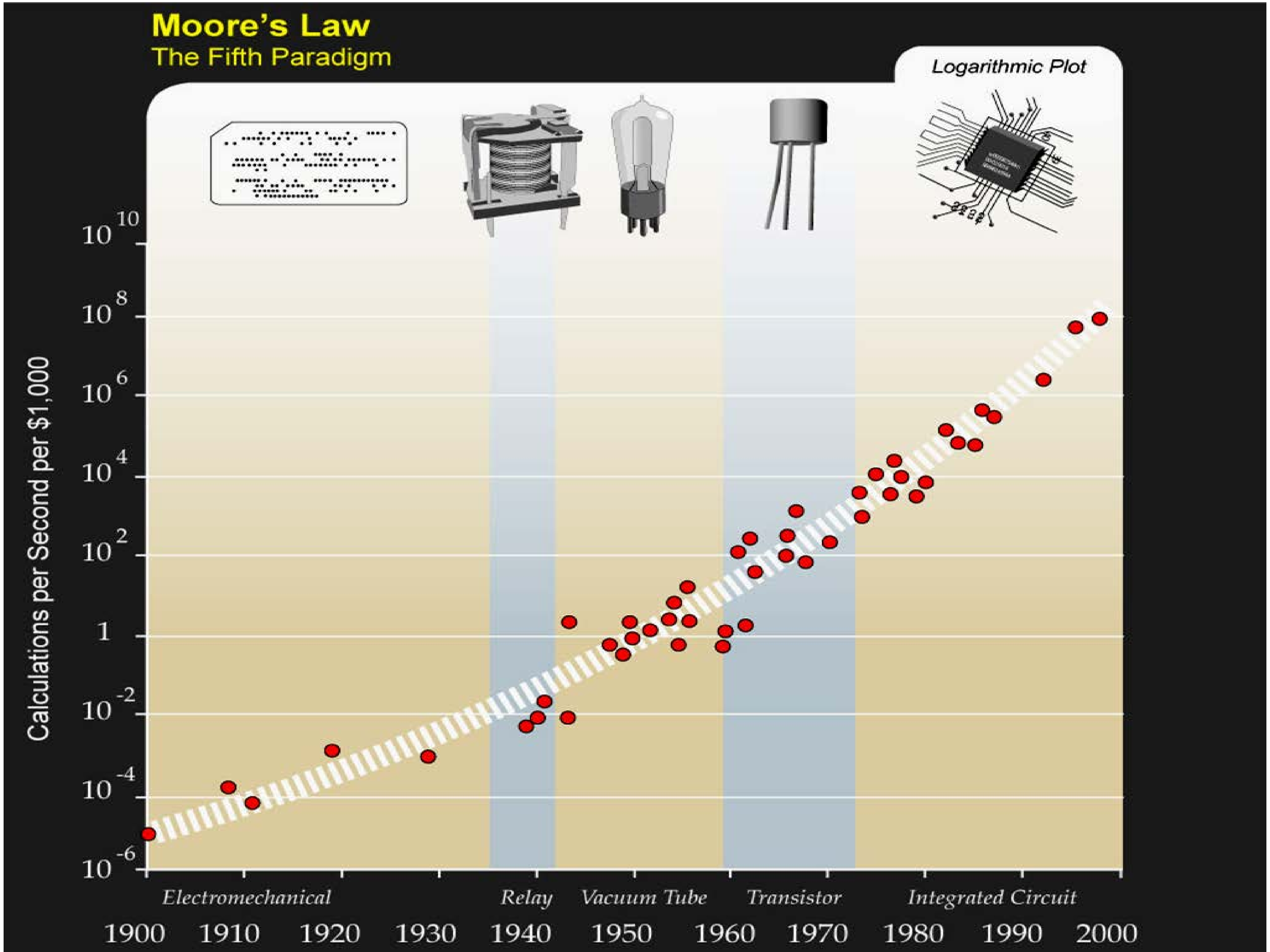
Bandwidth is increasing, but maximum dynamic range is not.





