Test Instrumentation Workshop
Technical Abstract Descriptions

Wednesday, May 24, 2023, 10:30 – 12:30 p.m.

Session 1 **Cybersecurity**
Chair Steve Seiden, President, Acquired Data Solutions

10:30 a.m. **"Endpoint Cyber Tool Considerations in Constrained Environments"**
Jeff Kalibjian, Security Architect, Peraton

Endpoint cybersecurity defense is a key element of an organization's overall cybersecurity strategy. Constrained testing environments offer additional challenges in cybersecurity tool deployment as CPU, memory, and network connectivity may be limited, impacting the viability of the classes of cyber tools that can successfully operate. After reviewing the current endpoint cybersecurity tool product landscape, discrete categories of cyber tools will be discussed in consideration of constrained operating environment deployment, emphasizing strategies, trade-offs and prioritization for selection based on most optimal cyber coverage given external constraints and mission requirements.

11:00 a.m. **"Cybersecurity and the Rise of AI: Risks and Opportunities"**
Jason Schalow, Chief, Special Missions Flight, 412th Communications Squadron

Over just the last year, the state-of-the-art for Artificial Intelligence has developed exponentially, with capabilities such as ChatGPT and Stable Diffusion capturing the media spotlight and open-source communities such as Huggingface and Kaggle making these technologies more accessible than ever. This presentation will discuss the cybersecurity risks and opportunities of these technologies as they apply to Test and Evaluation, with the goal of posturing both cyber defense and T&E professionals to operate securely in an AI-enabled environment. Discussion will include applications of AI as a defense tool, as well examining security relevant aspects of these technologies and the open-source ecosystem that is quickly growing around them.

11:30 a.m. **"Automated Cybersecurity Risk Management Framework (RMF) for DoD"**
Steve Seiden, President, Acquired Data Solutions, Inc.

As Federal requirements for cybersecurity protection increase so has the importance and need to demonstrate how Operational Technology (OT) is compliant with these standards. These requirements have placed a heavy burden for automated Cybersecurity Risk Management Framework (RMF) tools as networks and data become a bigger part of test and evaluation T&E), the need for compliance to cybersecurity standards has grown. T&E has become a bigger part *of IT and IT requirements. Meeting Federal requirements means showing evidence of a secure supply chain, protection of sensitive information, and readiness to mitigate cyber-attacks. Acquired Data Solutions will cover preparing your OT to comply with today's government standards and the necessary artifacts through RMF automation.*

12:00 p.m. **"Testing and Training at the Tactical Edge"**
Jacob Burch, Systems Engineer, Command Post Technology

TED is a secure (all classification levels) information technology (IT) device that allows for connectivity to any cloud based, on premises data center or hybrid (part cloud-based and part on premises) cloud capability from austere test and evaluation and training environments. The so what for this previous statement is most T&E and Training events are conducted in remote, austere, and low bandwidth areas. The data that is produced during these events needs to be collected, analyzed, and synthesized to form actionable intelligence either for the test owner or the commander of the training audience in real or near real time. In most T/E and Training events today this data is collected on external media devices (USB, DVD, Blu Ray, etc..) then transported physically to a data center at a different location and uploaded to that environment whether it is a cloud-based, on prem or a hybrid solution. If by some chance the range conducting the T/E and Training event has connectivity (fiber, 5G, WiFi, 4G, satellite, etc…) then the data collected could be uploaded to a cloud-based, on prem or a hybrid data center to begin the analysis. The analytics would be done at the specific location (cloud, on prem, hybrid) where there are enough resources (compute, storage, Artificial Intelligence and Machine Learning solutions) then transferred back to the site where the test or training event took place. This takes a lot of time and resources to accomplish this analysis. The tactical edge device concept is to put those resources into a deployable, ruggedized, and manageable (small) form factor that could be maintained and operated on whatever range was conducting the test or training event. These edge devices could be customized (scalable) based on the requirements of a specific test or training event. Scalable means the amount of compute and storage resources could be determined so you wouldn't have a device with too little or too much resources (ie…cost could be manage) for that specific test or training event. These devices would be able to run AI and ML solutions at the tactical edge and give real time analytics to the test owner or commander responsible for the test or training event. Also, if time was not the most limiting factor these devices could upload that data back to an already established data center where analytics could be performed by trained analysts with AI and ML solutions.

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Session 2 **Leveraging Data Analytics/Machine Learning to Gain Efficiencies in T&E**
Chair Robert Poulson, 812 TSS

10:30 a.m. **"Application of Artificial Intelligence to Aviation Communication"**
Dr. James Brownlow, 812 TSS/ENTR

US Air Force manned-unmanned teaming (MUM-T) technologies are under development to support incursion into contested airspace. Because of higher workload in these environments, voice communications are of paramount importance since there must also be audio communication with unmanned systems. Natural Language Processing (NLP) as an enabling technology for MUM-T. Unique technological challenges common in tactical environments include high stress, audio noise, and communication dropouts. The first part of this effort involves the simulation of both vocabulary and voice to aid the development of the expert human machine (EHM) communication system. This presentation details the results of this simulation effort. Furthermore, we will show how these expert systems will be used in an AI/ML environment to develop NLP models adapted to predict missing words in voice communications. Current work uses automatic speech recognition (ASR) to extend/enhance the NLP/EHM model to improve voice communications.

11:00 a.m. **"Firth's Maximum Likelihood Bias Reduction for Rare Events: A Case Study of Onboard Oxygen System Events"**
Andrew Zastovnik, 812 TSS/ENTR

The goal of this presentation is to show that applying Firth's maximum likelihood bias reduction to rare events and small sample size binomial data will allow confidence intervals to be developed where the stated confidence in more in line with the true confidence. Use of the binomial distribution is standard practice in flight T&E. In this presentation the On-Board Oxygen Generation System (OBOGS) events from 2003-2011 will be used to illustrate the effect of using Firth's maximum likelihood bias reduction. This has the potential to find rare events such as OBOGS earlier. Thereby, allowing us to do more with less.

