Portable Range Threat Simulators For T&E of Radar Warning Receivers

2015 ITEA Test Technology Review

Gilbert R. Gil
Center for Countermeasures
November 2015

Approved for public release; distribution is unlimited

AGENDA

- The Center for Countermeasures: Who we are and what we do
- Portable Range Threat Simulator &
  High Power Portable Range Threat Simulator Overview
- PRTS & HPRTS Capabilities & Performance
- Software Architecture: Emitter Modes & Scenarios
- PRTS in the T&E Process

OSD/DOT&E Center for Countermeasures

- ***Mission:***

- ". . . to *direct, coordinate, support, and conduct countermeasure (CM)/counter-countermeasure (CCM) test and evaluation (T&E) activities* applicable to all precision-guided weapon (PGW) systems, including electro-optical guided weapon systems, millimeter wave guided weapon systems, and related components, and such other T&E activities as the Director, Operational Test & Evaluation may direct. "

- Supports ALL military services.

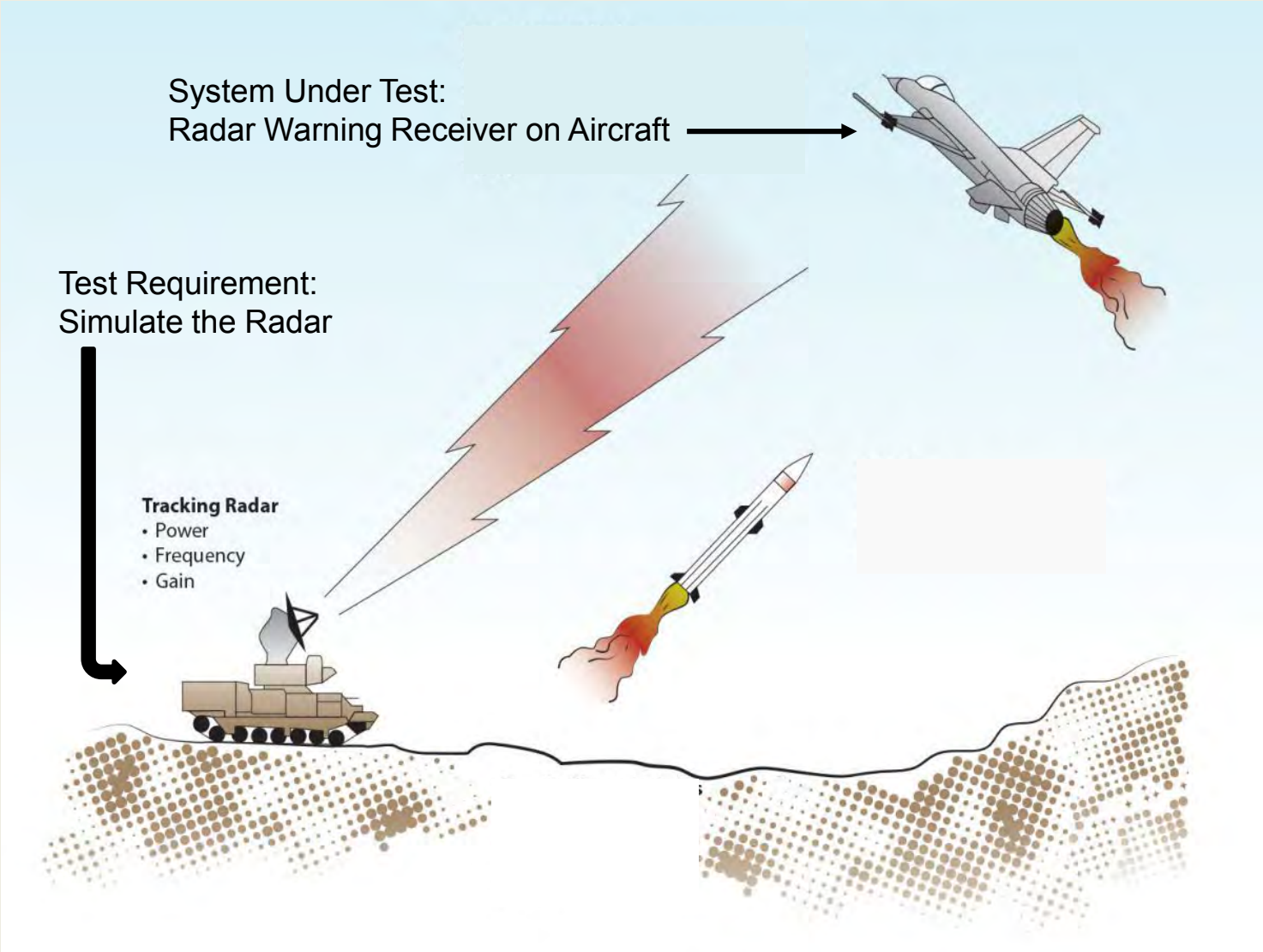
- We are a tenant organization at White Sands Missile Range, New Mexico, but only report to and receive guidance and funding from the Office of the Secretary of Defense, Director, Operational Test and Evaluation.

