Your Mission…
Our Commitment

Practical Use of Reconfigurable Radios in Air Combat Training Systems

SDR'11 - WInnComm 2011 Presentation
10 February 2011

Michael Cary, DRS TCS Program Manager
Mcary@drs-ds.com 850-302-3797

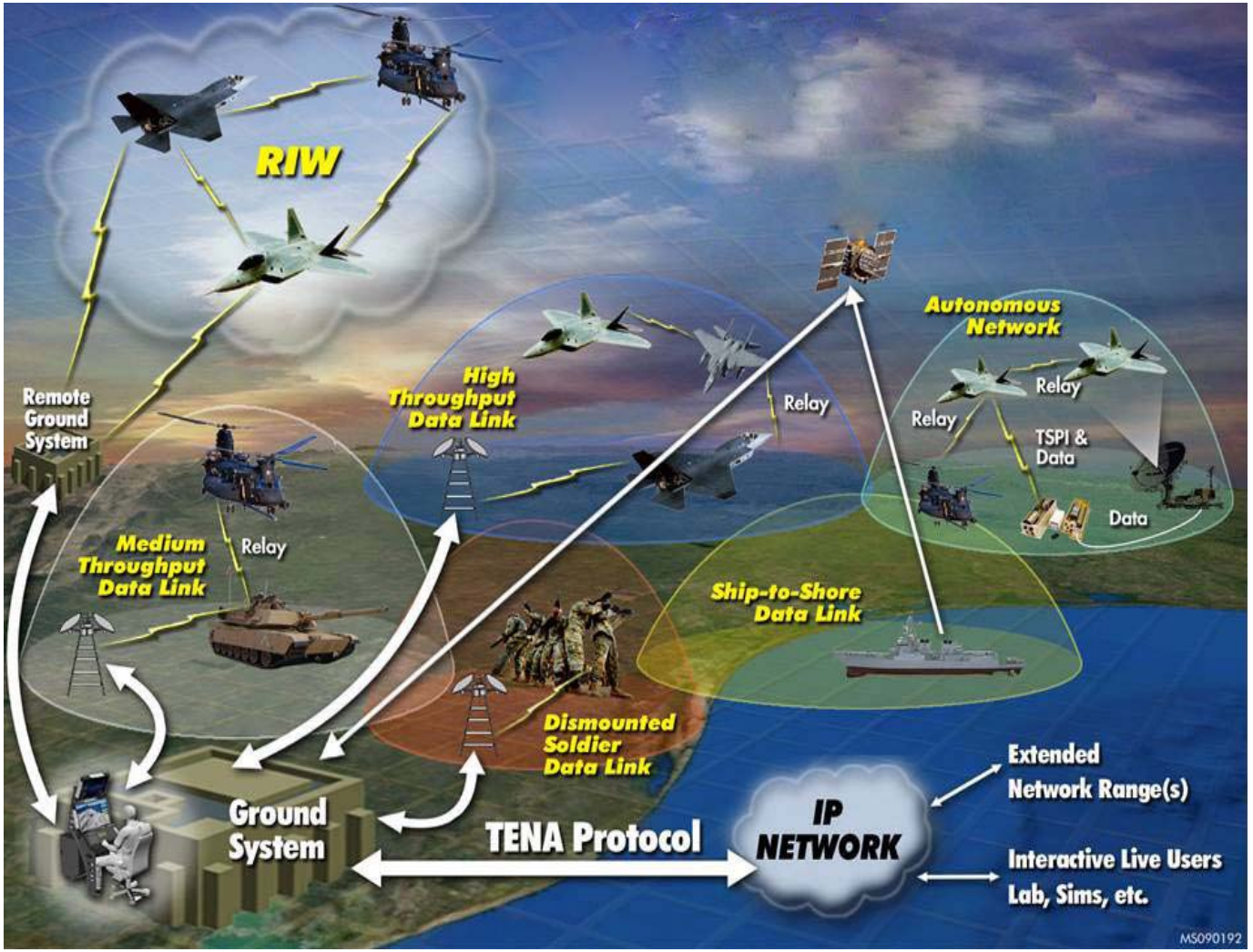
Robert Normoyle, DRS SSI System Architect
Rnormoyle@drs-ds.com 301-944-8250

DRS
DEFENSE SOLUTIONS

Today's Overview

SDR Interoperability and Reconfigurable Concepts

- Identifying a reference Platform and Target Radio
- Waveform Modeling
- Development Flow and Verification
- Major Challenges
- Software Configuration Architecture
- Conclusion



DRS Air Combat Training
SDR Goals

- Per The Net-centric Enterprise Solutions for Interoperability (NESI v3.1) best practices (BP 1880, rev 5) in 2009:

  → "**Justify, document, and obtain a waiver for all radio terminal acquisitions that are not JTRS/SCA compliant.**"

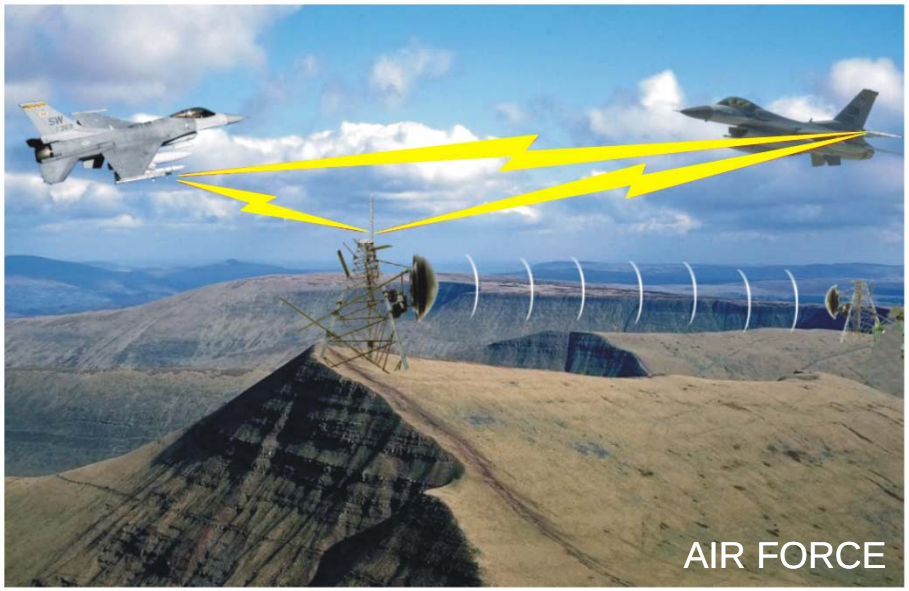
- Many US tactical and strategic data links may be upgraded to JTRS

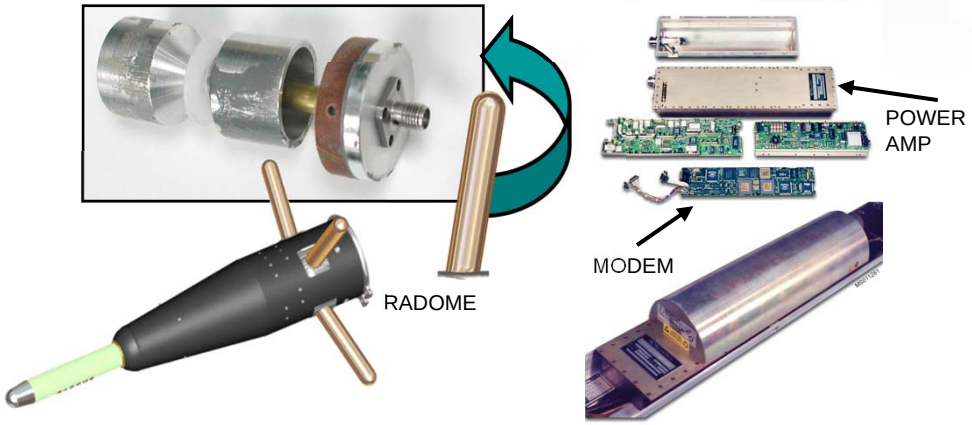
- DRS goal – upgrade product radio links to JTRS/SCA standards: best practice.