11:30 a.m. **"Predicting Flight Loads with Deep Neural Networks"**
Michael Kidman & Leo Salgado, 773rd TS/ENFS

Flight test may, in some cases, require execution of maneuvers that result in wing/tail surface forces suspected to be near safe and design limits. Structures test engineers developed linear regression models (LRMs predicated on flight dynamics) to predict maximum forces for a given set of flight-test conditions / parameters. An inherent weakness of LRM predictions is they may require an extrapolation beyond the region used to develop the models. LRM were made *based on assumptions of independence, normality, homogeneity of variance and lack of multicollinearity. To address possible difficulties posed by these issues, an AI approach was proposed. Specifically, a Deep Neural Network (DNN) that fused information from LRM predictions and flight test data was designed to model / predict maximum forces. This presentation details development and example application of this AI technique. Python PyTorch, and a Nvidia GPU were used to develop the DNN.*

12:00 p.m. **"Under Pressure? Using Unsupervised Machine Learning for Classification May Help"**

Dr. Nelson Walker & Ms. Michelle Ouellette, 812 TSS/ENTR

Classification of fuel pressure states is a topic of aerial refueling that is open to interpretation from subject matter experts when primarily visual examination is utilized. Fuel pressures are highly stochastic, so there are often differences in classification cation based on the experience level and judgement calls between a particular engineer. This hurts reproducibility and defensibility between test efforts, in addition to being highly time-consuming. The Pruned Exact Linear Time (PELT) changepoint detection algorithm is an unsupervised machine learning method that has shown promise towards leading to a consistent and reproducible solution regarding classification. This technique combined with classification rules shows promise to classify oscillatory behavior, transient spikes, and steady states, all while having malleable features that can adjust the sensitivity to identify key chunks of fuel pressure states across multiple receivers and tankers.

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Session 3 **Spectrum Limitations**
Chair Allen Hagopian, 812 TSS/ENTI

10:30 a.m. **"5G Cellular Airborne Transceiver for AMT: Integration and Deployment Update"**
Achilles Kogiantis, Peraton Labs

A novel 5G airborne transceiver has been designed and developed for 3GPP-based 5G cellular-based aeronautical mobile telemetry (AMT). To support telemetry at high aircraft speeds, the transceiver implements Doppler pre-compensation within the on-board transceiver via the self-contained Velocite solution. An overview is given of the airborne transceiver's overall design approach that includes a commercial 5G mobile modem and a field-programmable gate array (FPGA)-based Doppler compensator. A description is given of the capabilities of the transceiver and the ground network architecture needed to support cellular telemetry, as well as system-level operation aspects, including coverage in air and on ground. Finally, details are provided of specific design aspects and trade-offs to be considered for AMT, including a ruggedized design for integration with the test airframe to support AMT at the testing range.

11:00 a.m. **"Spectrum Sharing in Aeronautical Mobile Telemetry"**
Mark Wigent, Principal, Laulima Systems

It is well understood by senior leadership of the Department of Defense and across all levels of government that electromagnetic spectrum is a vital and limited resource. The demand for spectrum to support and enable an ever-increasing set of applications across myriad classes of users, among them the DoD test community, has been growing at an unprecedented rate. At the same time, the supply of electromagnetic spectrum is finite, and without changes in the way that spectrum is accessed, managed, and utilized, what is currently a shortfall in spectrum availability will only grow.

Given the value of spectrum, and the benefits derived from use of spectrum, this shortfall in spectrum brings with it a great loss to our nation, whether that loss be economic or a reduction in preparedness for emergency or national security, whether the application supports telecommunications or national defense.

In an environment in which supply of RF spectrum is fixed, demand is increasing, and exploitation of spectrum ushers in a variety of economic, social, and national benefits, the only reasonable response to the growing imbalance between supply and demand is to change the ways in which we view, manage, and access spectrum. Traditionally, spectrum has been viewed as a resource that should be carved out for specific users. Management of spectrum involved allocating, partitioning, and licensing of spectrum in static ways which lead to inefficient use *of spectrum. As we look toward the future, we must change how we view and manage spectrum; we must move toward a paradigm of spectrum sharing and flexible management of spectrum, and this requires development of new mechanisms to access spectrum. This includes development of advanced radio technologies to use spectrum in non-traditional ways.*

This presentation will discuss development of a prototype radio for aeronautical mobile telemetry (AMT) that implements concepts of spectrum sharing between Federal and non-Federal users in highly constrained environments in a project funded through the National Spectrum Consortium.

11:30 a.m. **"Updated Status on the Ground Based Phased Array Telemetry Antenna (gPATMA) System"**
Scott Kujiraoka, GBL Systems

As reported in last year's presentation, upon analysis of formally documented test scenarios, it was determined there is a significant telemetry(TM) collection capacity gap at the Point Mugu Sea Range (PMSR). The reduction of available spectrum due to the Spectrum Sell-Off, along with extremely high bandwidth requirements for the most stressing test scenarios, required missile systems to transition to C-Band (4400-5150 MHz). PMSR has upgraded many of its' telemetry receive systems to include C-Band reception. However, emerging customer requirements have increased the number of missiles simultaneously operating in C-Band. The current TM collection architecture at the major Government Test Ranges utilize parabolic antennas and it is not cost effective or realistic to scale for data collection from over twenty spatially separated TM signals. Therefore, the Navy Major Range Test Facility Base (MRTFB) office partnered with the Test Resource Management Center (TRMC) to develop the ground-based Phased Array TM Antenna (gPATMA) System that could collect TM data from a high number of airborne platforms (missiles, targets, and planes). This paper will discuss the latest developmental status of the gPATMA project and provide data if available.

12:00 p.m. **"Spectrum Management and Geolocation in Complex RF Environments"**
Jade Long & Jim Wargo, CRFS, Inc.

Radio Frequency (RF) environments around the globe continue to increase in complexity and density, which is largely driven by advances in wireless communication technologies across multiple sectors. This is further complicated by the availability and proliferation of consumer electronics, such as smart phones, home automation devices, drones, Bluetooth devices, portable radios, etc.

CRFS designs and manufactures equipment and software specifically targeted at spectrum management, spectrum monitoring and emitter geolocation to mitigate such increased spectral densities. CRFS systems employ Multilaterization (or Time Difference of Arrival [TDOA]), Angle of Arrival (AoA), and Power-on-Arrival (PoA) techniques to provide customers with specific tools to address their spectrum management needs. CRFS' technology has been built from the ground up to *directly address the challenges brought about by complex emitters in dense RF environments using sample-based and detector-based TDOA, which allows users to filter out specific transmitter types of interest.*

During this session, we will present common RF challenges that adversely affect our military and public safety sectors, followed by a discussion of how CRFS systems are used to mitigate these challenges. This includes operation within GPS denied environments using our featured GPS holdover module as well as operating in dense RF environments such as populous urban locations. This session aims to equip attendees with the knowledge of what challenges are out there, and what techniques can be applied to combat them.