- ***Vision:***

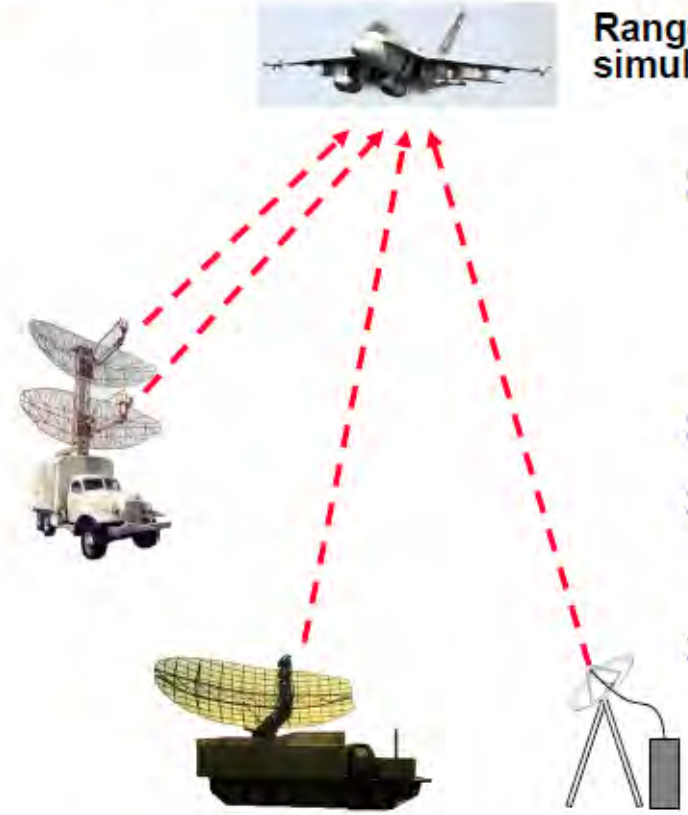
- To be the preeminent DoD resource for countermeasure test and evaluation of U.S. military systems.

Portable Range Threat Simulator
&
High Power PRTS
Overview & CONOPS

General Engagement Scenario: Radar, Missile, Aircraft



What are Range Threat Simulators?



Range Simulators are open air threat simulators.

A typical test scenario:

- The aircraft (fixed or rotary) flies in a pre-determined path.
  - The Range simulator either tracks the target.

    - or -
  - The antenna is fixed and the aircraft flies through the beam.
- The range simulator transmits threats.
- The aircraft and pilot countermeasures are verified / tested.
- Range tester types vary from large, expensive systems to small man-portable systems.

Types of Range Simulators

- The following chart illustrates some design tradeoffs between various types of range simulators.

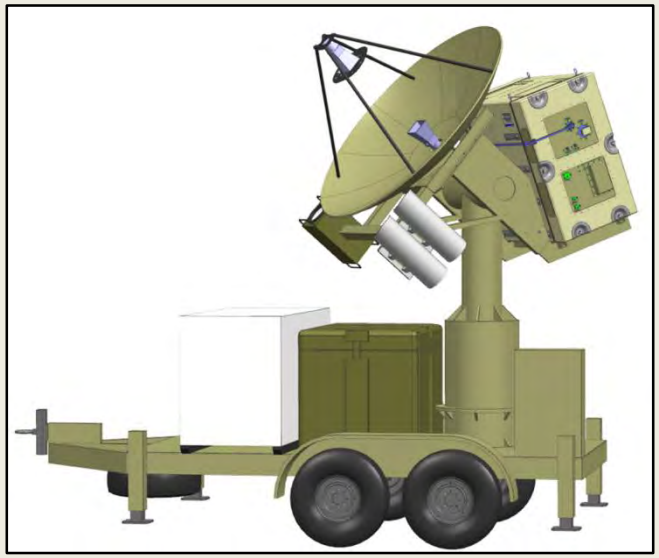
	Large simulators (highest cost)	PRTS	Lowest cost solutions
Frequency range	0.5 – 18 GHz	**(2.0 to 18) GHz** (0.5-2.5GHz, 26-40GHz optional)	7-16GHz (in narrow band slices)
Effective range	>10 nmi	~1-2 nmi w/dual mode TWTA ~5 nmi w/higher power TWTA	5 nmi
Effective radiated power (ERP)	90-109 dBm	80-96 dBm Band dependent	92-99 dBm (narrow band)
Pointing mechanism	Radar, IFF,ACMI, Data Link	Man in the loop steering	Man in the loop steering
Emitter generation	Multiple emitters, CW & pulsed. Multiple techniques supported.	CW & pulsed emitters, time interleaved emitters, multiple techniques supported	Pulsed emitters only Narrow band solution
Portability	Prepared site, vehicle, trailer.	1 trailer or transit cases (for all implemented bands)	Man-portable (in narrow band slices)

RF Threat Simulators

(PRTS) Portable Range Threat Simulator

- Designed for manned operation on tripod or can be mounted on a tactical vehicle or trailer
- Can also be used as a flight-line test set
- Portable and mobile