- DRS internal investment for advanced SDR data link:
  - JTRS/SCA compliant
  - Support legacy waveforms and future waveform(s)
  - Consolidate HW baselines, increase waveform baselines via reconfigurable SDR
  - Focus on airborne networks of the Test and Training community

- Prepare airborne training instrumentation for **GIG** interface.

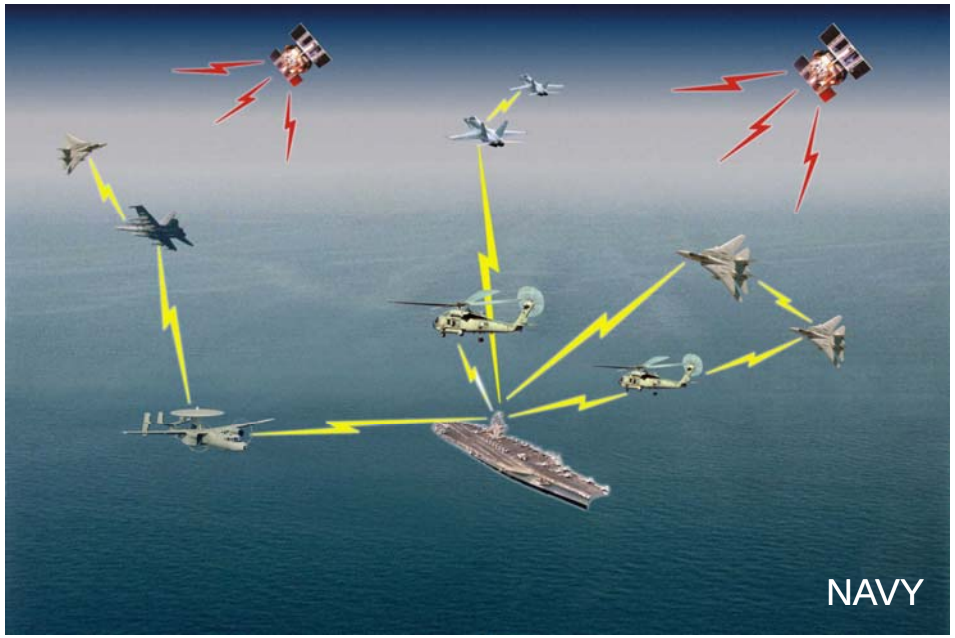
Legacy Waveform Overview





TDMA DATA LINK SUPPORTS:

- Rangeless Operations
- Live Monitor
- Live Monitor with Control
- Fixed Range Operations
- Shipboard Operations
- Includes relay and is self-forming/healing

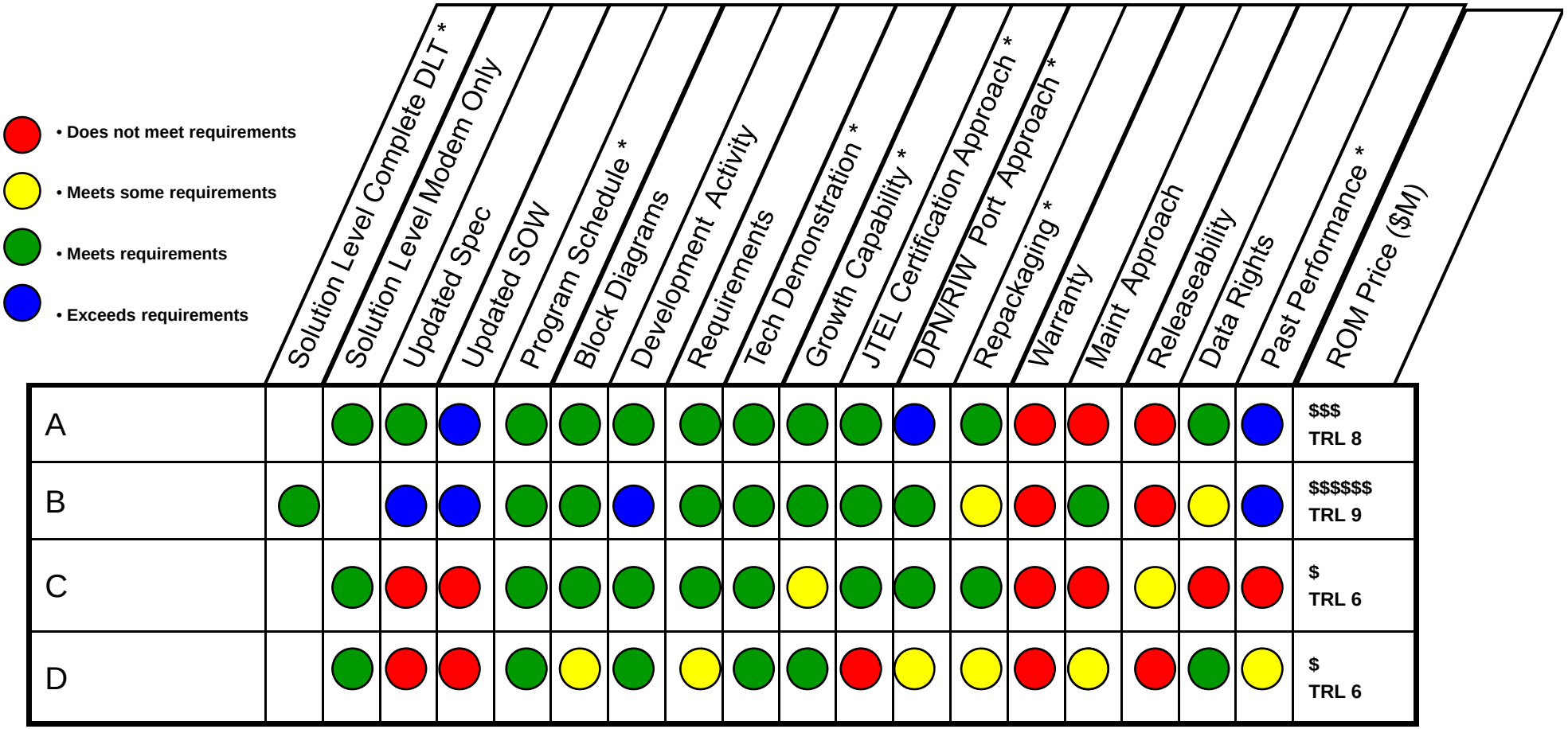


Training Waveform Characteristics

- **Link success:** 99%
- **Bit Error Rate (BER):** 10^{-6} (max).
- **Frequency:** Upper L-band and S-band
- **Network:** TDMA with 330 slots per second
- **Modulation:** Minimum Shift Keying (MSK)
- **Bandwidth:** 2.0 MHz; 99% power bandwidth
- **Waveform char:** buffer time, preamble, header and CRC
- **Encoding:** Viterbi and convolutionally interleaved.