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Session 4 **Aircraft Instrumentation**
Chair Larry (Joe) Dale, Director, 812th Aircraft Instrumentation Test Squadron

10:30 a.m. **"Network Telemetry Development at Edwards Air Force Base"**
Mike Delaney, PE, Electronics Engineer, 812th Aircraft Instrumentation Test Squadron

The Telemetry Network Standards (TmNS) have the potential to improve test efficiency while also making more efficient use of available spectrum. The TmNS bi-directional network telemetry link allows users to request desired data (including data that was not previously on the PCM stream), and also enables correction of PCM dropouts. This presentation discusses the progress of TmNS development at 412th Test Wing to date, 412th TW vision for network telemetry, and upcoming test flights.

11:00 a.m. **"TmNS Rascal Pod"**
Grecia Roman & Clinton Mazone, 812th AITS/ENIE

The 412th Test Wing out of Edwards AFB is currently developing a fully functional unclassified testbed for TmNS Development. This system intends to validate basic functionality such as a bi-directional network link, queryable recorder capability and PCM backfill. The system will be housed in a RASCAL pod to reduce aircraft downtime.

11:30 a.m. **"Using TmNS to Request Recorded Data That Was Not Telemetered"**
Rocco Docimo & Ben Kupferschmidt, Curtiss-Wright

The Telemetry Network Standard (TmNS) was released as part of the 2017 version of the IRIG-106 standards. Traditionally, serial streaming telemetry data has been sent on a unidirectional link from the test article to the ground. The TmNS standard offers a new approach to acquiring flight test instrumentation (FTI) data that changes this paradigm by allowing the use of bi-directional data links. These bi-directional links allow for commands and requests to come from the ground back to the aircraft. This offers a new capability to the flight test community to request data on demand from the flight test recorder.

The ability to request data from the ground makes it possible for flight test engineers to request data from an aircraft's data recorder that was never planned to be telemetered during a flight. This allows for the real-time investigation of anomalies in the data during the test flight rather than having to wait for the flight to end. This has the potential to save time and money. This paper explores a system that Curtiss-Wright has created that allows users to perform data on demand requests for data of interest using our COTS hardware.

12:00 p.m. **Packet Telemetry at Edwards AFB with IRIG 106 Chapter 7”**
Mike Delaney, PE, Electronics Engineer, 812th Aircraft Instrumentation Test Squadron

Packet telemetry is a flexible telemetry format that allows a mix of data types encapsulated within serial streaming telemetry. The 412th Test Wing is using IRIG 106 Chapter 7 telemetry on multiple platforms. This presentation will provide an overview of current and future Chapter 7 use cases, issues encountered and lessons learned. In particular, multi-vendor interoperability and configuration communication issues will be addressed.

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Session 5 **Techniques for Enhancing Data Collection**
Chair Mike Cook, 412th Communications Squadron

10:30 a.m. **"Determining Antenna Performance via Comparative Methods"**
Mark Radke, Bevilacqua Research Corporation (BRC)

Currently, a method does not exist to obtain direct far-field G/T measurements of active antennas. Due to the high variability of solar calibration, that include hot and cold sky antenna pointing, daily solar flux measurements from an offsite location, and dependence on an antenna operator. A method has been developed using a repeatable lab defined, or measured, G/T for a reference antenna system. The lab defined system considers electronic noise and environmental noise, or aperture noise, measurements and analytically produces a value for G/T. The threshold measurement of G/T is then used to compare a system under test (SUT) using bit error rate (BER) differences. The content of this presentation will focus on the reference antenna definition, test setup of reference-to-SUT, post test results, and will give the viewer the knowledge how to apply this methodology to their own SUT.

11:00 a.m. **"Airborne Instrumentation Technical Training Curriculum"**
Tiffany Johnson, 896 TSS/RNME

A modular technical training plan that contains educational material, lab assignments, and knowledge assessments. Technical training for airborne instrumentation that includes a hands-on, practical application of the material. Topics covered include analog sensors, calibration, GPS/time, data acquisition (1553, serial, discrete, video), PCM, recorders, telemetry, networks, IRIG standards, and design considerations.

11:30 a.m. **Ka-band Transmit/Receive Aperture (KaTRA)"**
Jerry Jost, Star Dynamics Corporation

KaTRA is a TRMC T&E/S&T's sponsored effort developing a high-EIRP Ka-band radar cross section aperture with high-power and high-duty cycle.

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Session 6 **Range Instrumentation**
Chair Doug Nelson, Teknicare

10:30 a.m. **"Eos – A Software TMoIP Decommutator to Increase Test Agility"**
Pearson Wade & Cameron Bertram, 96 Range Control Squadron

Eos is a fully software telemetry (TM) decommutation solution utilized by the 96 Range Control Squadron at the Eglin Test and Training Range (ETTR), developed and owned by the government using open architecture principles. Eos supports military platforms and emerging drone technology by processing an infinite set of data stream arrangements utilizing dynamically linked software modules. Modules consist of IRIG-106 TM standards, Internet Protocol (IP) standards, platform-specific data encoding, and any custom processing module as needed. New data processing modules can be easily implemented and integrated utilizing the Eos module interface. Eos can deliver Engineering Unit (EU) converted parameterized data, digital video frames, audio, or MIL-STD-1553 values and various additional payloads to a variety of different output feeds. Additionally, the processing performance of Eos is regularly tested against complex stream configurations and consistently outperforms the legacy hardware solution. As this software reaches final operating capability including user interfaces, data recording functionality, and configuration file generation/processing, it will be a viable alternative to expensive COTS solutions and can be rapidly integrated into T&E range architectures. The 96th Range Control Squadron at Eglin has committed to adopting Eos as the Squadron telemetry decommutation solution during the transition away from the legacy COTS TM solution. Additionally, Eos provides a new level of cross-platform flexibility for integration. Eos is readily deployable and can run on any system that can run Java. Compatible systems can range from high-powered rack-mounted servers to handle complex streams at high rates, to simple lightweight streams decommutated in the field on a laptop. Eos has been designed to change the T&E landscape, enabling agility to support current and future generations of ethernet based weapons systems.