(HPRTS) High Power Portable Range Threat Simulator

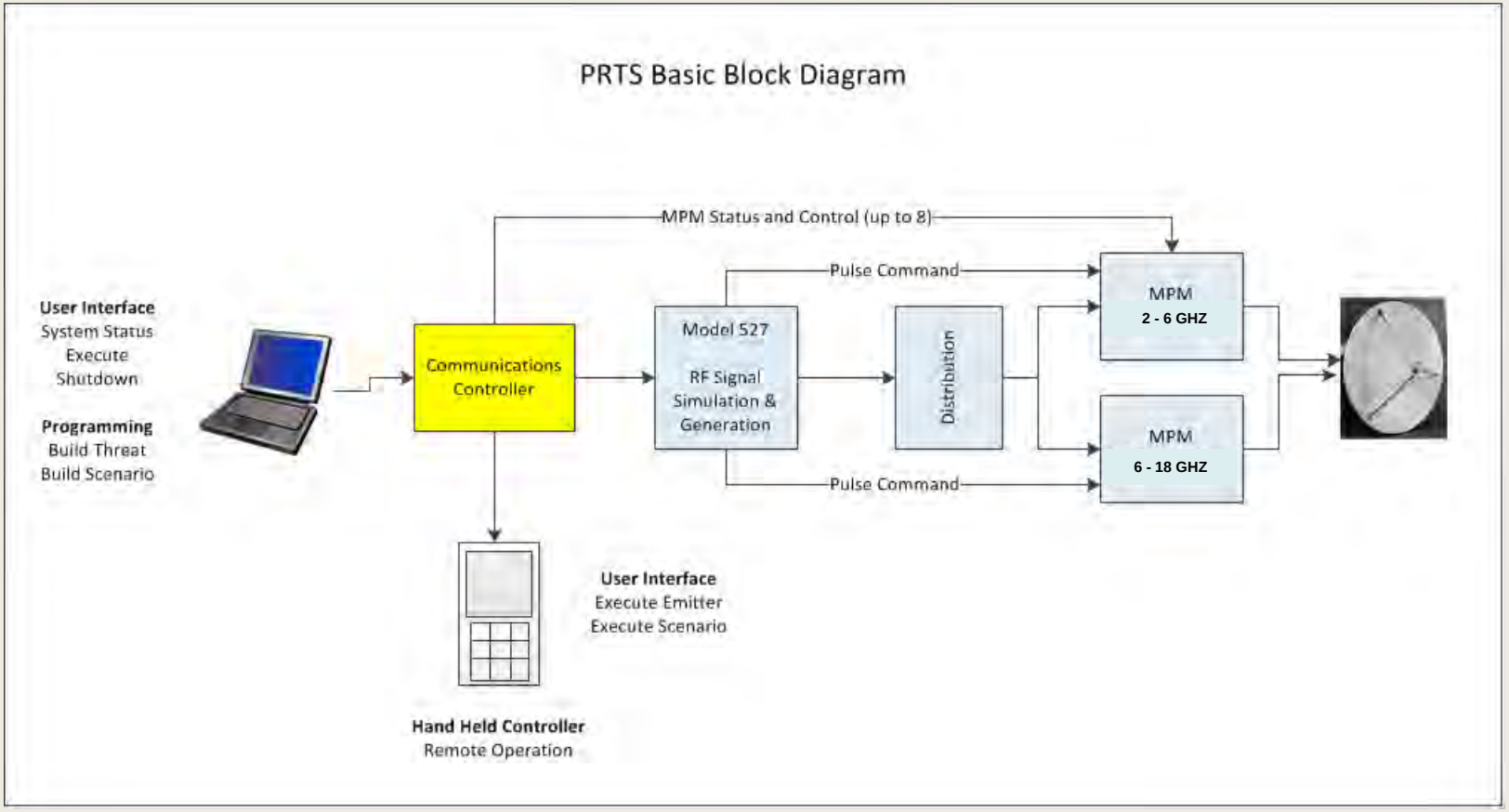


- Designed for remote operation and mounted on a trailer
- Transportable and mobile
- Can be integrated with MWS stimulator for multispectral capability

RF Threat Simulator Overview

- Ground Based Open Loop RF Threat Simulators
  - Can simulate search, acquisition, track, and missile guidance signals of RF threats (i.e., AAA, SAM)
    - PRTS simulates in 2 – 18 GHz frequency range
    - HPRTS simulates in 4 – 18 GHz range
  - Threat simulation files developed by accredited emitter file generation process
  - Can generate full threat modulations including frequency, PRI, PW, and scan
- Provides the ability to test installed system on aircraft in open air environment

PRTS BASIC BLOCK DIAGRAM



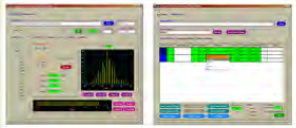
PRTS/HPRTS CONOPS

Test Planning

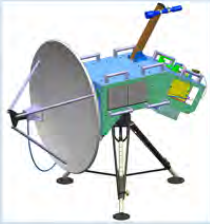
1. Customer identifies threats
2. CCM communicates PRTS's capabilities
3. Customer creates engagement scenarios

Test Design

1. CCM enters threat (emitter) definitions into PRTS Build Threat Software
2. CCM enters engagement scenarios into PRTS Build Scenario Software
3. CCM stores emitter files and engagement scenarios on PCMCIA Disk.