Identifying a Target Platform (Dec 2009)

- Summarized Assessments from 58 Point Standard
- Evaluation Criteria on 19 Issues



DRS-SS Overview

Surveillance Receivers

HF to 40 GHz

SI-9155

250 MHz to 26 GHz

Picoceptor

2 MHz to 3 GHz
Freq Ext to 12 GHz

SI-8500

2 to 40 GHz

Software Definable Transceivers

SI-7051

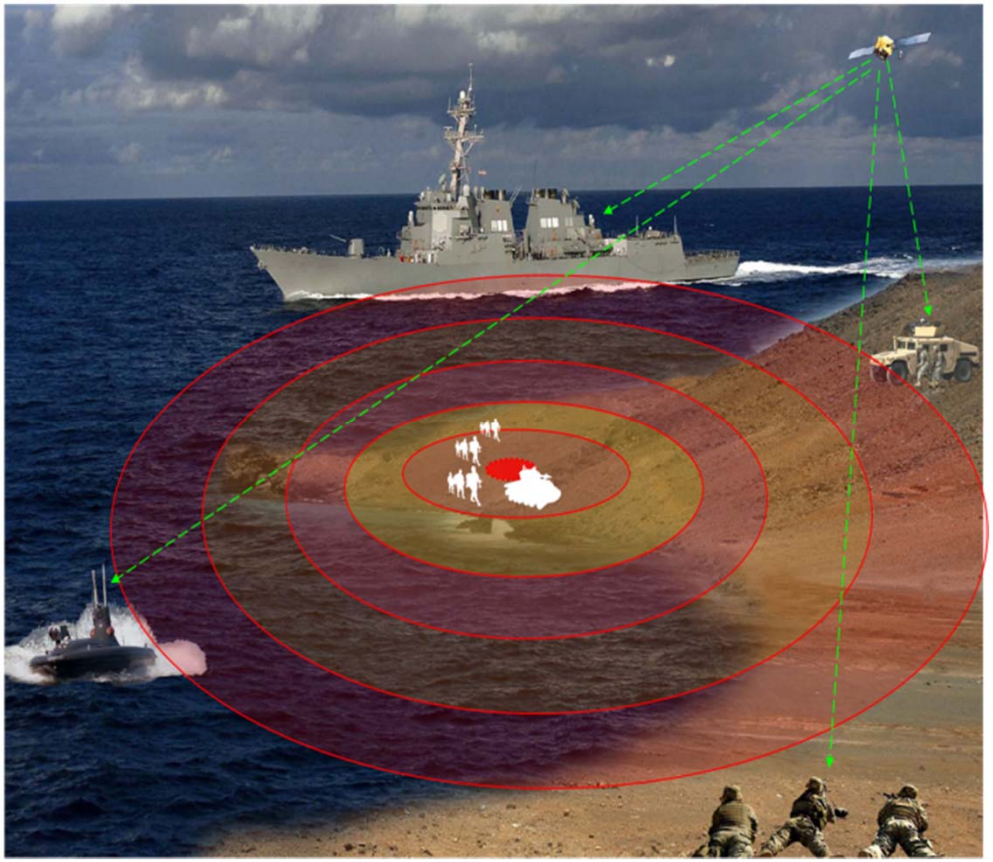
2 MHz-6 GHz

DART

2 MHz - 3 GHz

High Speed Digital Recorders

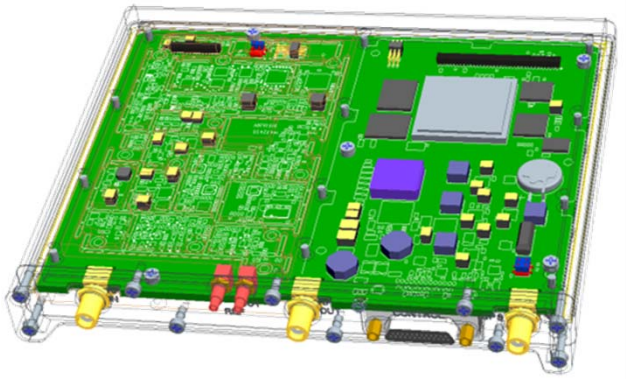
Applications:
F/TDOA Geolocation
Wireless Demods



DART SDR Overview

DART

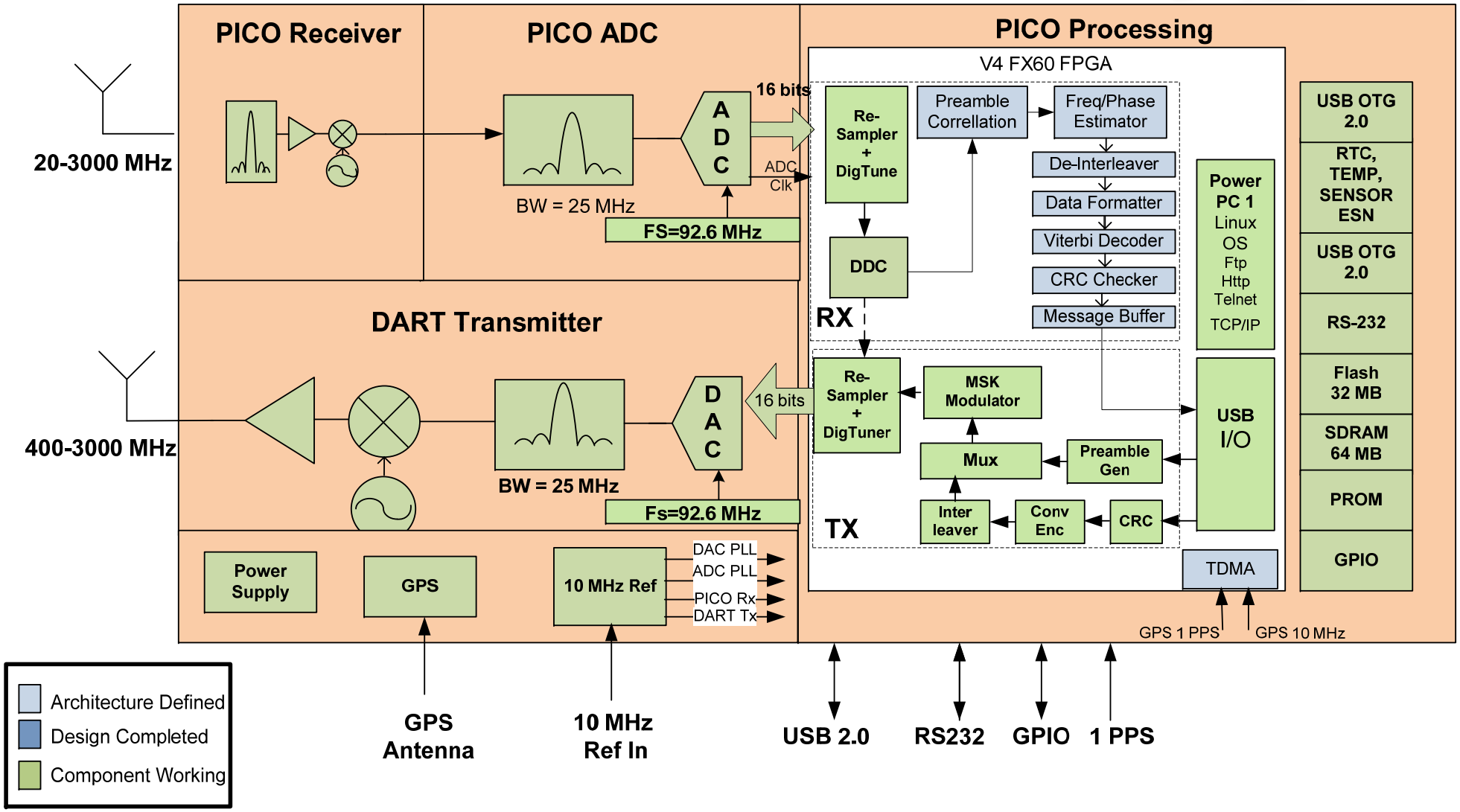
- **D**RS Defense Solutions
- **A**dvanced
- **R**adio
- **T**ransceiver



