ATTACHMENT 1: T&E EWT Domain and Topic Area Technology Development Prototype Requirements

The purpose of this attachment is to describe the Domains, Domain A: Electro Optics (EO) and Domain B: Radio Frequency (RF) and associated topic areas as well as provide associated response requirements. The topics outlined in each domain are primarily associated with Science & Technology (S&T) investigations that culminate with a Training Readiness Level (TRL) 6 demonstration prototype, with the exception of Topic areas 5 & 6 listed under Domain B, which are more likely to fall within a TRL 7 or higher and result in a demonstrated prototype. Figure 1, Overview of T&E EWT Topic Areas show how these may fall.

The Government requests vendors to self-assess their TRL within their responses. It is not considered detrimental to an award if a vendor self-assesses under a TRL 7. The response should clearly discuss why the vendor is self-assessing at the TRL declared and provide a technical approach for achieving a greater TRL for potential production and fielding of the capability and prototype.

The Government understands that higher TRL technologies may begin with some S&T feasibility risk reduction but are intended to progress and produce fielded capability(ies) quicker than those technologies assessed between a TRL 1-6.

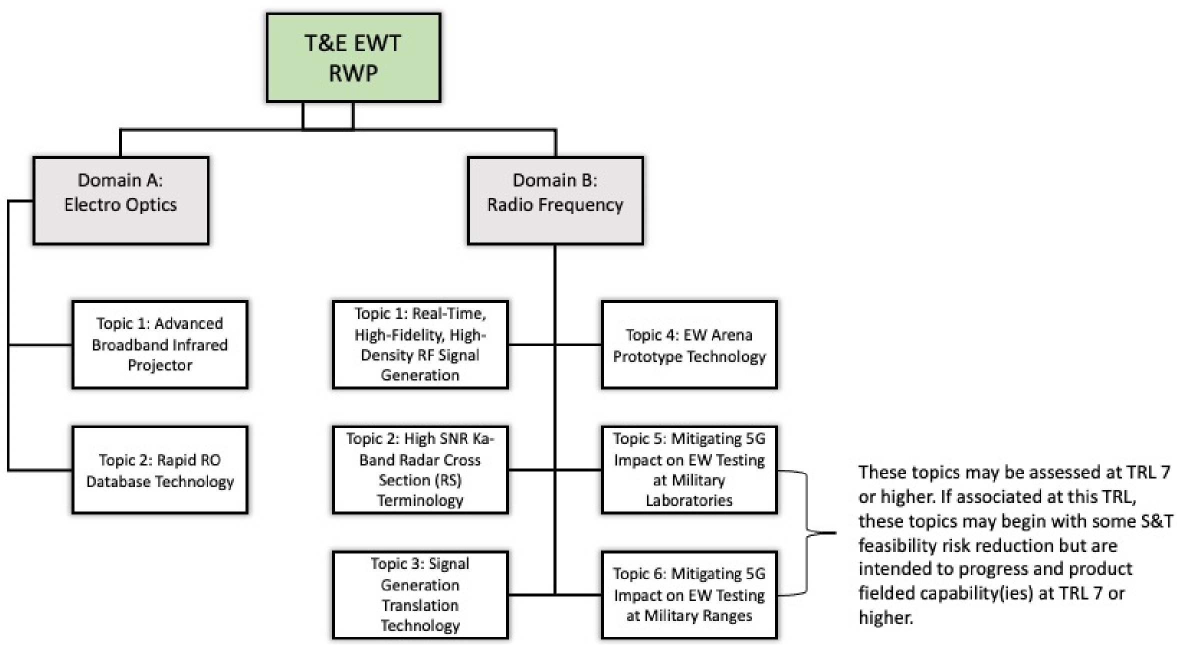

Fig 1. Overview of TEPP EWT Topic Areas

Domain A: Electro Optics (EO)

1. Advanced Broadband Infrared Projector

Current state-of-the-art in thermally emissive, IR array technology is capable of achieving systems with a 1024 x 1024 format with effective temperatures of 1000K that can be driven at 200 frames per second. The next generation of weapon seekers will have larger pixel formats and operate at higher frame rates. In addition to large formats and high frame rates, the infrared (IR) scene projectors needed to test these seekers must also be capable of high effective temperatures over broad emission bands. An advanced IR projector system is needed with broadband emissions (emissions at all wavelengths in each waveband) in MWIR (1-5 □m) and LWIR (8-12 □m) bands and with emitting array characteristics given below. The system must also be cryogenically compatible, produce “flickerless” emissions, and run asynchronously with the sensor-under-test (i.e. no synch with sensor). Another key component for this effort will be the development of the real-time processing electronics to distribute the incoming digital scene across multiple projector modules, perform latency correcting I-J offset (horizontal and vertical shift of rows to correct for latency effects), apply Non-Uniformity correction (NUC) and provide precision drive currents to the emitter elements. Access to classified materials is not required.