11:00 a.m. **"NetAcquire Advanced Correlating Source Selector (A-CSS) - A New Approach to Best Source Selection"**
Madalyn Danielak, 96 Range Control Squadron/RNCEE

Best source selectors (BSS) are an incredibly important component of the telemetry pipeline. They not only ensure that the best available data is put in front of test engineers during real-time test events, but they also provide a simplified telemetry stream for post mission data processing and analysis.

Many contemporary and legacy BSS systems rely on a single metric for determining the best source out of multiple identical telemetry streams. They act simply as a *junction of the telemetry pipeline, only passing through whichever stream is determined to be the best source by its own metric. The process by legacy BSSs does not involve any real-time bit error correction or modification to the output stream and fails to take advantage of the inherent redundancy of the multiple identical streams as its input. Other limitations include not accounting for time offsets between different streams, causing bits to be repeated or dropped entirely when the determined best source changes mid-stream. Some BSSs are also unable to accept input streams that have undergone data encryption, leaving operators responsible for manually switching between telemetry streams should the selected stream fail or drop out.*

The NetAcquire Advanced Correlating Source Selector (A-CSS) can output the best available sources from multiple identical telemetry streams as well as create a correlated output stream containing the best available data from all input sources. The A-CSS can look at multiple metrics of telemetry streams such as frame sync, data quality metrics (DQM), and redundancy between identical streams to create a correlated output stream that contains fewer errors than a traditional BSS output stream.

In addition, the A-CSS also accounts for time offset between multiple identical streams stemming from different geographical sources and therefore prevent the final output stream from dropping bits or repeating bits in both the best source stream as well as the correlated stream. The A-CSS is also capable of receiving and best source selecting data streams that have undergone data encryption.

The A-CSS was implemented at 96 RNCS initially for a particular mission effort to account for time offsets between geographically diverse range sources. Data analysts were having to collect each range's locally recorded telemetry streams post-mission to properly correlate data from all range sites. The introduction of the A-CSS has saved post-mission analysts time and effort, reduced bit error rate (BER) in recorded output streams and allowed for best source selection for telemetry streams that have undergone data encryption.

Tests of the A-CSS under normal range conditions have shown that the system can produce correlated output streams with BERs 500x better than any of the individual inputted telemetry streams. In identical, geographically diverse sourced telemetry streams, the A-CSS uniquely offers the potential to capture more precise and encompassing telemetry streams than traditional BSS. The briefing will cover the 96 RNCS's implementation and testing of the A-CSS, lesson learned from its use on mission efforts, its benefits and drawbacks compared to BSS, and future uses of the system.

11:30 a.m. **"Miniature High-Accuracy Time Space Position Information (TSPI) Data Acquisition"**
Ben Kupferschmidt, Curtiss-Wright

Flight test applications require accurate and plentiful data to verify and validate the test article's performance. This data is most useful when it is properly *correlated with other contemporaneous test data. This includes ensuring that all data is in sync with the aircraft's position and orientation in space. This enhances one's knowledge of what is happening during different maneuvers, allowing engineers to better determine the limits of an airborne platform.*

Time space position information (TSPI) systems deliver this positional data. TSPI systems are able to provide very accurate data by combining highly accurate and precise internal electromechanical components with careful installation and calibration. This presentation discusses Curtiss-Wright's new MiTSPI nTTU-2600 Miniature TSPI device and presents some real-world test data that demonstrates its performance.

12:00 p.m. **"Electronically Steerable Arrays for Range Applications"**
Tres Thurston, Vice President of Sales & Marketing, Haigh-Farr

Imagine the following test scenario:Multiple attack assets are released from ground and air positions simultaneously to neutralize an incoming bogey. These rockets are on target to destroy the threat; and they are coming from mobile missile batteries spread across the test range grounds and from airborne platforms flying overhead. A system test engineer's job during this melee is to capture data from each player in the multi-faceted test operation—attack vehicles, missiles, and the adversary alike. All of these components are telemetering data to somewhere, and the equipment used to capture this information reliably, consistently, and continuously will play as big a role in the overall success of the test as the assets streaking across the sky. A key element of this test hardware will be the antennas used to capture the RF energy being emitted from all of these vehicles. That is where an Electronically Steerable Array (ESA) antenna comes into play.

Already developed and beta-tested at a range in the United States, the ESA discussed in today's presentation was developed with a similar application in mind—a flight platform tracking and collecting data coming from multiple airborne assets. The technology driving these Next Generation ESA's are the modern 5G digital-era chipsets. This ESA uses connectable, modular, multi (single or dual pol) antenna element building blocks to construct arbitrary size, planar, multi-beam phased arrays. These phased array modules collect both horizontal and vertical components (in the dual pol arrangement) of any RF signal within their predetermined and tuned frequency range and within the ESA's electrical field-of-view. The RF signals from each element are amplified, sampled, conditioned, filtered, digitized, and finally passed through FPGAs and ARM Cortex Processors running customized complex vector math functions to provide beamforming functionality. The net result is channelized preconditioned Digital or Analog RF for further use by the customer. This entire architecture allows for fully digital beamforming rather than analog RF beamforming. Furthermore, this architecture can move the aforementioned test scenario into the next generation of telemetry gathering during complex range operations, and it is the focus of this presentation—using modern-day ESAs for range testing of airborne and ground subjects collected by airborne and ground assets.

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Session 7 **Electronic Warfare**
Chair Jeff Weisz, Global Power Fighters Combined Test Force

10:30 a.m. **"Generating Insights from Test and Evaluation Data (GIFTED)" **CUI: US Citizen CAC/PIV Required for this one presentation****
Gregory Tauer, Principal Engineer, CUBRC, Inc.

Research and Engineering (R&E) Test Resource Management Center (TRMC) is sponsoring development of the Generating Insights from Test and Evaluation Data (GIFTED) prototype system which provides automated data ingestion, knowledge extraction, and Artificial Intelligence/Machine Learning (AI/ML) algorithm configurations for processing of audio, video, and imagery datasets. NAWC WD serves as the Executing Agent for the Command, Control, Communications, Computers, & Intelligence (C4I) and Software Intensive Systems Test (C4T) Test Technology Area to mature technologies from technology readiness levels 3-6. The goal of the GIFTED system is to help revolutionize the way that acquisition systems are evaluated. GIFTED will enable Test & Evaluation (T&E) Analysts to make better/faster decisions, by rapidly analyzing previously unstructured datasets to generate new information and gaining new insights to support T&E effectiveness determinations. GIFTED will enable the T&E Analyst to examine 100% of collected datasets to uncover the behaviors in very large/big datasets in support of acquisition T&E and experimentation.