Specifications:

Frequency range:	400-3000 MHz
Bandwidth:	25 MHz
Size:	5” x 6” x 0.9”
Weight:	< 2 lbs
Interfaces:	USB 2.0 OTG, RS-232, 1 PPS, 10 MHz
Processor:	Xilinx V4FX60

DART Block Diagram



Waveform Processing

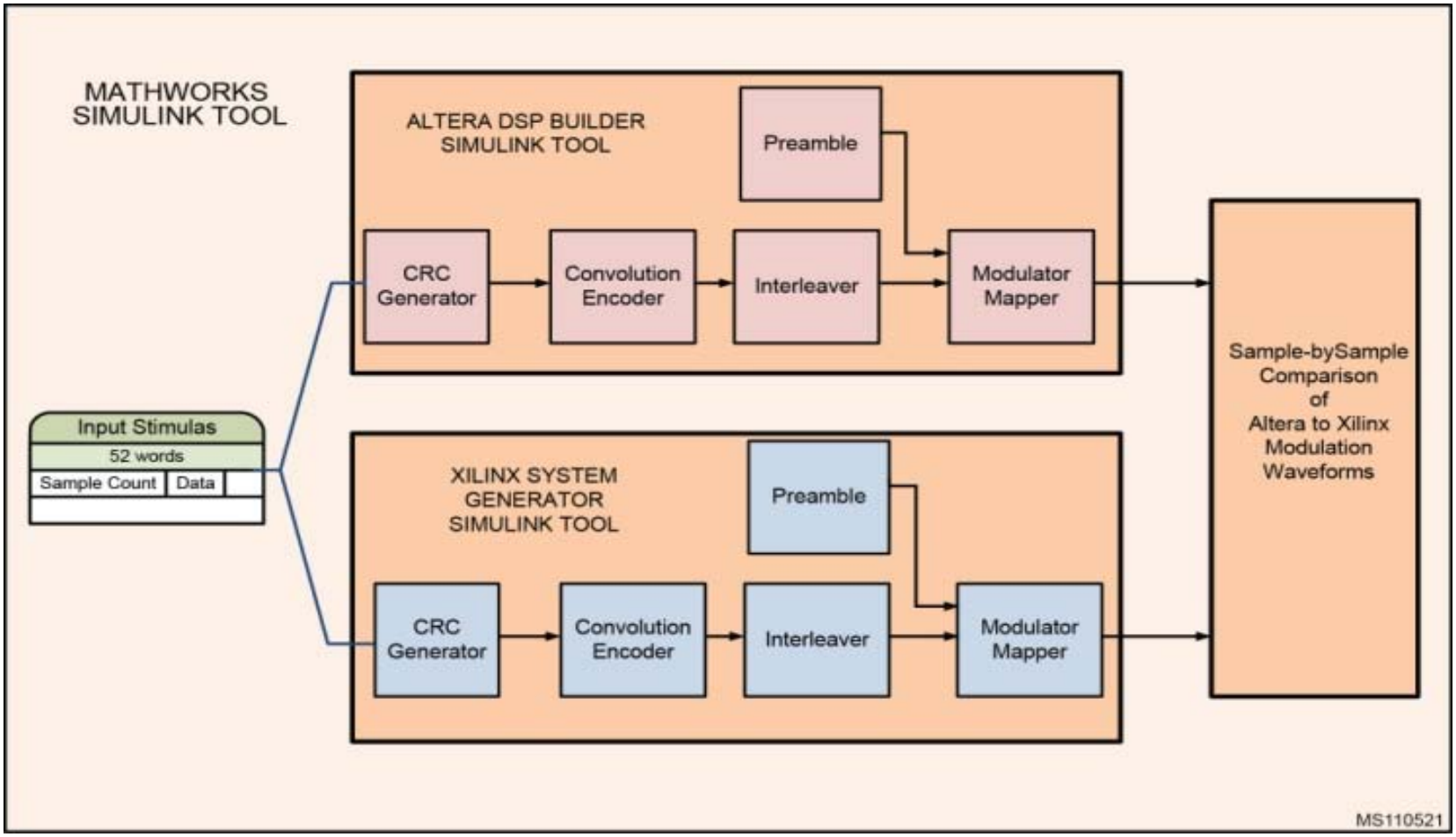
Modulation and Demodulation Functional blocks:

- Preamble Generator/Detection
- Frequency/Phase Estimation
- Resampler/Rate Adjustment
- Timing/Slot Controller
- Convolution Encoding/Decoding
- Interleaver/De-Interleaver
- Modulation Mapper (BPSK, MSK, etc.)
- CRC Generator/Checker

DRS Waveform Porting Process

DRS Defense Solutions Waveform Porting Process <u>Demonstrated</u>

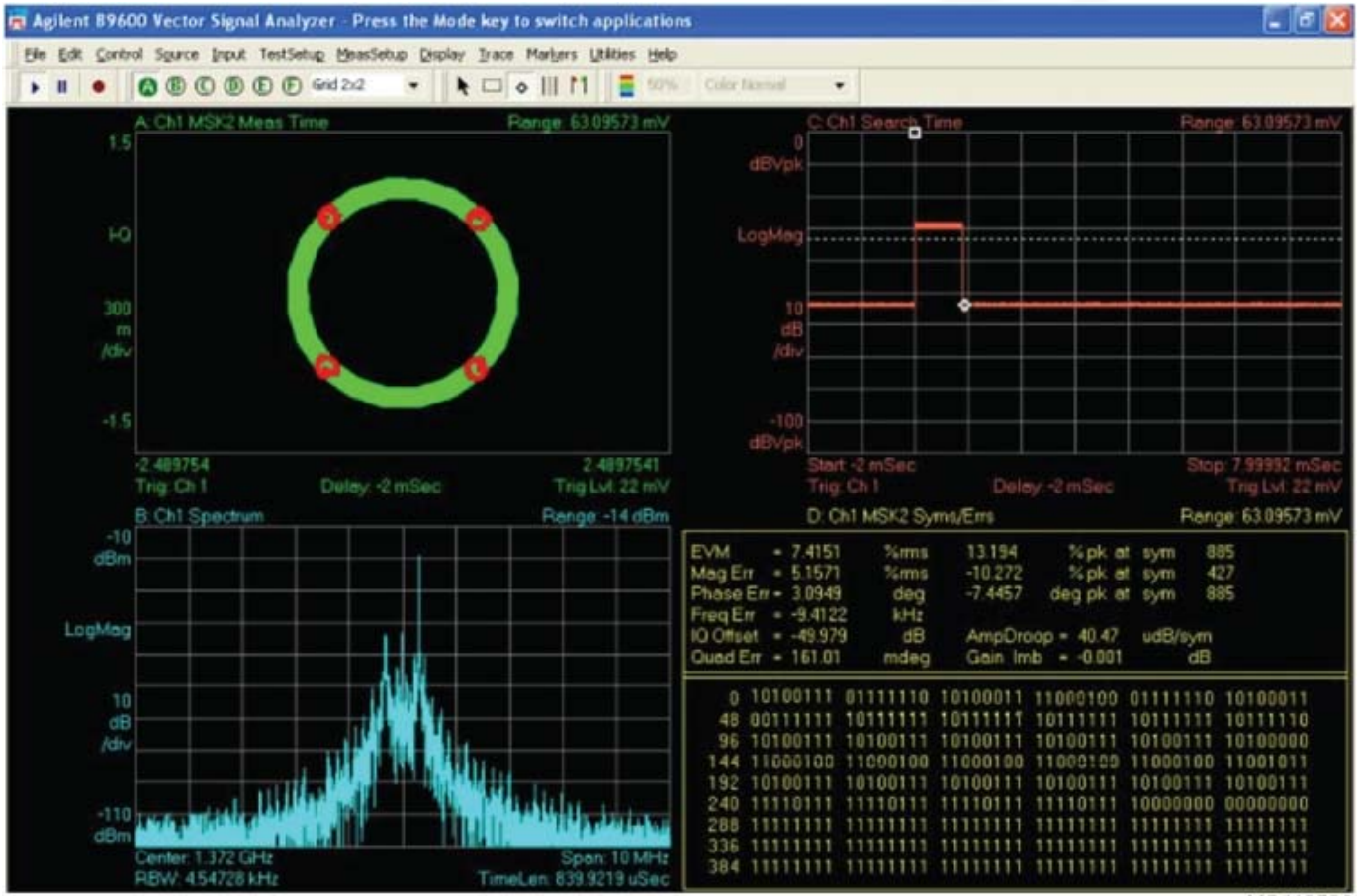
- Functionally compatible HW platform
- Functionally compatible software architecture
- Integrated toolset flow from modeling thru test