Test Execution

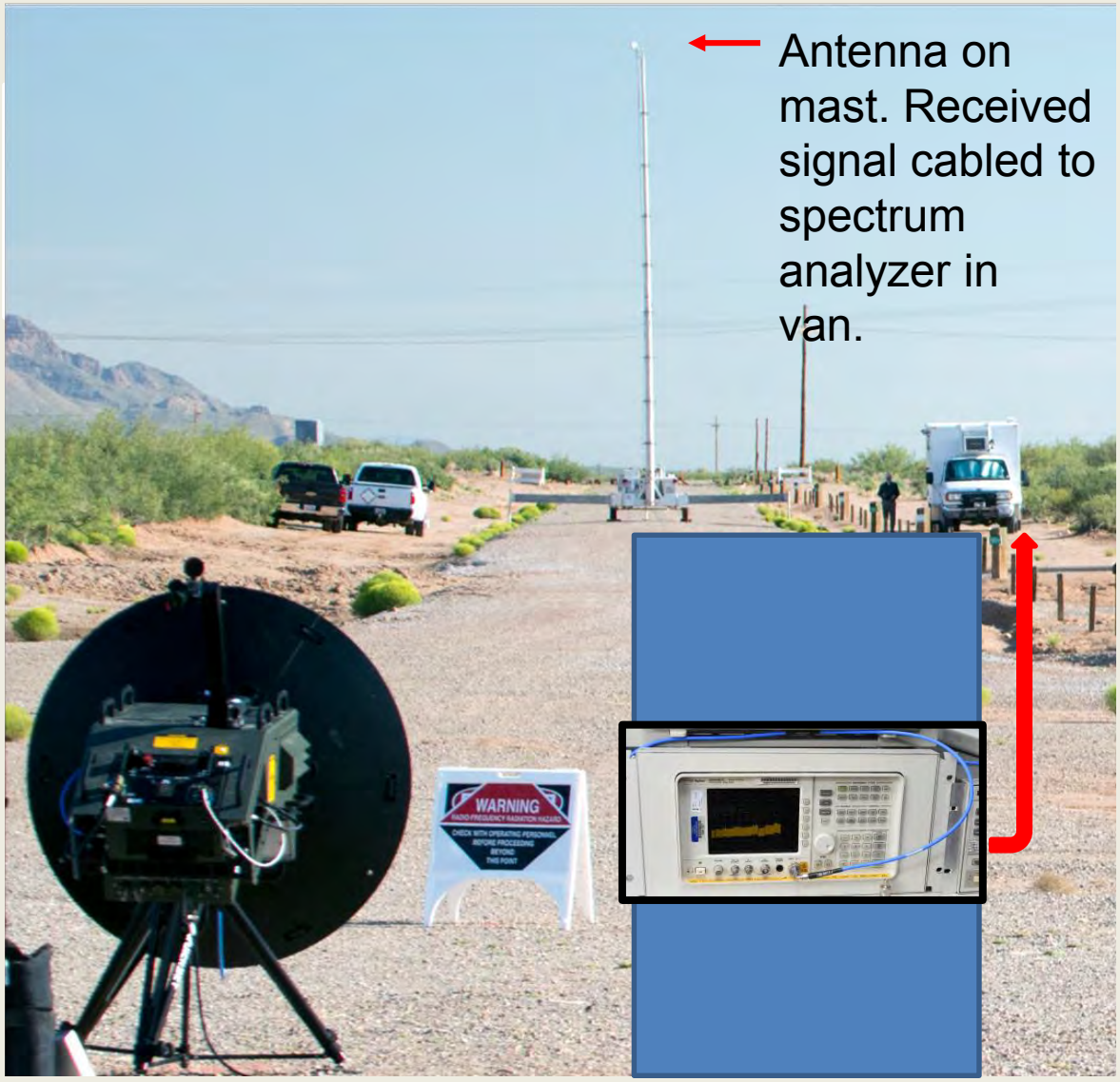


PRTS

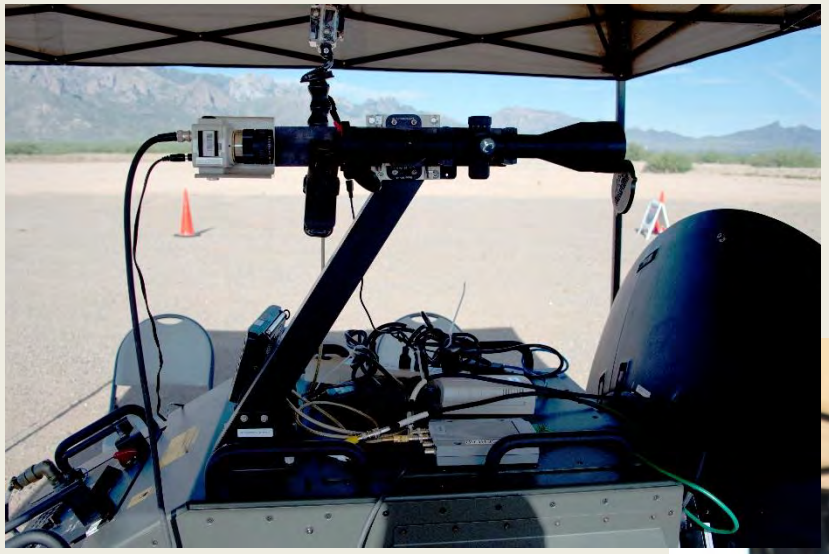
OR

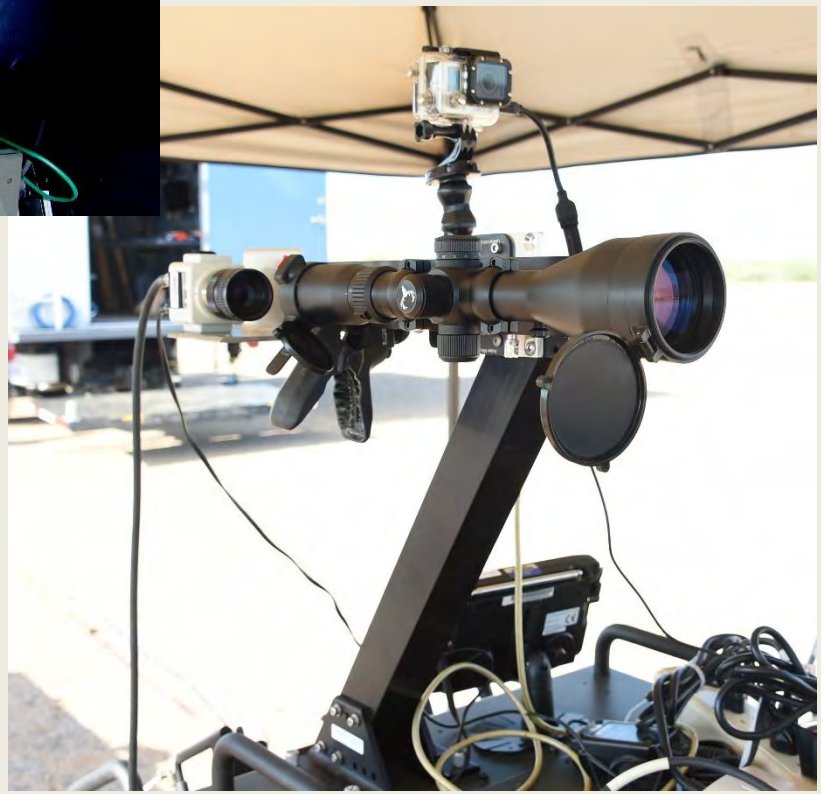
HPRTS

Pre-test Prep: Optical-to-RF Boresighting



Video Data Collection System





PRTS & HPRTS
CAPABILITIES & PERFORMANCE

PRTS Hardware Capabilities

PRTS Tripod Configuration

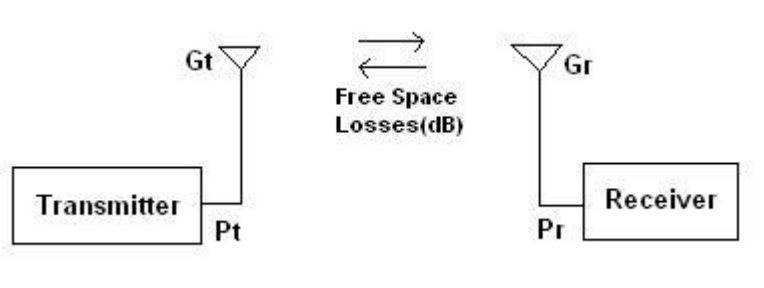
- Signal simulation and generation is controlled by “Model 527” waveform generator
- Model 527 includes capability to time multiplex RF generator to simulate as many as 8 simultaneous signals
- Frequency range: 2 – 18 GHz
- MPM Output Power: 100 W CW and pulsed
- ERP: 53 dBW
- Antenna: 4-foot diameter, high gain, two single linearly polarized feeds
- All components have been ruggedized for outdoor use

HPRTS Hardware Capabilities