Digital Processing is Improving Rapidly

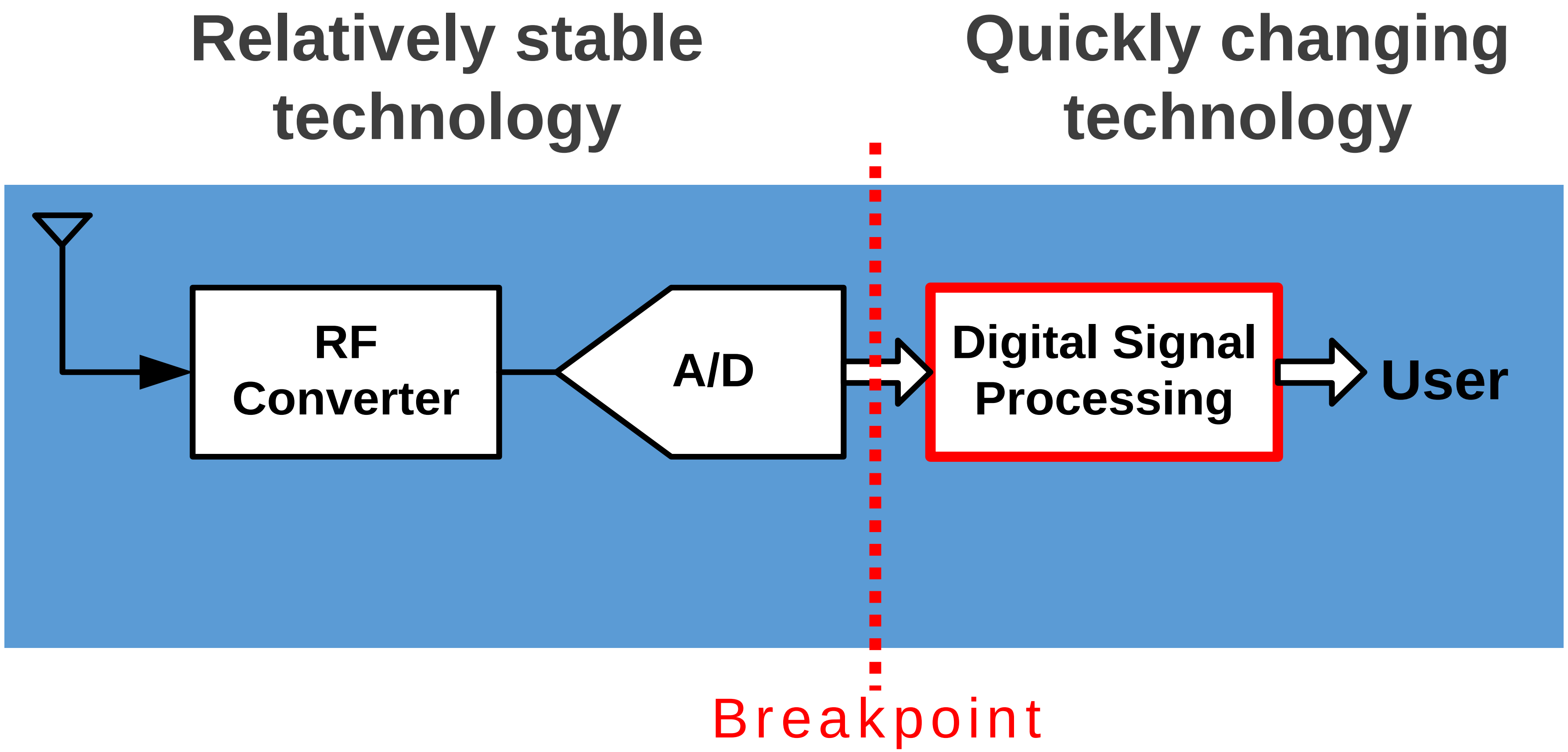




Moore's Law
The Fifth Paradigm
Logarithmic Plot
Calculations per Second per $1,000
10^{10}
10^{8}
10^{6}
10^{4}
10^{2}
1
10^{-2}
10^{-4}
10^{-6}
Electromechanical
Relay
Vacuum Tube
Transistor
Integrated Circuit
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000