Parameter	Goal	Ultimate Goal
Array Size (pixels)	2048 x 2048	4096 x 4096
Radiance (W/m^2-sr)		
1 – 3 µm (MWIR)	6,500 (~1045 K)	192,700 (~2000 K)
3 – 5 µm (MWIR)	13,300 (~1225 K)	99,900 (~2770 K)
8 – 10 µm (LWIR)	1,600 (~1000 K)	4,600 (~1875 K)
Frame Rate (Hz)	500	1000
Dynamic Range (bits)	14	16

2. Rapid EO Database Technology

Current processes for converting raw satellite terrain imagery are manually intensive and can require three months to complete. High-speed techniques are needed to convert raw satellite terrain images and other informational sources (e.g., LIDAR terrain maps) to attributed EO databases for sensor-specific wavelengths and frequencies to allow for a real-world presentation to the sensor under test. New high-speed techniques are also required to convert existing EO databases to change solar angles, atmospheric conditions, and other parameters needed to support testing under varying conditions. Mission rehearsal and reprogramming labs need fast turnaround of terrain imagery or other intelligence data into terrain databases suitable for use with 3D EO/IR rendering systems. The goal is to be able to create or convert/update a 100 km x 100 km (threshold) to 250 km x 250 km (objective) database as a result of a change (e.g., new band, time of day, day of year, etc.) in less than 3 hours.

May require access to secret level information. Domain B: Radio Frequency (RF)

1. Real-time, High-Fidelity, High-Density RF Signal Generation

Electronic warfare T&E systems require real-time, high-fidelity RF signals that represent radar and communications signals of interest. Technology needs to be developed that can affordably produce large numbers of high-fidelity modulated signals with control over phase, amplitude, time, modulation on pulse (MOP), and Doppler. This technology should use an open architecture. All of these parameters and more shall be generated from a pulse descriptor word (PDW) to form a signal at RF. It is envisioned that prototype modules will operate over banded RF spectrum covering 50 MHz to 300 GHz (e.g., 50-500 MHz, 500-2,000 MHz, and 2,000-40,000 MHz, 40-100 GHz, and 100-300

GHz). In addition, the modules must also be able to generate narrow and wideband signals from a recorded Intermediate Frequency (IF) or a baseband signal loaded into memory. Example technology areas of interest are Direct Digital Synthesis (DDS) and Photonic processing in the form of low-cost circuit card assemblies (CCA) with unlimited software and hardware data rights so that other vendors can build full EW systems from the advanced technology investment in the open-source RF signal generation modules.

May require access to secret level information.

2. High-SNR Ka-Band Radar Cross Section (RCS) Technology

Existing technologies employed in outdoor Radar Cross Section (RCS) measurements in the Ka-band (26.5-40 GHz) do not yield sufficient signal-to-noise ratios (SNR) when tunable transceivers are employed to measure small targets or low-observable (LO) vehicles at ranges of 10-to-20 miles. Typical SNR values achievable with current technologies are on the order of 0 dB or less when measuring targets that exhibit nominal RCS values of -20 dBsm. Current technological limitations in Ka-band typically relate to the atmospheric losses, two-way space losses, and transceiver path losses. New technology is sought for components or systems that will optimize tunable coherent transceivers covering 34-36 GHz that exhibit SNR of 10 dB or greater when measuring -20 dBsm targets at ranges of 20 miles. The objective coherent transceiver must be capable of duty cycles of 12% or greater, and phase noise of -120 dBc/Hz or less at 10 kHz offset from the center frequency. The objective system will exhibit Effective Radiated Power (ERP) of at least 113 dBm employing an antenna with a beam-width of approximately 0.5 degrees. The objective system will measure a 12-inch aluminum calibration sphere at 20 miles to validate performance. Testing of proposed prototypes will take place at Patuxent River Naval Air Station at the Atlantic Test Range.

May require access to secret level information.