HPRTS System

- Model 527 waveform generator
- Contains a dual-axis pedestal assembly allowing a 240 degree maximum rotation
  - Low light day camera and MWIR camera mounted on trailer and integrated with video tracker electronics
- Frequency range: 4 – 18 GHz
- TWT Output Power: 4 kW
- ERP: 67 to 80 dBW typical
- Antenna: 6-foot diameter, high gain
- All components have been ruggedized for outdoor use

A MEASURE OF PERFORMANCE: RF LINK BUDGET AND FRIIS EQUATION



$$P_{RX} = P_{TX} G_{TX} G_{RX} \left(\frac{\lambda}{4\pi r} \right)^2 \frac{1}{L_{sys}}$$

transmit power

wavelength

received power

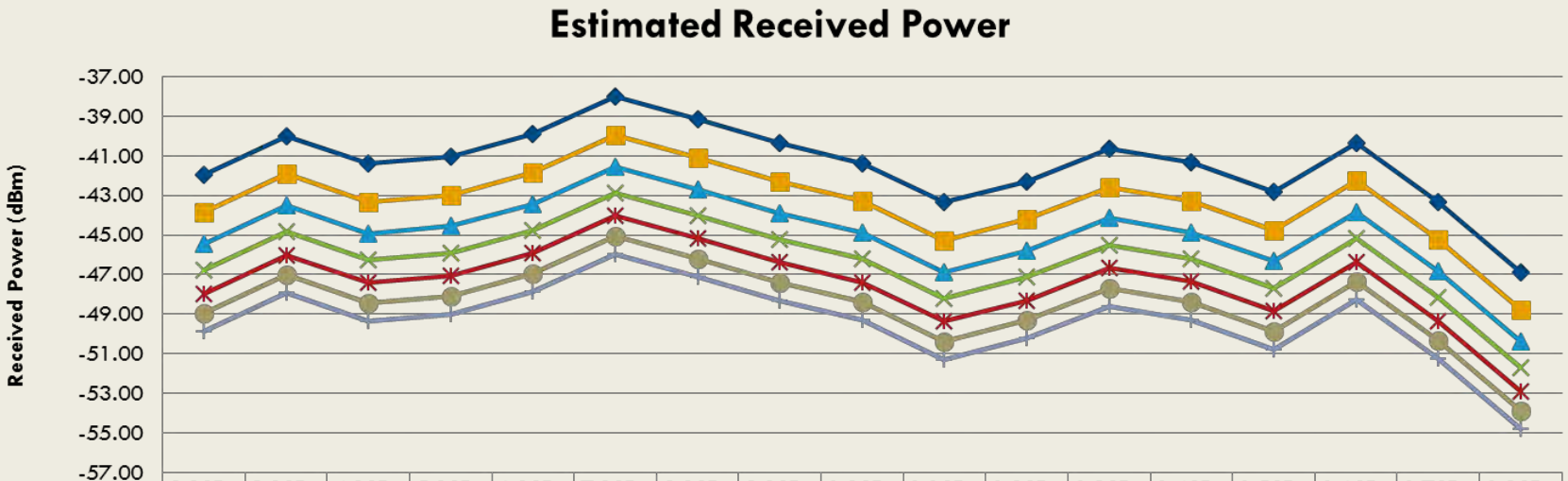
gain of transmit and receive antennas

separation distance

various losses

$$P_R = P_T + G_T + G_R - 20 \log \frac{4\pi}{\lambda} - 20 \log r - 10 \log L_{sys}$$