Computer Servers are a Commodity Item

The Logical System Breakpoint



Standardizing the Interface For Rapid Integration

- **Data Formats**
- **Electrical Interface**
- **Mechanical Interface**

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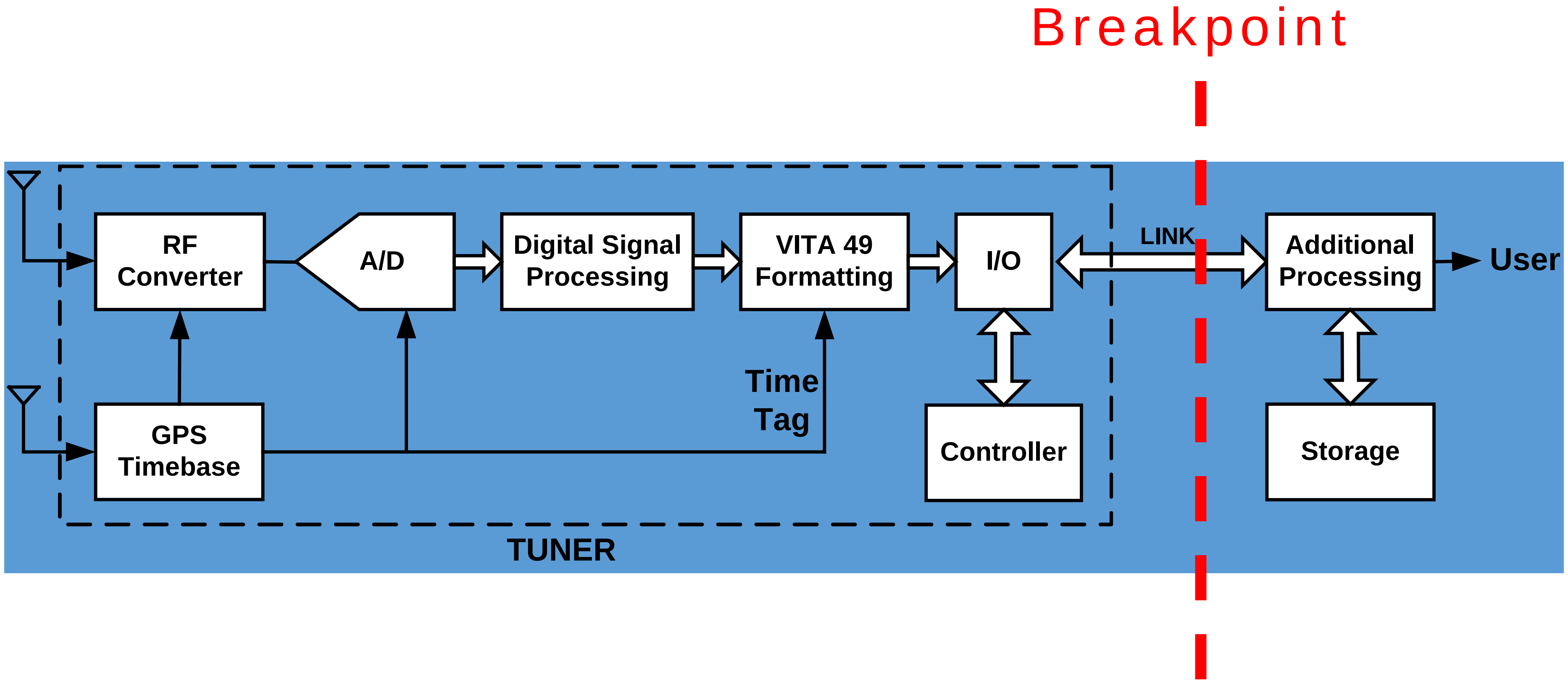
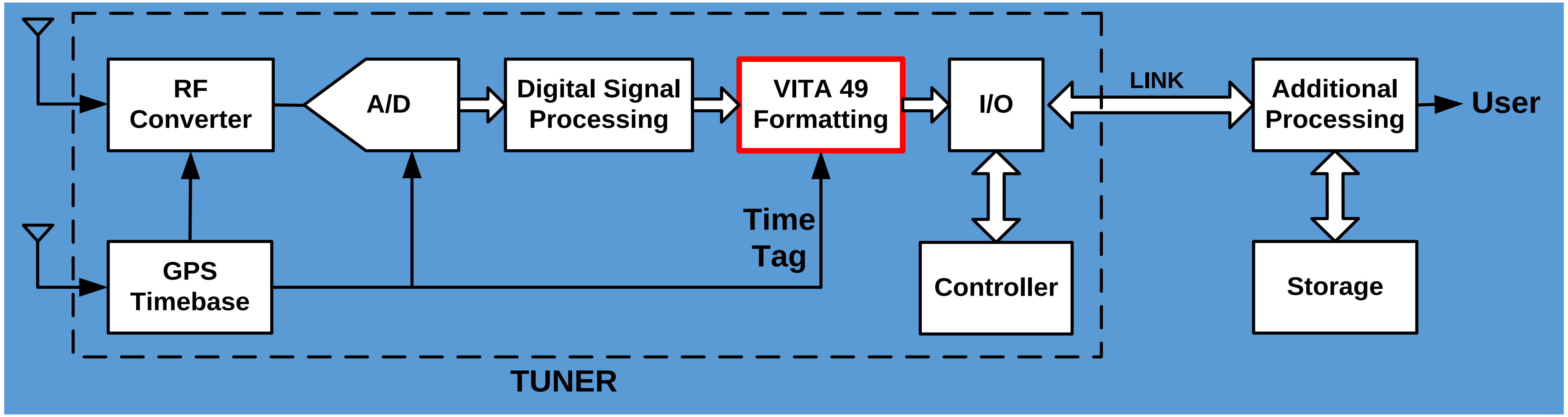
Basic System Detail