The GIFTED framework automates manual processes performed by test analyst. The goal is to provide faster post-exercise analysis of collected data. Machine learning is applied to accomplish much of the automation. The GIFTED core architecture is designed to provide a common pattern to support machine learning and artificial intelligence algorithm training and deployment across different use cases. Different use cases will require processing different data modalities and types using a variety of different models. For example, of the two active use cases, one works with video and structured data, while the other processes audio recordings. Each use case will require the development of specialized algorithms and analysis user interfaces. In addition to automated analysis, GIFTED provides tools for analytics visualization. GIFTED automated analytics will be capable of incorporating new sources of information. For example, if a new sensor or aircraft is included, the algorithm will still be able to analyze it. Post flight test video review of complex displays such as a Tactical Situation Display are time consuming, and for complicated tests can be incomplete due to significant amount of information being displayed. An algorithm that can identify and log symbols and then compare them to truth data will focus the limited analysis capability on the areas of most interest. Additionally taking recorded audio from cockpit, range safety, or test control centers and making that information discoverable as structured data will *help test analysts be able to access all test data at a given point in time to understand the outcomes of a given test scenario event.*

11:00 a.m. **"Improving the Capabilities of Cognitive Radar and EW Systems"**
Bill Kardine, Radar and EW Business Development Manager, Rohde and Schwarz

This paper will discuss the challenges that face modern electronic warfare systems that are used to identify adversarial emitters and jammers that may change their operational modes in times of conflict. These systems may operate in mode-agile, also known as WArtime Reserve Modes (WARM), that fundamentally change the unique identifying characteristics of the emitter, by modifying attributes such as operating frequency, occupied bandwidth, frequency agility (hopping) schemes, modulation, pulse repetition interval (PRI) and signal to noise ratio, for example. These WARM modes present insurmountable challenges to legacy Electronic Protect (EP), Electronic Attack (EA) and Electronic Support (ES) systems that utilize traditional static threat library implementations in RADAR and EW systems.

A new class of emerging ES, EP and EA systems utilize Artificial Intelligence (AI) and Machine Learning (ML) to deploy countermeasures against signals that the system has never seen before. The paper will review common AI and ML algorithms that are used to implement the cognitive functions and discuss the challenges of deploying systems that need to make split-second decisions at the tactical edge.

A cornerstone of implementing cognitive systems is the training of those systems with realistic data in the presence of impairments. The paper will discuss the collection of real-world signals and/or creation of synthetic training data and will review systems that can be used to create closed-loop RF In the Loop (RFIL) systems to train and measure the performance of cognitive algorithms. The system discussed can simulate wideband, complex RF environments of long duration with impairments and can be used to determine how an algorithm responds in the presence of those impairments. The paper will conclude with a discussion of how the same system can be expanded to deliver a testbed that enables FPGA algorithm deployment that accesses the raw RF IQ data and can be used to create a testbed for deterministic closed loop algorithm development.

11:30 a.m. **"Low Cost AESAs for Test and Training"**
Jay Grove & Noel Lopez, Viasat

Viasat is currently developing low-cost Active Electronically Scanning Arrays (AESA) by leveraging commercial technologies and approaches to Satisfy the demand for a high volume arrays for commercial markets such as in-flight entertainment. The Test and Training community may find an important solution with low cost AESAs. Our potential adversaries have large inventories (both commercial and military) of fielded RF emitters creating high-density and congested RF environments making it challenging to discriminate the 'true threat'. Meanwhile, test and training activities field a limited number of threat simulation systems that may not suitably represent high-density RF environments.

While there remains a need for high fidelity/high power systems, it is also important to accurately replicate signal density, not practical with current approaches. Low cost AESAs, rapidly fielded with commercial techniques may offer the best opportunity to accurately represent war-time RF density. This presentation surveys technologies and approaches to dramatically reduce the cost of AESAs for test and training applications.

12:00 p.m. **"Advanced Airborne DRFM (A2DRFM)"**
John Matthews, Mercury Defense Systems

A2DRFM is a TRMC T&E/S&T's sponsored effort developing a representative adversary cognitive jamming system to test blue force's air, sea, and land-based advanced radar, data links, and communications systems operating simultaneously and in coordination over extremely wideband frequencies.

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Session 8 **Hypersonics**
Chair Ben Tomlinson, NASA

10:30 a.m. **"Development of a Low SWaP Non-Contact Temperature Measurement System"** ****CUI: US Citizen CAC/PIV Required for this one presentation****
Jackson Winter, NASA

Hot Structures tests have been conducted for over 60 years. However, in the last 10-15 years, advancements in computational tools and increased emphasis on model validation has created a need to improve test data correlation while reducing error sources. Recent, current, and future efforts to develop and implement a digital transformation of the test design process for large scale thermal tests of high speed vehicle structures will be presented.

11:00 a.m. **"Pursuing the Digital Transformation of Large Scale Thermal Testing"**
****CUI: US Citizen CAC/PIV Required for this one presentation****
Nic Heersema, NASA

Obtaining temperature measurements on high temperature structures during reentry or high speed flight has been challenging since the beginning. While measurements have been made, there continue to be challenges reliably obtaining data during flight tests. Challenges can be due to the difficulty in bonding sensors to hot structures with a bond that can survive to the limit of the sensor, or the brittle nature of tungsten-based thermocouples, or the EMI sensitivity of thermocouple lead wires, or simply the process of managing the thermocouple lead wires during vehicle integration. The Adaptable Radiometric Measurement System (ARMS) seeks to solve all of these challenges through the development of a low SWaP, non-contact temperature measurement system. The presentation will share progress to date, and future plans.

11:30 a.m. **"Unique Requirements for a Hypersonic Telemetry System"**
Paul Cook, Director Missile Systems & PLM RF Products, Curtiss-Wright

With the various hypersonic vehicle developments happening today, there are several unique Telemetry requirements that differ in use case, from the ones used in everyday flight test that migrates from the standard practice in our industry. This paper discusses reusing the standard product technology to address the unique requirements for the hypersonic use case, what and whys behind the list, and why these are unique from the airborne perspective to drive new design to full fill the hypersonic requirement and still meet the guidelines that the IRIG-106-20 sets forth.