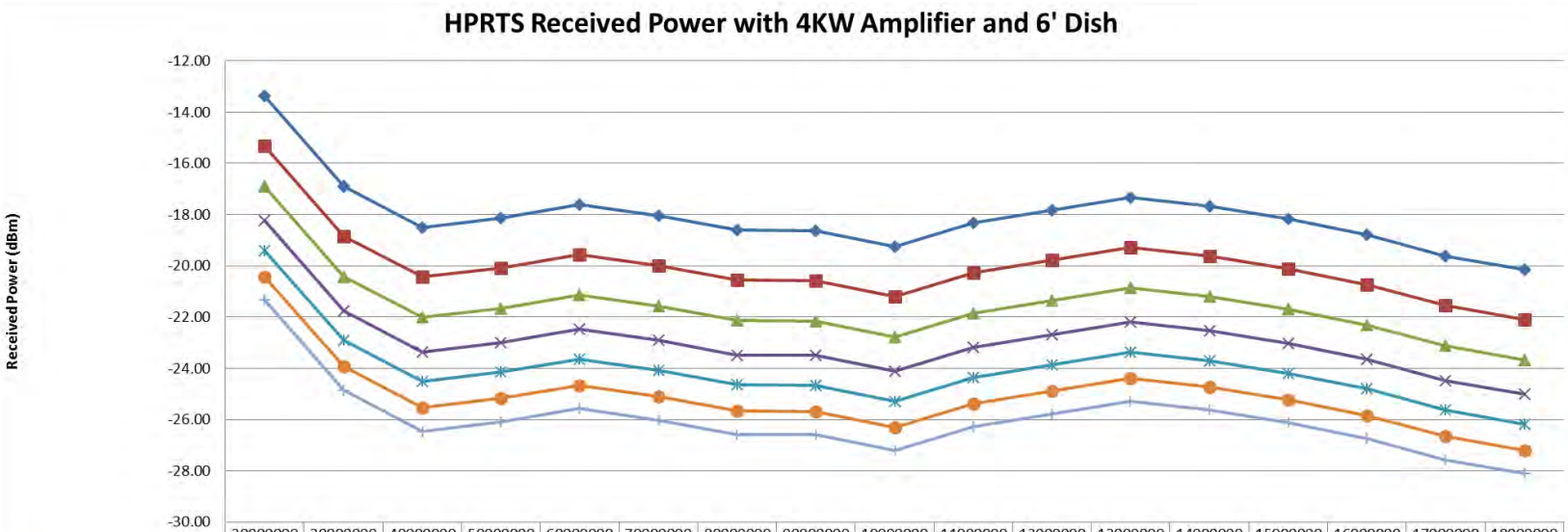
PRTS Performance Graph



	2.00E+09	3.00E+09	4.00E+09	5.00E+09	6.00E+09	7.00E+09	8.00E+09	9.00E+09	1.00E+10	1.10E+10	1.20E+10	1.30E+10	1.40E+10	1.50E+10	1.60E+10	1.70E+10	1.80E+10
2.0 Miles	-41.94	-39.98	-41.39	-41.03	-39.90	-38.03	-39.17	-40.37	-41.36	-43.36	-42.28	-40.64	-41.35	-42.81	-40.33	-43.31	-46.87
2.5 Miles	-43.87	-41.92	-43.33	-42.97	-41.84	-39.96	-41.10	-42.31	-43.30	-45.29	-44.22	-42.58	-43.28	-44.74	-42.26	-45.25	-48.81
3.0 Miles	-45.46	-43.51	-44.91	-44.56	-43.43	-41.55	-42.69	-43.89	-44.88	-46.88	-45.80	-44.16	-44.87	-46.33	-43.85	-46.83	-50.39
3.5 Miles	-46.80	-44.85	-46.25	-45.89	-44.77	-42.89	-44.03	-45.23	-46.22	-48.22	-47.14	-45.50	-46.21	-47.67	-45.19	-48.17	-51.73
4.0 Miles	-47.96	-46.00	-47.41	-47.05	-45.93	-44.05	-45.19	-46.39	-47.38	-49.38	-48.30	-46.66	-47.37	-48.83	-46.35	-49.33	-52.89
4.5 Miles	-48.98	-47.03	-48.44	-48.08	-46.95	-45.07	-46.21	-47.41	-48.40	-50.40	-49.32	-47.69	-48.39	-49.85	-47.37	-50.36	-53.91
5.0 Miles	-49.89	-47.94	-49.35	-48.99	-47.86	-45.98	-47.12	-48.33	-49.32	-51.32	-50.24	-48.60	-49.31	-50.76	-48.29	-51.27	-54.83