VITA Radio Transport (VRT)

VITA 49 is the ANSI approved, industry adopted standard for digitally formatting RF signal data.



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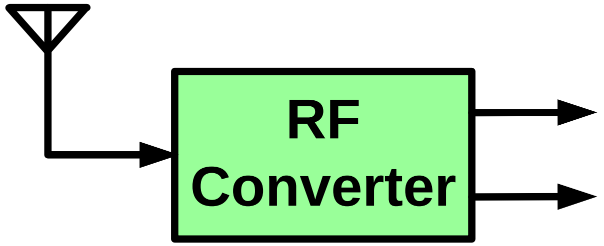


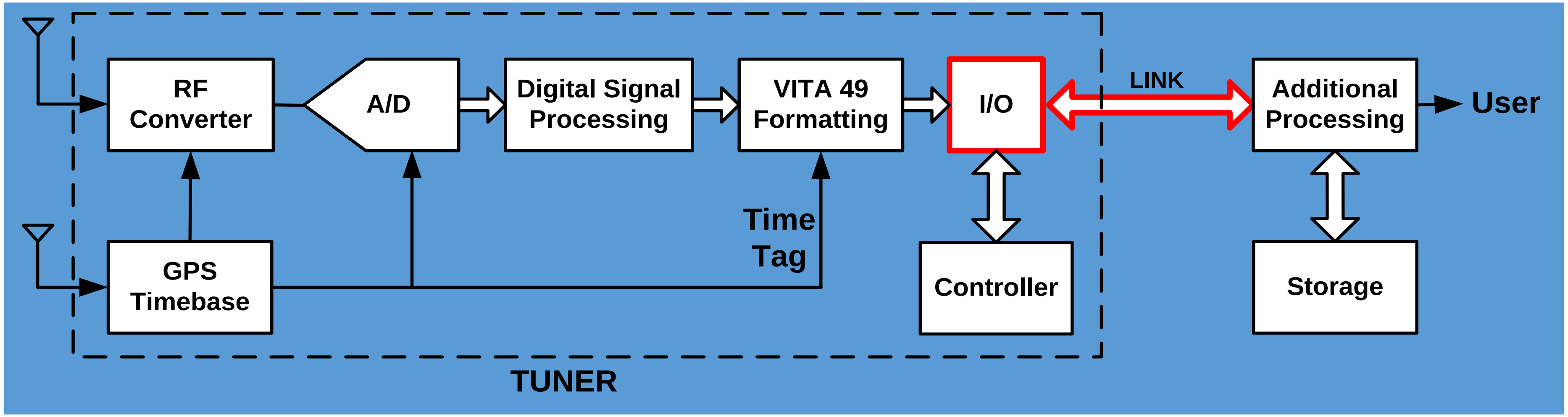
Digital IF Signal Data Packets

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.