12:00 p.m. **"Hypersonic High Cadence Airborne Launch Platform"**
Paul Phillipsen, CTO, Fenix Space, Inc.

The slow cadence of existing hypersonic flight testing is inhibiting the advancement of hypersonic technology and the introduction of hypersonic capabilities for both defense and commercial applications. Some estimates from the hypersonic community put the combined defense and commercial payload flight test backlog at more than five years. Testing infrastructure has been a significant limiting factor in the development process, with most major programs conducting only a few trials each year. A key DoD goal is to establish a high-cadence (i.e., weekly) and low-cost testbed for both cruise and boost glide systems. Defense Innovation Unit HyCAT is one piece of the national test puzzle, providing TRMC and its partners options for flight tests. To address this challenge, Fenix Space, Inc. is adapting a commercial, patented, responsive, flexible tow-launch platform to deliver payloads to hypersonic conditions as part of the HyCAT program. The reusable launch platform operates out of existing airfield infrastructure with a very small operational footprint, keeping costs low. This paper will cover the concept of operations, general payload capability, notional trajectory information, and hypersonic conditions achievable. Future uses of this technology will be discussed.

Thursday, May 25, 2023, 10:30 – 12:30 p.m.

Session 9 **Wireless Airborne Instrumentation**
Chair Chris Stewart, 896 TSS, Eglin AFB

10:30 a.m. **"Wireless Instrumentation System for Aircraft Testing"**
Kurt Rasmussen, RF Systems Engineer, NextGen Aeronautics

NextGen has developed a Wireless Instrumentation Systems (WIS) that provides a wireless communications interface to connect analog or digital sensors to an existing airborne instrumentation system. The WIS consists of a central aggregator and multiple wireless sensor nodes, with each node capable of handling one or more sensors. This presentation will address the challenges of reliable data transfer, time synchronization and power options.

11:00 a.m. **"Airborne Instrumentation in a Time Constrained Environment"**
Paul Cast, Instrumentation Chief Engineer, 896 TSS, USAF

This presentation addresses utilizing processes and technology to significantly reduce the amount of dedicated time required to install airborne instrumentation. The specific use case addressed is the F-16 fighter jet. Process innovations include changes to the way we currently fabricate and terminate wiring, standardization of equipment locations across instrumented aircraft, and other process improvements. Technical innovations include the use of wireless instrumentation, batteries, and other technologies. It should be noted that all of these technological and process innovations are not new to industry; due to cybersecurity, airworthiness, and other concerns, however, Department of Defense aircraft instrumentation organizations have been slow to incorporate these new devices and/or processes into their solutions. In spite of these concerns and challenges, the application of these innovations should greatly reduce aircraft downtime when installing airborne instrumentation on aircraft. This presentation will discuss technology, processes, and anticipated time savings of applying the aforementioned innovations towards instrumentation installs on F16.

11:30 a.m. **"Wireless Airborne Instrumentation"**
Benjamin Baird, 896 TSS, USAF

This presentation addresses the use of wireless technology in the area of airborne instrumentation with a focus on the reduction of aircraft downtime required for instrumentation installation. Although it may seem trivial, since wireless technology is used almost everywhere from your home Wi-Fi to keyless entry for your vehicle, aircraft instrumentation technology is trailing behind in this field with hardwired Ethernet systems being installed just a few years ago. Topics include the use of wireless technology for various applications with a focus on control and status using Wi-Fi and general purpose input output (GPIO) interfaces to the *instrumentation system. This application of wireless technology has the potential to significantly reduce the timely installation of wiring into and out of the cockpit and to other difficult to access locations throughout the aircraft. The presentation will discuss technical details, interfaces, and use cases.*

12:00 p.m. **"Wireless Hub for Wireless Sensors"**
Wendy Yang, NASA

The wireless hub technology, currently being developed at NASA, enables flight data collection via wireless connection to data sensors. The hub is composed of a Software Defined Radio (SDR) unit and a ruggedized PC, with USB connections to antennas for data transfer. Sensor data is wirelessly transmitted to the hub via RF communication, then timestamped via a connection to a NTP server from the PC. Multiple sensors can be connected to the hub, with data transmitted via a single frequency band using time-division multiplexing. The hub can also interpret multiple RF protocols as needed by the sensors. Data is locally stored on the hub for later retrieval and can be wirelessly transmitted via telemetry if needed.

The elimination of wired connection between the sensors and the data collection hub greatly reduces the complexity of sensor integration and de-integration. This enables faster flight test setup and increase R&D capabilities for new sensors. Faster and cheaper flight test capacity will increase the collaboration relationship between NASA and partners and greatly benefits NASA's policy goals of achieving Urban Air Mobility (UAM) and Advanced Air Mobility (AAM).

The wireless hub will be first flight tested onboard the NASA 801, a Beechcraft 200 King Air, with the Boundary Layer Data System (BLDS), a sensor developed by Cal Poly San Luis Obispo (SLO). The BLDS measures boundary layer characteristics of in-flight aircraft wings and was previously validated on flight tests in wired configuration, thus making the sensor an appropriate, low risk test for the wireless hub. During the flight test, the sensor will be operated by Cal Poly SLO personnel, and the hub will be monitored by inflight personnel as needed. If validated, the wireless hub can then be used for other sensors.

Thursday, May 25, 2023, 1:30 – 3:30 p.m.

Session 10 **Instrumentation under PEO STRI** ****CUI: US Citizen CAC/PIV Required****
Chair Kyle Platt, Director IMO, U.S. Army Program Executive Office for Simulation Training and Instrumentation (PEO-STRI)

1:30 p.m. **"Directed Energy T&E Technologies"**
Whitney Winchester, Assistant Program Manager (APM), PEO-STRI

This presentation will survey current and new Test and Evaluation (T&E) infrastructure for Directed Energy weapons with a special focus on test assets that have application in the development and testing of airborne High-Energy-Laser (HEL) systems. The content will highlight current projects such as the Mobile High Energy Laser Measurement (MHELM) and successes from the Directed Energy Instrumentation Initiative (DEII) sponsored by the Test Resource Management Center (TRMC).