Laboratory analysis of transmitter

MXA Analyzer provided invaluable feedback on transmitters operation:

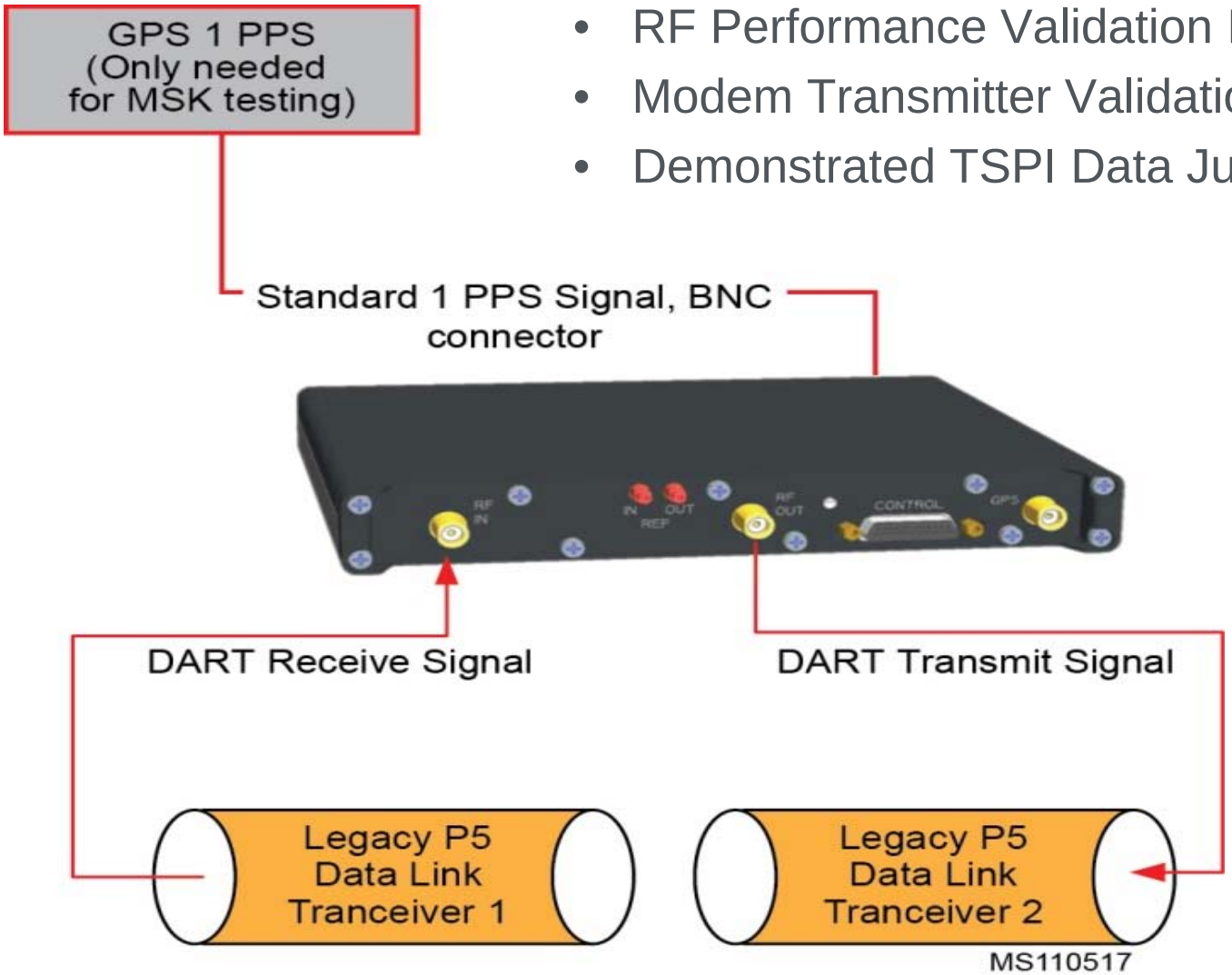
1. Spectrum characteristics
2. Constellation shape
3. Error Vector Magnitude
4. Preamble content
5. Time length
6. Number of bits
7. Data pattern



DART Performance Validated

Proved Performance in three phases:

- RF Performance Validation Nov 2010
- Modem Transmitter Validation May 2011
- Demonstrated TSPI Data July 2011



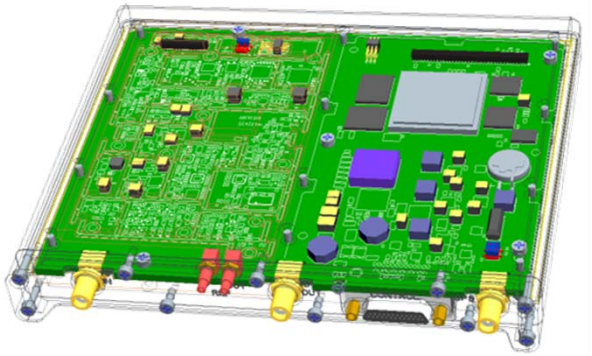
Summary of Waveform Porting Approach

Accomplished:

- **Model** P5 legacy waveform with SIMULINK
- **Validate** RF performance of DART
- **Port** P5 legacy waveform to DART (Altera to Xilinx)
- **Verify performance** of DART waveform is compatible with legacy P5 pod

Future:

- **Integrate** into product baseline as tech refresh
- **Enhance** network with new SDR waveforms and capability