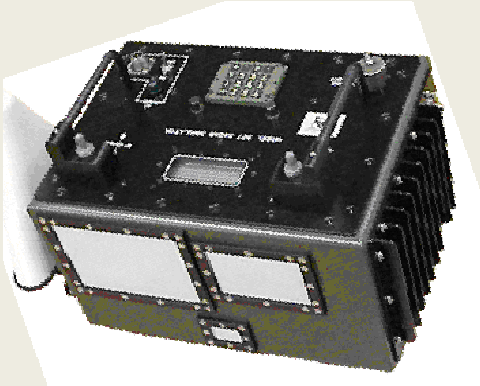
Frequency (GHz) with Estimated Received Power (dBm) in Chart Form for Clarity

HPRTS Performance Graph



	2000000000.0	3000000000.0	4000000000.0	5000000000.0	6000000000.0	7000000000.0	8000000000.0	9000000000.0	10000000000.0	11000000000.0	12000000000.0	13000000000.0	14000000000.0	15000000000.0	16000000000.0	17000000000.0	18000000000.0
Received Power 2.0 Miles	-13.37	-16.90	-18.50	-18.13	-17.62	-18.06	-18.62	-18.64	-19.25	-18.33	-17.84	-17.33	-17.68	-18.18	-18.79	-19.61	-20.16
Received Power 2.5 Miles	-15.31	-18.83	-20.43	-20.07	-19.56	-19.99	-20.55	-20.58	-21.19	-20.27	-19.78	-19.27	-19.61	-20.11	-20.72	-21.55	-22.10
Received Power 3.0 Miles	-16.90	-20.42	-22.02	-21.66	-21.14	-21.58	-22.14	-22.16	-22.78	-21.85	-21.36	-20.85	-21.20	-21.70	-22.31	-23.13	-23.68
Received Power 3.5 Miles	-18.24	-21.76	-23.36	-22.99	-22.48	-22.92	-23.48	-23.50	-24.11	-23.19	-22.70	-22.19	-22.54	-23.04	-23.65	-24.47	-25.02
Received Power 4.0 Miles	-19.40	-22.92	-24.52	-24.15	-23.64	-24.08	-24.64	-24.66	-25.27	-24.35	-23.86	-23.35	-23.70	-24.20	-24.81	-25.63	-26.18
Received Power 4.5 Miles	-20.42	-23.94	-25.54	-25.18	-24.66	-25.10	-25.66	-25.68	-26.30	-25.38	-24.88	-24.38	-24.72	-25.22	-25.83	-26.66	-27.20
Received Power 5.0 Miles	-21.33	-24.86	-26.45	-26.09	-25.58	-26.01	-26.57	-26.60	-27.21	-26.29	-25.80	-25.29	-25.64	-26.13	-26.75	-27.57	-28.12

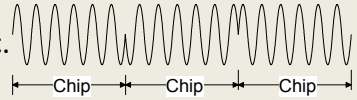
PRTS/HPRTS RF Signal Generator Capability



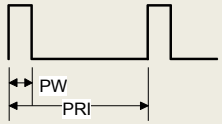
millimeter wave source

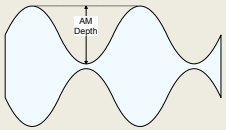
- Frequency range 28 to 40 GHz.
  - Accuracy: 0.002% single emitter.
  - Accuracy: 20 MHz multiple emitters.
  - Resolution: < 500 KHz.
- -15dBc spurious, -10dBc harmonics.

- Frequency range: 0.5 to 18 GHz.
  - Accuracy: 0.001% single emitter.
  - Accuracy: 5 MHz multiple emitters.
  - Resolution: < 500 KHz.
- Switching time:
  - < 200 usec single emitter to 0.001% accuracy.
  - < 1 usec to 5 MHz accuracy.
- -50dBc spurious, -10dBc harmonics.
- Intrapulse modulation.
  - FM deviation rate ± 50MHz / 20usec.
  - Bi-Phase: up to 32 chips.
    - Chip width 100 nsec min.



- Pulse modulation.
  - PRI range 1 usec (min).
  - PW range 50 nsec (min) to CW.
  - Rise/fall < 15nsec.

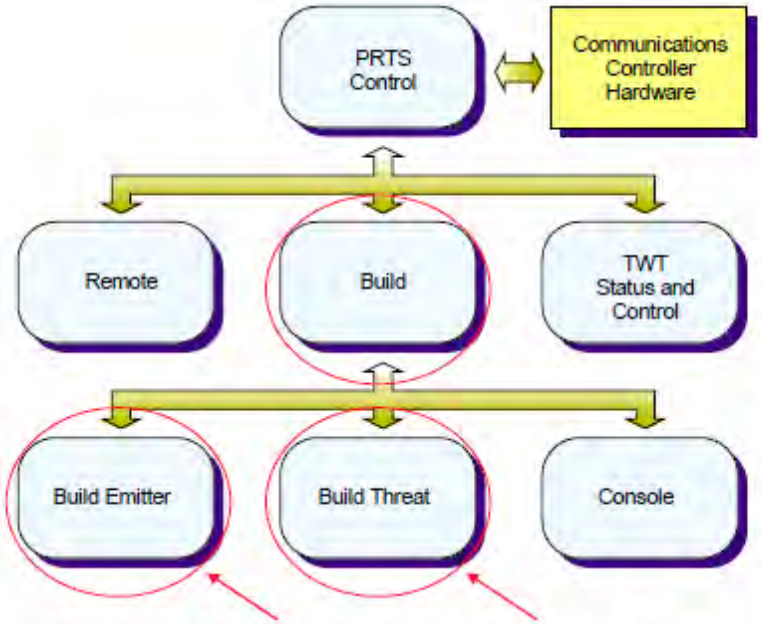




- Amplitude modulations.
  - Range: 45 dB ± 2dB.
  - Rate: 0.005 to 2 KHz.
  - Supported types: Conical, raster, helical, sector, dwell, height finder, circular, palmer modification, orthogonal, LORO, spiral.