2:00 p.m. **"Advanced Range Tracking and Imaging System (ARTIS)"**
Nicole Bui, PEO-STRI & Philip Kiel, Photo-sonics

The Advanced Range Tracking and Imaging System (ARTIS) is a CTEIP-funded development of the next generation optical tracking systems (OTS). The ARTIS program is developing two types of OTS to meet current and future test needs across DOD test ranges. The Fly-Out prototype systems were developed and delivered to White Sands Test Center in FY22. The Close-In prototype systems are in development and will undergo testing in FY24.

2:30 p.m. **"System of Systems Controlled Environment Test Infrastructure (SCETI)"**
Michel Berry, PEO-STRI & John Beene, Chief Engineer, GAN

Located at Redstone Test Center (RTC), System of Systems Controlled Environment Test Infrastructure (SCETI) is a multi-use facility for developers, testers and evaluators that will support Future Vertical Lift (FVL) Cross Functional Team by providing repeatable Degraded Visual Environment (DVE) for aircraft sensor testing.

3:00 p.m. **"Roadmapping Future T&E Needs"**
Trung Nguyen, Executing Agent, TRMC's Electronic Warfare Test (EWT)

This presentation will be an overview on Test Resource Management Center's (TRMC) roadmapping process and preliminary findings for the Ground Electronic Warfare Test and Evaluation Roadmap (GETER), Sensor and Seeker Test and Evaluation Roadmap (SSTER) and Cognitive Electronic Warfare Test and Evaluation Roadmap (CETER).

Thursday, May 25, 2023, 1:30 – 3:30 p.m.

Session 11 **Current /Future Secure Telemetry Directions 2023 Update** ****CUI: US Citizen CAC/PIV Required****

Chair Ron Pozmantier, Chief Engineer, 812th Aircraft Instrumentation Test Squadron (812 AITS/ENI)

1:30 p.m. **CHECK IN**.

2:00 p.m. **"Type 1 HAIPE Encryption for Securing Current and Future Telemetry Data Distribution and Transmission"**
Ken Ottaviano, Solutions Architect, General Dynamics - Mission Systems

Presentation will address current Type 1 HAIPE equipment used to secure network data in transit. The current TACLANE HAIPE product family will be discussed as they bring unique capabilities to the telemetry mission space. Latest features such as layer 2 VLAN passthrough, redundancy, and modern remote management will be discussed as well as the use of HAIPE secure encryption to distribute TMoIP data between sites. Presentation will conclude with future capabilities for next generation HAIPE and EDE encryption.

2:30 p.m. **"Commercial AES256 Block Encryption Applied to Streaming Telemetry – Methodology and Results"**
Dr. Scott Wolfson & Mr. Greysen Blumkin

The continual advances in military system technologies compel the T&E community to constantly mature, adapt and apply innovative methodologies and numerical methods. This progression requires a clear understanding of technique capabilities and limitations. With respect to telemetry, the encrypted telemetry requirement trend is increasing at a rate faster than telemetry encoder designers can address the need in current, future and legacy systems. The primary objective of the presentation is to provide design details pertaining to the commercial AES256 block encryption algorithm and how it was adapted for use with persistent streaming serial data like telemetry. The presented material will also provide details relating algorithm integration variants and the associated impact on the data rate, bit error rate and acquisition/reacquisition times.

3:00 p.m. **"Future Secure Telemetry (TM) Directions, Bulk Encryption: 2023 Updates**
Ronald Pozmantier, 812 AITS/ENI & Jon Morgan, Laulima Systems

Current SST and TMoIP Solutions will be presented. Current Unified TMoIP Secure Telemetry Program (UTMOST) will be presented and compared with current solutions. Capabilities, features and status of the UTMOST Ground Unit development will be covered along with the associated technical and cybersecurity certification challenges. Candidate UTMOST Airborne Equipment developments will be presented, along with status. Limitations, Flexibilities and Use Cases will be presented for discussion.

Thursday, May 25, 2023, 1:30 – 3:30 p.m.

Session 12 **Data Analytics**
Chair Jenny Green, KBR

1:30 p.m. **"Advances in Developing a Unified Post-Flight Data Analysis System"**
Dale Jones, Software Development Engineer, Curtiss-Wright

Several years ago, the IADS group at Curtiss-Wright Defense Solutions set about designing a comprehensive, unified platform for post-test analysis. This design aimed to satisfy a collection of core requirements that were gathered from meeting with a number of engineering groups throughout the flight test community at that time. The ultimate goal was to create a standardized system for post-test analysis from those requirements that could be used (and reused) by different flight test disciplines across different projects.

While the IADS team has made significant progress implementing these requirements in recent years, the team has also received valuable feedback from the flight test community on ways to improve this system, specifically when dealing with big data. This presentation will explore some of the obstacles and challenges the team has encountered when dealing with big data in a real-world environment, as well as some solutions that have been used to overcome these obstacles. Topics will include strategies for fast and efficient data visualization of entire flights, the importance of a common API for reading different data types, as well as managing large amounts of data in a cloud environment.

2:00 p.m. **"Optimizing PCM Telemetry Bandwidth by Performing Onboard FFTs"**
Pat Quinn, Curtiss-Wright

There is an ever-increasing demand for more data to be captured during flight test applications, placing more demand on the limited bandwidth available for PCM data transmission. Some strategies can help, such as performing analysis on the platform itself. For example, by performing Fast Fourier Transform (FFT) analysis in the air and sending just the results down over PCM in real-time, the PCM bandwidth usage can be optimized, saving the users time and reducing the overall cost of ownership.

This presentation discusses data analysis methods, specifically FFT analysis on accelerometer data in real-time during flight, that can be used without additional flight test instrumentation hardware onboard the aircraft.

2:30 p.m. **"Providing Real Time Inter-Range Data Portability Using a Unified Data Library"**
Dr. Seth Harvey, Bluestaq, LLC & Rob Patterson, One Dev, LLC

As part of a digital engineering strategy, the ability to share data within and between test and evaluation ranges provides technical and cost benefits to the U.S. Government. Data is available in real time or near real time for analysis, while test data is always available for test planning to determine if a previous test data can *save the Government valuable budget by avoiding unnecessary testing. Additionally, the Government must have the ability to ingest, store and share data at any classification level, while moving data between classification levels as required. Developed in a partnership between the Air Force Research Lab, Space Systems Command, and Bluestaq LLC, The Unified Data Library (UDL) offers unique, Government Purpose capability to securely ingest, store, and share test and evaluation data. This paper will address the UDL key features as a Data Fabric Layer and how it is available to support the test and evaluation community to store and share data from all data sources. The UDL is a proven solution with three deployment options to support most digital strategies: an enterprise option deployed to secure Government cloud services; within a closed network or on-premises at the test facility; and a tactical option deployed to the airborne asset and/or on the ground throughout the range. The tactical option will synchronize with the enterprise via satcom (or via other comms) either real time or when the test team establishes communication with the enterprise UDL. With an ATO (authority to operate) at all classification levels, the UDL is available to support the community immediately.*

3:00p.m. **"Accelerated Signal Processing with Graphics Processing Unit (GPU) and Deep L Learning Algorithms to Enhance Both Real-time and Post Flight Data Analytics"**
Steve Seiden & Sanjib Sarkar, Acquired Data Solutions, Inc.