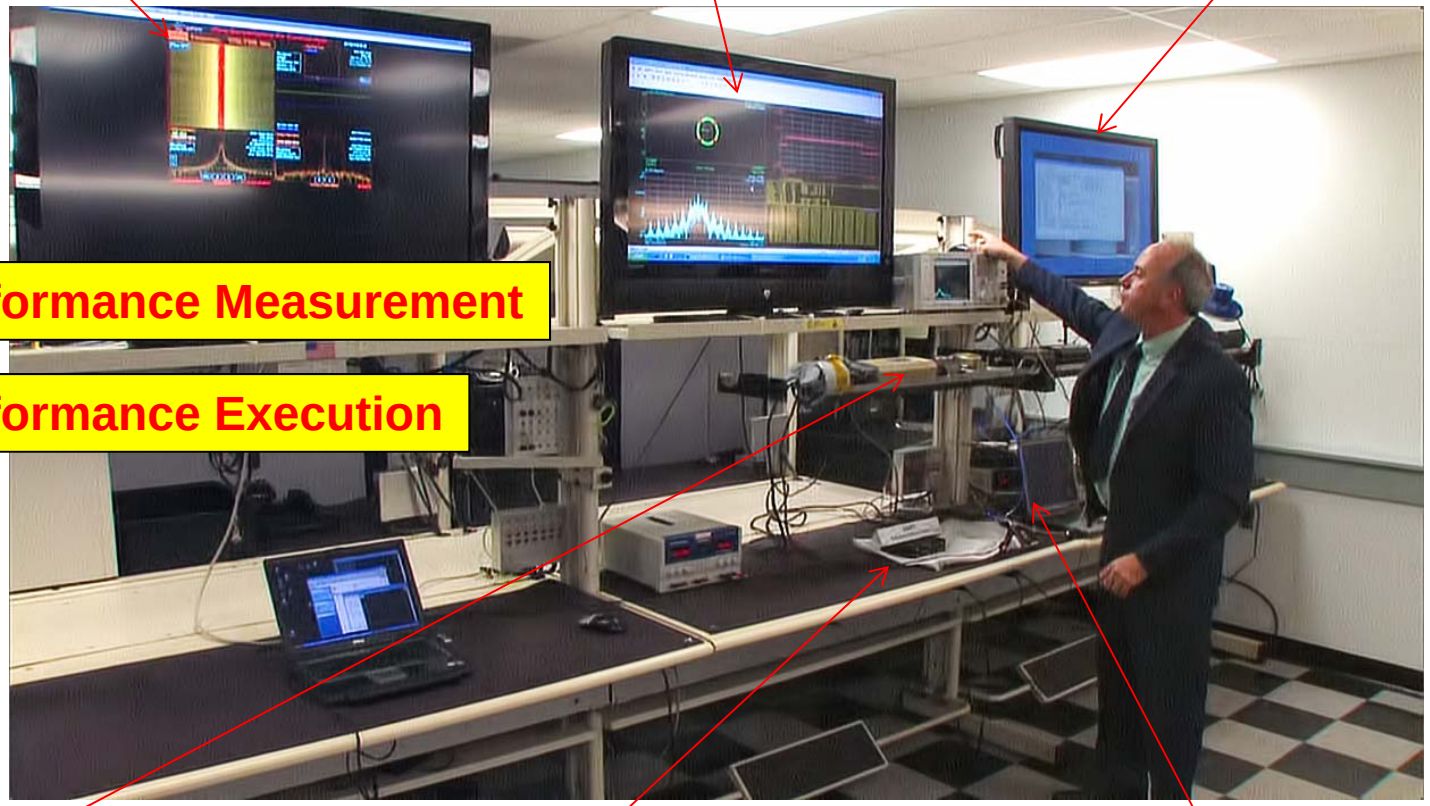


Demonstrations Setup

Analysis & Survey Tool

Vector Signal Analyzer

Modem CDU Display



DLT Performance Measurement

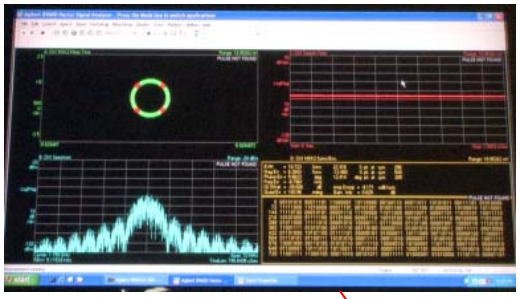
DLT Performance Execution

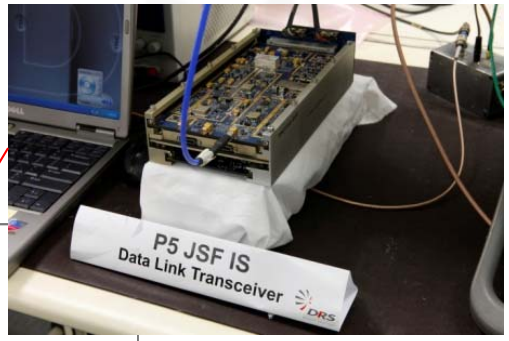
P5 Pod

DART Modem

5th Generation AC P5 Internal Sub-system Modem

DART SDR Demon





GPS RECEIVER

LAB GPS DISTRIBUTION

JSF MODEM

1 PPS

1 PPS

Analyzer

VECTOR SIGNAL ANALYZER

CDU

Out of Net

COMPUTER

DART

TX

COUPLER

RX

RX

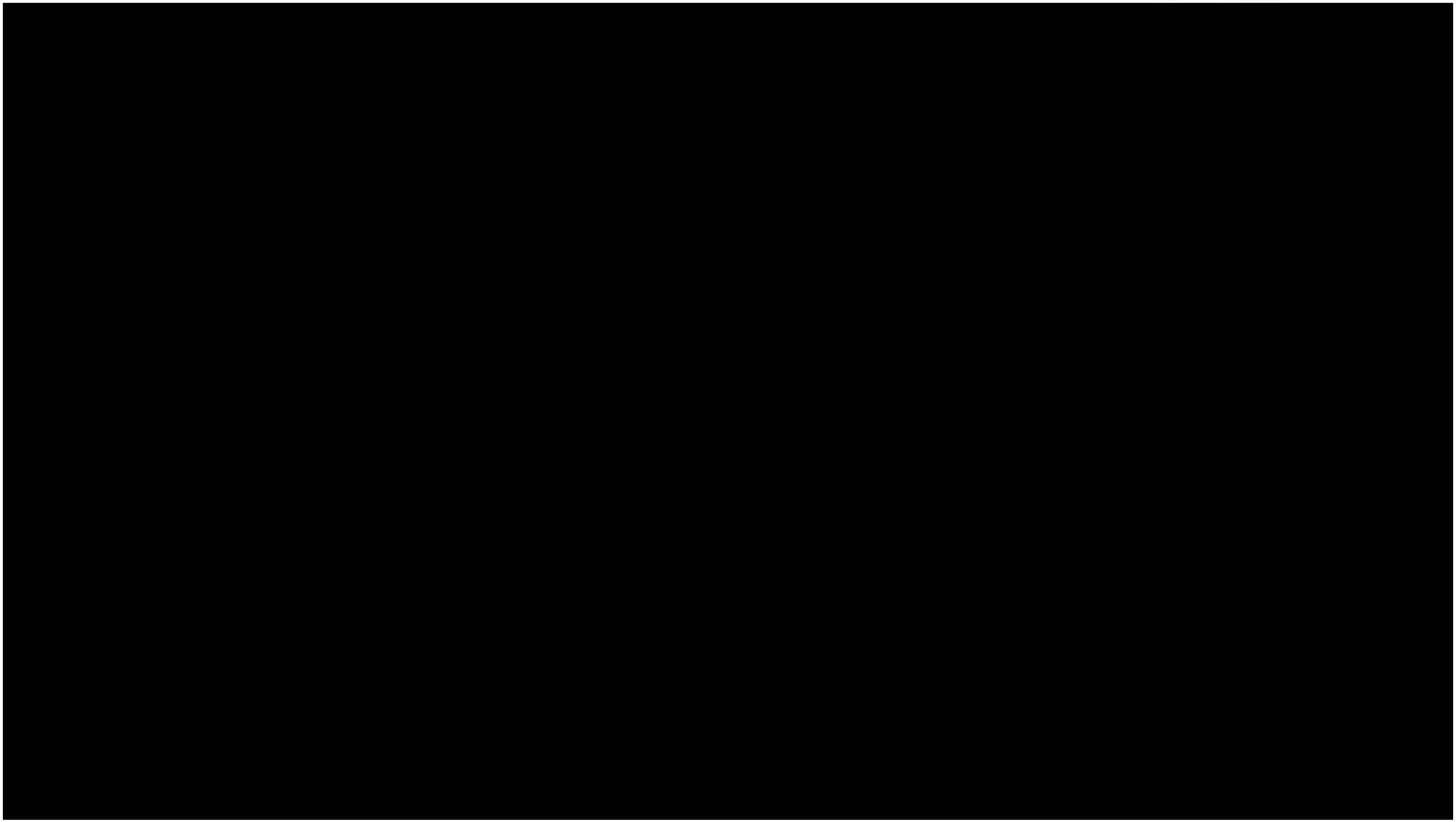
COMPUTER

RX

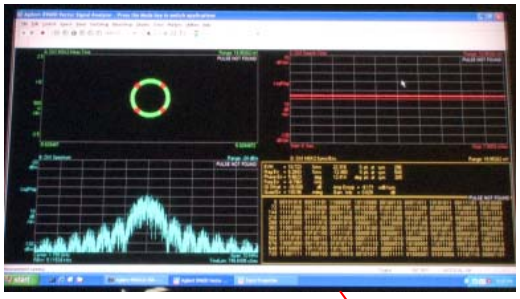
MODEM

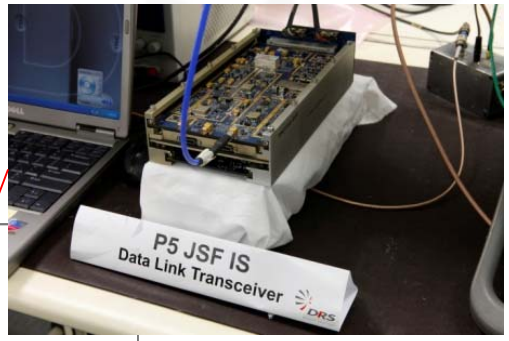
TX

Analyzer



DART SDR Demon





GPS RECEIVER

LAB GPS DISTRIBUTION

JSF MODEM

1 PPS

1 PPS

Analyzer

VECTOR SIGNAL ANALYZER

CDU

Out of Net

COMPUTER

DART

TX

COUPLER

RX