3. Signal Generation Translation Technology

The Next-generation EW Environment Generation (NEWEG) system utilizes NASIC Electronic Warfare Integrated Reprogramming Database (EWIRDB) emitter models and data directly to support signal generation to support both direct injection and free-space testing configurations. EW threat simulators utilize signal generation systems as core processes to synthesize threat signals for testing sensors installed on modern EW platforms. These signal generation systems require different types of inputs depending on the nature of the EW threat simulator; however, these inputs all trace back to common textual file structures commonly called Waveform Descriptor Words (WDWs). The WDWs must be translated into Pulse Descriptor Words (PDWs) thru the NASIC Real-Time Keystone tool and into usable waveforms formatted for efficient use by the real-time signal generation system. Baseband signal generation sampling rates may also be different from EWIRDB data sampling rates. New translation technology is required to optimize usage of the different levels of EWIRDB information and signals to support existing and future signal generators.

Keystone Pulsed/CW IQ Example: A 512 MHz specified sample rate is converted to 1953.125 ps (which is currently rounded to 1953ps in the OPANA Keystone data output). This results in an IQ file that is sampled at 512.0328 MHz (1/1953 ps), not exactly 512.0 MHz, which will induce a max frequency error of +8.2 kHz, ((512. 0328-512.0)/4). The SRS frequency accuracy spec is ~1 Hz. If the OPANA Keystone clock period is extended to 1fs, there will be no frequency error. The RFGEN will still need to resample the data using a 5/2 resampling factor and a 25 tap FIR filter to get to the native RFGEN sample rate of 1280 MHz.

4. EW Arena Prototype Technology

The EW development community has a growing requirement to expand the current real-time radio frequency (RF) Hardware-in-the-Loop (HITL) capabilities to provide effective test of EW systems in dynamic "many versus many" environments so EW systems can be tested in a congested RF environment, and the net effects for detrimental or additive behavior of the systems be evaluated. The HITL environment simulation architecture, EW Arena, developed in the 2012-2015 time frame is a multi-channel, FPGA based digital to RF converter includes modern radar characteristics and effects (phase, Doppler, time delay, clutter), bandwidths and wide dynamic power ranges applicable to modern radar scenarios, providing coherent input RF to output RF through the channels and maintains a coordinated air-picture with accurate Doppler and delay per-path for moving entities. The current architecture has defined interfaces to allow connection to existing radar simulators and EW platform hardware and incorporate their functional aspects.

Digital computer and RF technologies, including high bandwidth FPGAs and memory, are desired to upgrade the current EW Arena architecture to address key performance limitations in the areas of increased number of bits, reduced bit error rate, signal isolation, bands and instantaneous bandwidth, dynamic range, and range delay. In addition, the current 16-channel prototype is sought with the technology capable of being upgraded to 24 channels or more. Technology solutions are desired for:

- RF input/output (I/O) channel pair to be capable of operation over the frequency range from 80MHz to 18GHz with each channel frequency selectable with up to 1GHz selectable Instantaneous Bandwidth per channel.
- Individual input/output channel pairs to be combined into unique frequency bands allowing multiple frequency bands per simulation to support entities which radiate at different RF bands.
- Ability to propagate the signal with accurate doppler and two-way propagation of the signal with range and space loss attenuation over a range of 1km to 1000km.
- Dynamic range of the environment be greater than 100 dB.
- The EW Arena prototype environment must be capable of digitally combining, for each RF output, propagated RF signals from all transmitters and reflectors in the environment before converting back to analog RF and providing to the system under test or threat simulator connected to that output.

May require access to secret level information.

5. Mitigating 5G Impact on Electronic Warfare (EW) Testing at Military Laboratories

Innovative technologies and methods are sought to provide alternative testing functions from those currently used for Military open-air testing that are/will be impacted by of the loss of frequencies, specifically but not limited to 5G frequencies. The requested technologies are intended for use in secure EW laboratories to mitigate that impact. The U.S. Government sell-off of the 5G frequencies used to support EW operations on U.S. ranges engaging in EW activities is a concern because our adversaries choose the frequencies of operation. Military EW laboratories consist of Installed System Test Facilities (ISTFs) which conduct free space radiation of the System Under Test (SUT) and Hardware In The Loop (HITL) laboratories which perform direct inject radio frequency (RF) testing for the EW equipment. Both of these methods also use modeling and simulation (M&S) capabilities for representing the subsystems and elements needed due to the inability to operate in open air. These M&S functions include atmospheric models, antenna models, etc.