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Common Plug-in Module Standards:

- VME
- VXI
- VPX

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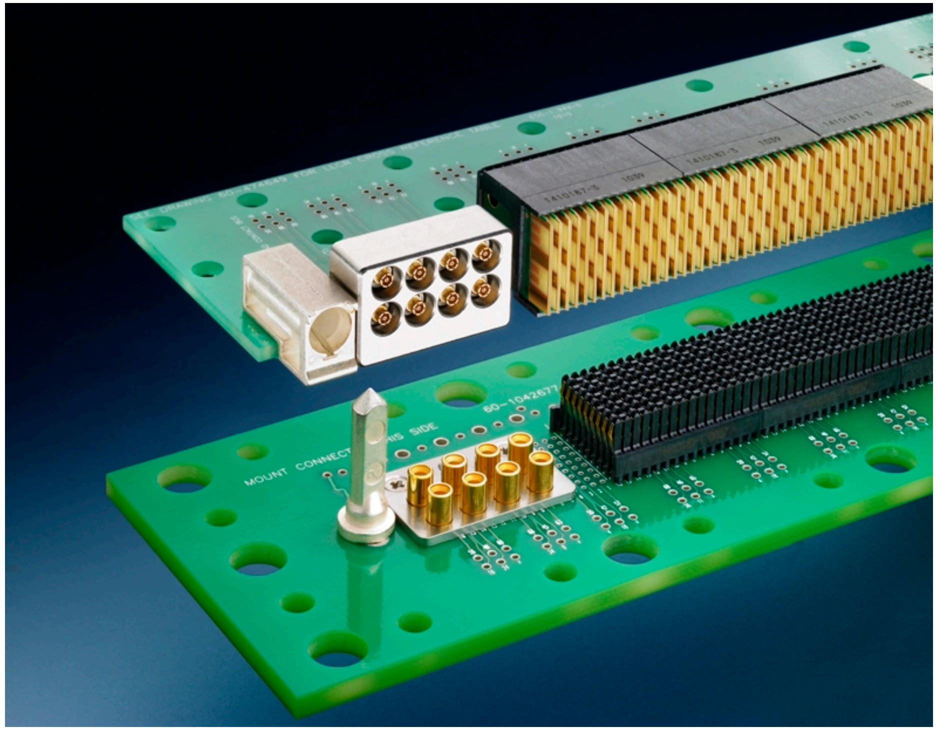
3U VPX or 6U VPX

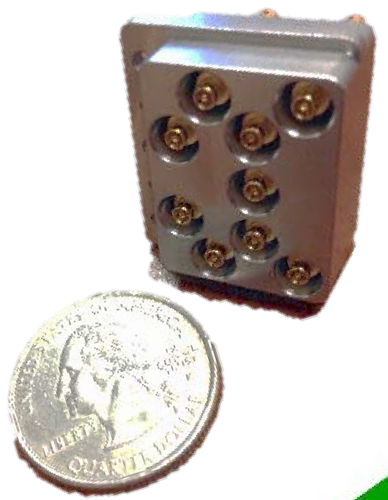
- Relatively compact
- Conduction cooled
- High speed back plane
- Coax plugability using Vita 67.3