RX

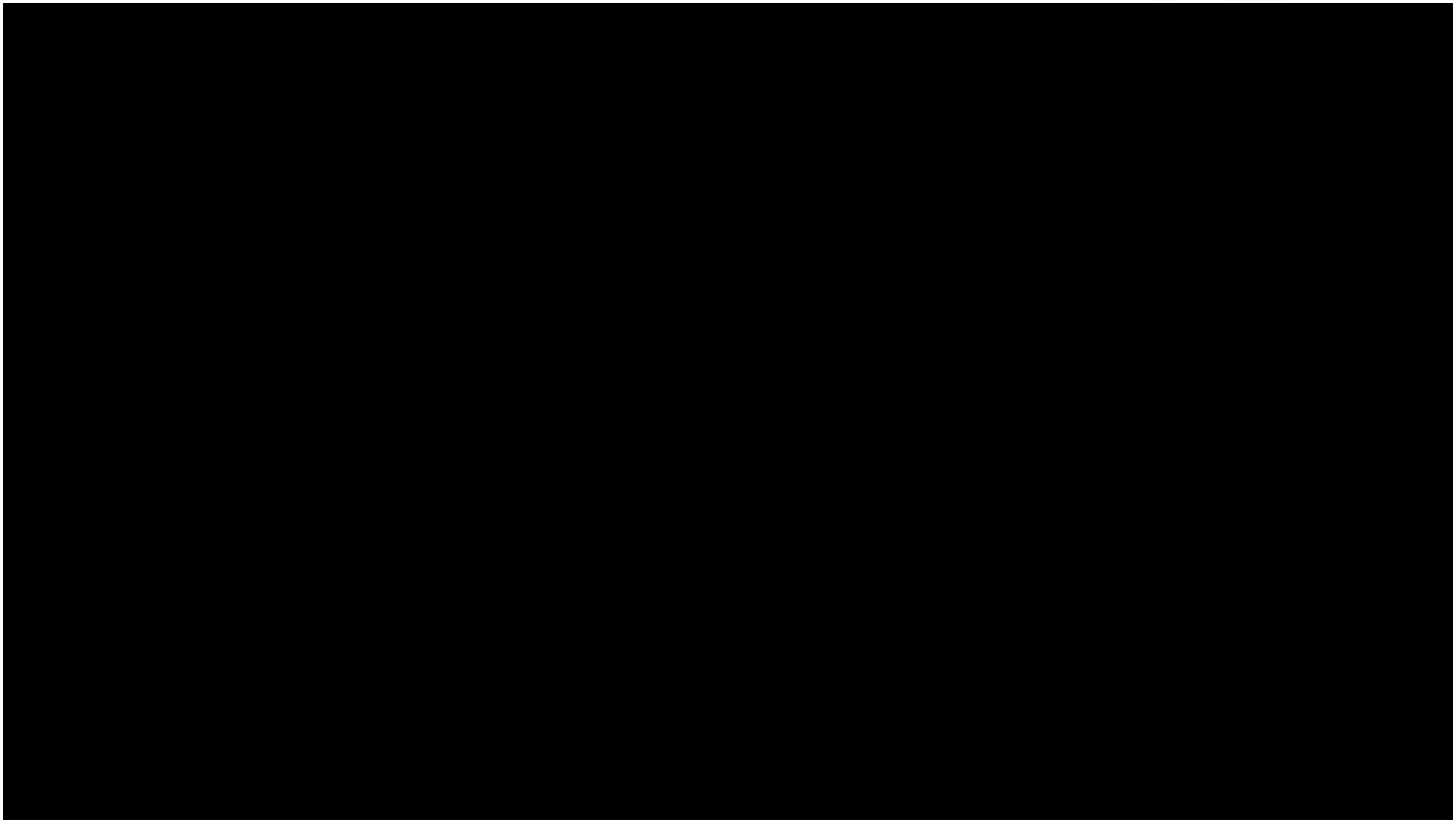
COMPUTER

RX

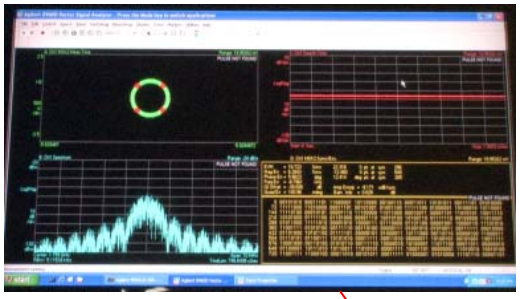
MODEM

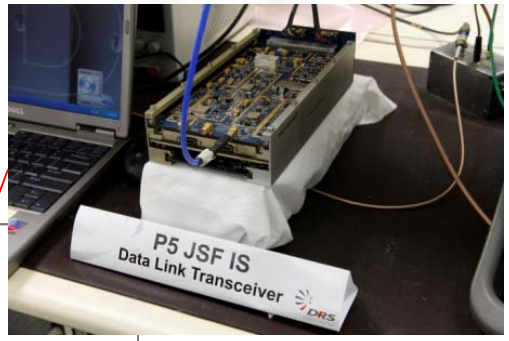
TX

CDU



DART SDR Demon





GPS RECEIVER

LAB GPS DISTRIBUTION

1 PPS

1 PPS

JSF MODEM

Analyzer

VECTOR SIGNAL ANALYZER

CDU

Out of Net

COMPUTER

DART

TX

COUPLER

RX

RX

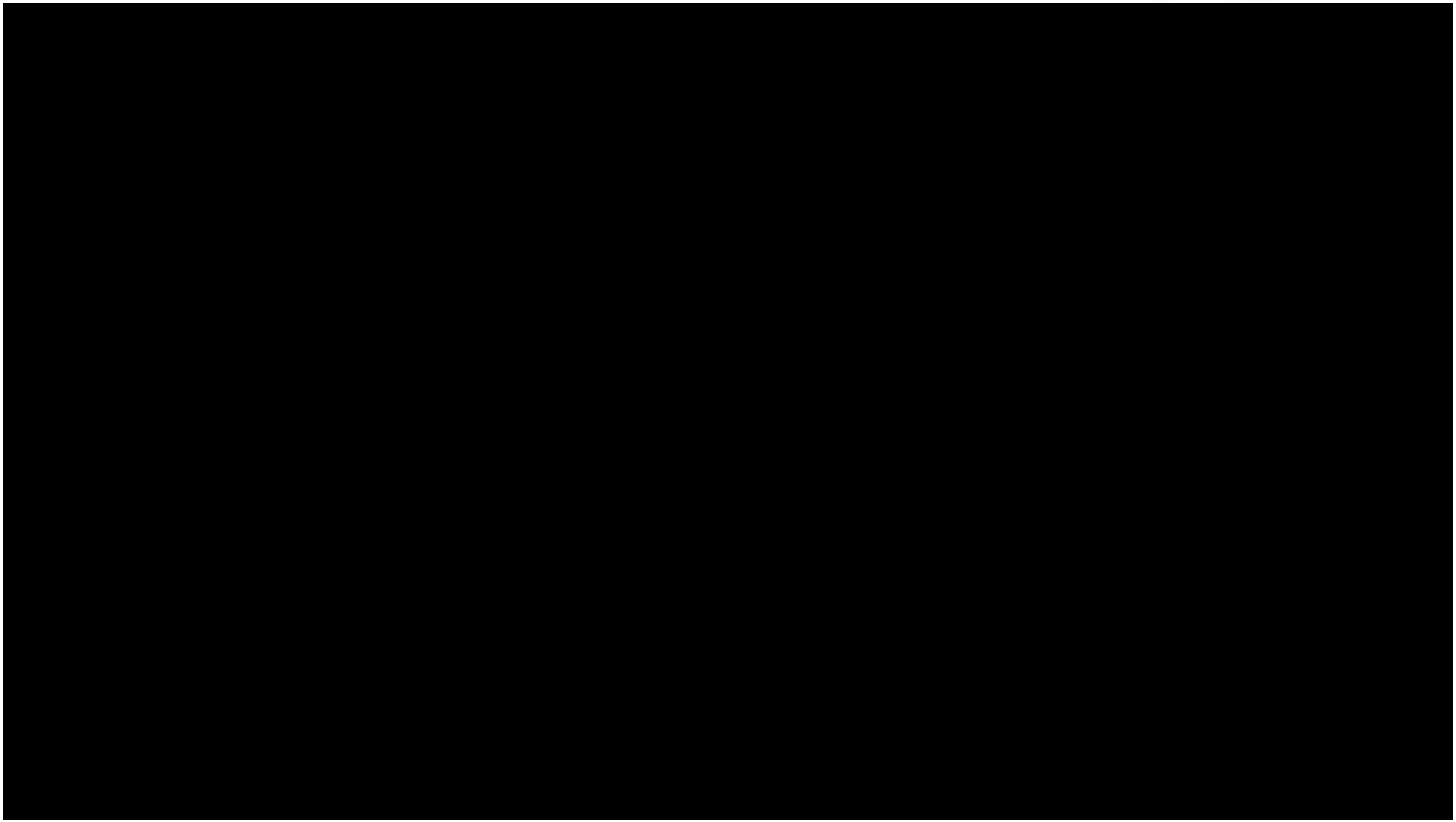
COMPUTER

RX

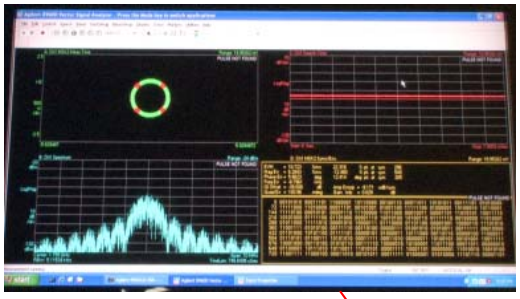
MODEM

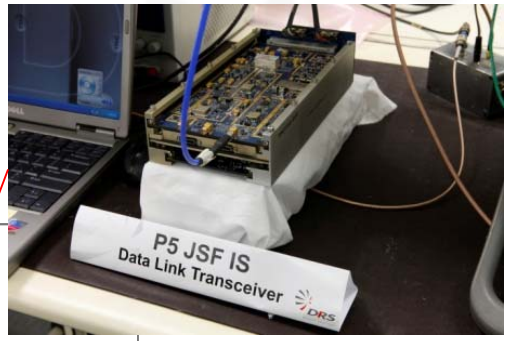
TX

Out of Network



DART SDR Demon





GPS RECEIVER

LAB GPS DISTRIBUTION

JSF MODEM

1 PPS

1 PPS

Analyzer

VECTOR SIGNAL ANALYZER

CDU

Out of Net

COMPUTER

DART

TX

COUPLER

RX

RX

COMPUTER

RX

MODEM

TX

Lessons Learned

- Establishing the **correct documentation for a 20+ year old waveform** can be like a reverse engineering effort.

- Use of **vendor specific SIMULINK** tools slowed down the porting process
  - Recommend selecting a SIMULINK primitives and blocks that **are FPGA and DSP hardware and vendor independent**

- Recommend **waveform designs easily allow different clock rates,** such as:
  - Reference clock
  - ADC & DAC clock

Conclusion

- There is a **need for SDR architectures** for range telemetry modem
  - Support legacy waveforms
  - Modern waveforms
  - Migrate to new frequencies to accommodate re-allocation

- A **waveform porting process** was developed using SIMULINK and MXA as
  - Porting tools
  - Waveform validation tools

- **DART is a viable SDR platform** for
  - Transmitter waveform was ported and tested with legacy hardware
  - DLT legacy waveform used in air combat training
  - Future JTRS waveforms
  - Multiple airframe platforms