Software Architecture: programming of emitter modes and scenarios

PRTS Software Architecture



The Build portion of the executive is key to simple threat and scenario definition.

- PRTS design has a common execution executive that provides monitoring and/or control of:
  - RF Signal Source.
  - External TWTA status and emergency shutdown.
  - Hand held controller interface (remote operation).
  - External EO/IR programming and triggering.
- Emitter (threats) defined using a simple, graphical user interface.
  - Build threat and build scenario.
  - Discussed more fully on the following slides.

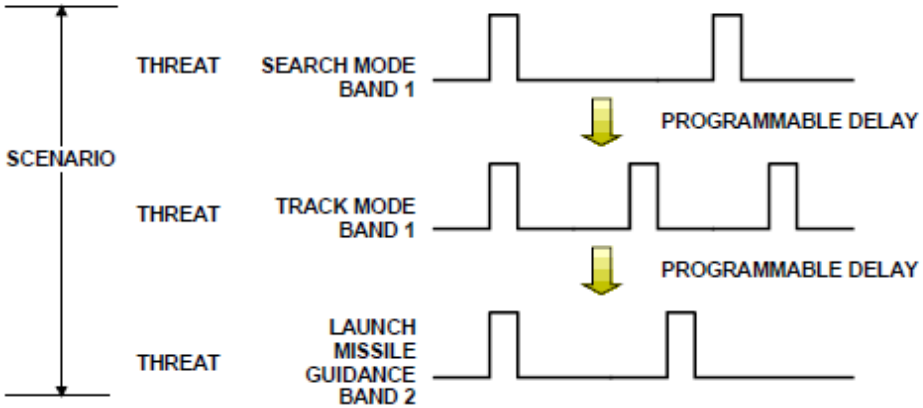
Emitters and Scenarios

- Once emitters are developed, they may be saved and then applied one at a time to the SUT.

- **Additional programming gives us the ability to do complex scenarios**

Scenarios

- Scenarios allow the user to build realistic threat situations.
- For example, the following scenario illustrates a search, then track, then launch with missile guidance.



PRTS in the T&E Process

- **Validation & Verification**
- **The Way Forward for PRTS in T&E**

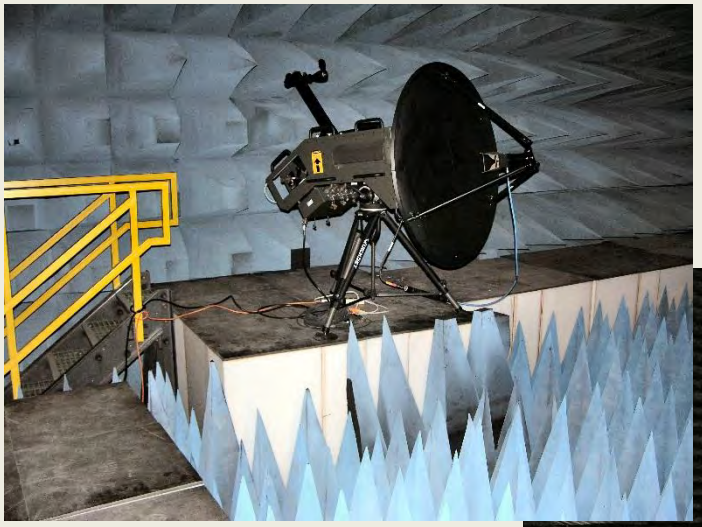
Validation & Verification

- Threat representations are required to be validated for operational tests

- PRTS support of specific programs requires PRTS validation

- **Validation -** The process of determining the degree to which a threat simulator, target, digital model or simulation is an accurate representation of the threat from the perspective of its intended use(s) – Final Product - Approved Validation Report
- **Verification -** The process of determining that a threat representation system accurately portrays the developers' conceptual description and specifications
- **Accreditation -** The official certification that a model, simulation, or federation of models and simulations and its associated data are acceptable for use for a specific purpose

V&V Chamber Tests



V&V Tower Tests

Tower Test

- Open Air Transmission
- Includes Power Amplifier

V&V Captive Flight Tests

- Helicopter-borne Receiver
- slant ranges
- Hovering & Dynamic Scenarios
- Scheduled For January 2016

Way Forward for PRTS in T&E

PRTS Baseline Objectives & Goals
- Low Cost
- Mobile
- Accurately Replicate
- RF Threats

Hardware & Software Description (Program Management Plan)
- Requirements Traceability
- T&E Toolkit Description
- WBS

PRTS Hardware
- Support Equipment

CON OPS
- Test Planning
- O & M
- Test Procedures
- Test Reporting

For T&E use of the PRTS/HPRTS, contact:

Gilbert R. Gil
Project Lead/Principal Analyst
OSD Center for Countermeasures
MLK, Jr. Ave, Bldg. 1407
White Sands Missile Range, NM 88002-5519
575-678-7231 (office)
575-202-9157 (mobile)

For training use of the PRTS/HPRTS, contact:

Tony Rankins
Project Lead
OSD Center for Countermeasures
MLK, Jr. Ave, Bldg. 1407
White Sands Missile Range, NM 88002-5519
575-678-6529 (office)
575-201-8161 (mobile)