The Government anticipates that the vendor will foresee the requisite testing shortfalls to be addressed in the developmental solution. The recommended prototypes must be justified with an analysis of alternatives (AoA) showing their merit over other alternative approaches/methods. The AoA shall provide definition of all perceived shortfalls with respective test use case scenarios, even where technology solutions may not be currently addressable. The prototype development activity should include the following component activities/objectives to comprehensively address the currently perceived problem space:

- Identify and address requisite prototype technologies for secure laboratories capabilities that replace open air T&E systems lost by frequency sell-offs, including 5G for both RF open- and closed-loop as well as M&S capabilities. This includes relevant M&S capabilities that, for example, may involve the use of an RF propagation model for 5G frequencies (initially for current 5G frequencies but potentially for future assignments). Prediction tools should address test planning and post-test event analysis.
- Identify and address RF threat representation test technology capabilities for use in secure laboratory environments to reduce dependency on electronic attack open-air testing requirements.
- Identify and address needed digital-to-RF environment technology-based conversion capabilities for Red/Blue interactions on relevant frequencies with the inclusion of M&S tools for multiple participant scenarios in congested and contested environments expected within Multi-Domain Operations T&E use case scenarios.
- Identify and address compatible technology-based direct RF injection mechanisms that provides sufficient isolation and phase stability to provide coherent beam stimulation of the SUT high-power array. Both physical interface and real-time digital instrumentation and stimulation are required.

Should the vendor assess that other needs beyond those above should be met, these should be identified for consideration, but not included in the initially proposed solution set.

May require access to secret level information.

6. Mitigating 5G Impact on Electronic Warfare (EW) Testing at Military Ranges

Innovative technologies and methods are sought to effectively assess the impact of both external (and internal range) 5G communications activity on EW testing operations to mitigate that impact during open-air test range operations. The U.S. Government sell-off of the 5G frequencies that are also used to support EW operations on U.S. ranges engaging in EW activities is a concern because our adversaries choose the frequencies of operation.

At a minimum this effort is the creation of a radio frequency (RF) validated propagation model. The Government anticipates that the vendor may foresee other requisite testing shortfalls to be addressed in the developmental solution. The model(s) should enable test range planning users for assessing impact on test events from concurrent external and range operations in the frequencies of concern, for EW test scenario development and rehearsal with surrogate systems to validate the test plan, and for use with range frequency managers to obtain authorization for test event emissions using frequencies of concern. The prototype development activity should include the following component sequential milestone activities/objectives to comprehensively address the currently perceived problem space:

- First, conduct an analysis of alternatives (AoA) and justify the merit of recommended approach(es) (at a minimum addressing RF propagation model selection) over other alternative approaches/methods. The AoA shall provide definition of all perceived shortfalls with respective test use case scenarios, even where technology solutions may not be currently addressable. The RF propagation model for 5G frequencies (initially for current 5G frequencies but potentially for future assignments), is to be adapted from among the many models owned or controlled by the U.S. Government to achieve the goal of this task. Sub-elements beyond initial model identification include analysis and recommendations for modifications to meet the stated needs above:
    - Identification/resolution with Government Integrated Product Team (IPT) participants of any needed enhancements in the selected model to improve model performance in common propagation conditions.
    - Identification/resolution with Government Integrated Product Team (IPT) participants of uncommon propagation conditions not addressed by the improved model (for which there is likely no validation data). The vendor is advised that during the validation effort current EW operations may not include all or even a large part of the currently proposed 5G frequencies to be addressed. As such the vendor should identify recommended method(s) to address validation of the model over those 5G frequencies not represented by current EW test operations for execution in successive step(s).
    - If other solutions beyond tailored propagation models are identified, this milestone activity shall include review and acceptance of AoA recommendations by Government IPT participants for proof of concept and further development in successive step(s).
- Second, upon approval of the Government IPT selection(s) from the prior milestone activity conduct a model validation effort with identified enhancements

to determine the current potential for interference with 5G operations of current EW activity focused on existing and currently planned 5G towers.

- Identify and develop any further improvements recognized by ongoing IPT participation.
- If other solutions beyond tailored propagation models are approved from the prior activity, this milestone activity shall include requisite proof of concept and functional development with validation activities for the proposed prototype(s). Note that if multiple development activities are proposed, the Government may elect to pursue them as parallel milestone activities for each separate need.

- The third milestone activity(ies) is/are to tailor the developed and validated RF propagation model as an easy-to-use test and training planning tool by range personnel for the 5G frequency EW operations. The tool shall predict interference, if any, with 5G activities by test operations (threat simulators used, flight operations, and any other emissions) during the proposed test activities. If other solutions froughhe second milestone activity are pursued, this activity includes development of operational prototype(s) also by implementing resolved participating range IPT inputs.

The emitter sources expected for use during EW test operations include but are not limited to: Advanced Reprogrammable Radars, Range Signal Density Enhancement, Radar Signal Emulator, Unmanned Threat Emitters, Joint Threat Emitters, and various air operations and testing activities.

May require access to secret level information.