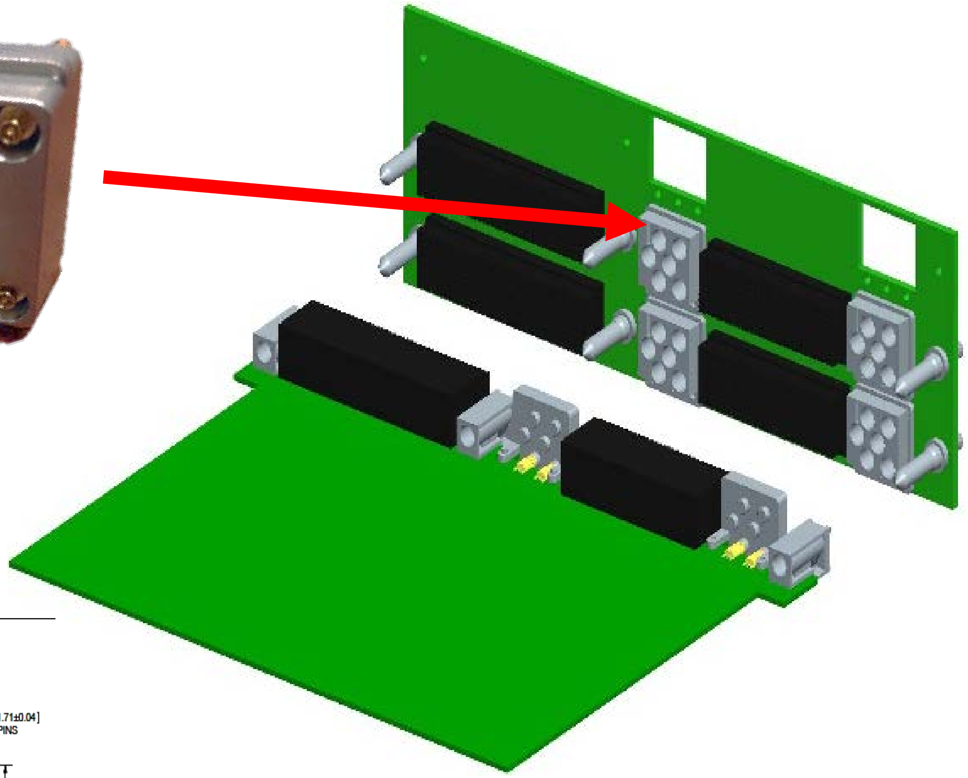


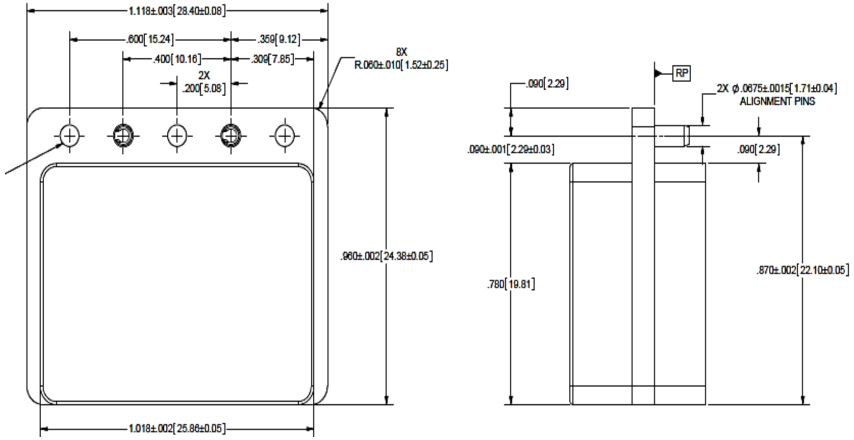
3U VPX

6U VPX

VITA 67.3 Backplane RF Connector Insert

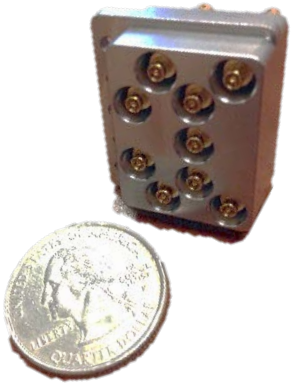






Standard Outline

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

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Choose Carefully for the Future

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