Modern GPUs (Graphic Processing Unit) come with powerful fast computational capability by their parallel structure to process large blocks of data parallelly. The GPU, has become one of the most important computing technologies, used in computer graphics and image processing. Electronic warfare (EW) systems, which exploit and control the electromagnetic (EM) spectrum, are capable of sensing, analyzing, and imposing appropriate countermeasures (CMs) to hostile spectrum use. EW systems designed and built with fast signals processing capability, can buy more decision time and reaction time. The Signal analyzer (SA) application advances by enhancing the capability of radio frequency (RF) signal processing by leveraging the computational power of the GPU processing with high throughput. The SA with GPU backend processes the data parallelly by transferring the real-time as well as historical data from a host to the GPU and back into the host after processing.

One of our focus areas of the SA besides conventional signal processing that includes power spectral density (PSD), correlation, cross-correlation and more, is deploying the Deep neural network (DNN) algorithms to classify the signal modulations. We are also expanding the capability of detecting the radar signals in spectrum sharing scenarios by utilizing the deep learning (DL) algorithms.

Thursday, May 25, 2023, 1:30 – 3:30 p.m.

Session 13 **Digital Engineering**
Chair Larry (Joe) Dale, Director, 812th Aircraft Instrumentation Test Squadron

1:30 p.m. **"Comparative Vacuum Monitoring Sensors as an Introduction to Condition Based Maintenance Plus for the KC-46"**
Thomas A. O'Brien, 2d Lt USAF, Georgia Tech Research Institute

The KC-46A Pegasus is a key part of the United States Air Force's (USAF) efforts to modernize their aging tanker fleet. The Department of Defense (DoD) and USAF have heavily emphasized the desire and need for Condition-Based Maintenance Plus (CBM+) in their maintenance programs. This study proposes the use of Comparative Vacuum Monitoring (CVM) sensors for Structural Health Monitoring (SHM) as an initial step for implementing CBM+ in the KC-46 maintenance program. In addition to being the first SHM sensor technology to receive Federal Aviation Administration (FAA) certification, an investigation into the commercial airline industry's research and use of CVM sensors showed it to be a viable enabling technology for the USAF CBM+ efforts. These efforts are the precursor to predictive maintenance and enterprise-wide scheduling optimization which require large data sets. Further research showed an appetite within the KC-46 sustainment program office for SHM as a test case and template for future CBM+ initiatives. Additionally, the USAF would benefit from the commercial industry's momentum in researching the technological, procedural, financial, and regulatory components of CVM sensors for SHM.

2:00 p.m. **"Digital Engineering 3D Scanned Models for Airborne Instrumentation"**
Joseph Lopez, 812th Airborne Instrumentation Test Squadron

The aircraft T-2 modification process to instrument F-16 aircraft employed by the 812 AITS is currently labor and time intensive and involves taking test aircraft away from mission support for measurement, installation, and troubleshooting. When aircraft are down for extended periods of time, they are unable to support critical test and training sorties for the 416 CTF. The 412 TW wishes to embrace the Digital Vision directed by AFMC and SAF/AQ and utilize Digital Engineering tools and processes to drastically reduce aircraft downtime.

Recently, 3 dimensional (3D) point cloud scans of interior bays of the F-16D have been captured, processed, and delivered to the 812 AITS design team. Using already existing software and modeling tools, the point cloud files have been converted into compatible formats to import into assembly models. Using these scanned models, virtual fit checks of the instrumentation installations were performed. Digital photographic results of the scanned files with models of installation equipment are compared with physical fit checks provide insight into the experience, benefits, and limitations of using 3D scans for aircraft instrumentation design.

2:30 p.m. **"Digital Engineering Innovation Approach for Airborne Instrumentation"**
Mike McAlister, 896 Test Support Squadron /RNMEF

The aircraft T-2 modification process to instrument DT/OT aircraft employed by the 896 TSS is currently labor and time intensive and involves taking test aircraft away from mission support for measurement, installation, and troubleshooting. When aircraft are down for extended periods of time, they are unable to support critical test and training sorties for the 96 TW. The 896 TSS wishes to embrace the Digital Vision directed by AFMC and SAF/AQ and utilize Digital Engineering tools and processes to drastically reduce aircraft downtime.

Performing 3 dimensional (3D) scans of aircraft interior bays will provide the ability to understand standard aircraft configurations and wire routing so that mechanical and electrical T-2 modification design teams will be able to provide input to existing hardware models and perform virtual fit checks before ever taking a jet out of service. Having accurate models will also greatly decrease the likelihood of rework and discovery of conflicts of physical space when installation begins.

Utilizing partnerships with industry, the 896 TSS can leverage already existing software and modeling tools to create digital twins of each specific OT/DT aircraft. These Model-based Systems Engineering tools will utilize existing technical data and modification documentation to model and have easily accessible all electrical, mechanical, and modification-specific drawings and documents. Utilizing the 3D models, these digital twins will be able to virtually accept new hardware and help understand interface and physical constraints, data traffic, and identify problems before the 896 TSS steps to the aircraft to begin the install.

3:00 p.m. **"Digital Twinning Process for T&E Telemetry Applications"**
Frank Cruz, 412th RANS/Applied Spectrum Technology Research Office (ASTRO)

Industries in the private sector currently utilize digital twinning technology for development purposes to reduce time and cost of their products. Typically, government test and evaluation (T&E) engineering groups do not develop products but can leverage digital twins for T&E purposes. The Applied Spectrum Technology Research Office (ASTRO), located at Edwards AFB in CA, has created a process using digital twinning for telemetry flight test applications. The methodology in this process/workflow focuses on small scale modeling and builds to bridge the gap from component twins to an overall system environment or system twin.