Test Instrumentation Workshop
Technical Program

Wednesday, May 18, 2022, 10:30 – 12:30 p.m.

Session 1 **TmNS Devices**
Chair Brian Keating, SA-TECH

10:30 a.m. **"Development of a TmNS Compatible Radio"**
Farhad Daghigh, Curtiss Wright

The Telemetry Network Standards (TmNS) was recently released for the telemetry community in the IRIG 106-19 defining the network-based telemetry system. These standards identify interfaces for configuration, management, network transport protocols, telemetry link, and various other system and component capabilities. TmNS system is a new tool for the flight test telemetry industry and its system requirements touch all of the standard flight test equipment, including data acquisition units (DAU), switches, recorders, radios, and the ground complements such as the antenna and the ground system software. As the development program whines down, the US ranges are rolling out TmNS aware equipment and such is becoming operational on range for current flight test programs. This paper discusses the current progress in developing a TmNS radio, the TTC nXCVR-3140A-2, the status of the radio system and the additional equipment designed to enhance the system performance. The paper concludes with a snapshot of 5G, and other radio solutions, being tested today and intended to support the TmNS of the future.

11:00 a.m. **"Software Tools for TmNS-Based Systems"**
Todd Newton, Southwest Research Institute

As defined in IRIG 106 Chapters 21-28, the Telemetry Network Standard (TmNS) provides a framework for end-to-end network connectivity between instrumentation systems and control rooms. It defines a two-way RF telemetry link, network protocols, and a common configuration language for TmNS components. While the iNET program produced the TmNS and tested some of the capabilities of systems based on the TmNS, the task at hand today is how to effectively utilize the TmNS for improving test capabilities on the ranges. The TmNS serves as a toolbox with several tools that have been tested and ready for use in a deployed system. Some of these tools are software tools to help manage, monitor, configure, and control components in the system, and other tools are new capabilities, such as a two-way telemetry link, that can support new and improved concepts of operation. However, there is still room in the toolbox for additional capability support. As ranges look to implement and deploy TmNS systems, their needs may vary from range to range. These needs will lead to the development and refinement of the software tools and capabilities. This presentation will discuss recent flight test results, TmNS software tools, and an implementation strategy for TmNS-based system deployment.

11:30 a.m **"Modern Network based Data Acquisition Units"**
Dan Green, Safran Data Systems

Modern, network-based data acquisition systems are increasing the capabilities of flight test organizations to include increased accuracy, higher data rates and more network friendly data formats. The resulting information flow from the test article to the analysis engineer is more accurate, more flexible and faster than ever before. We will explore what is currently possible with network-based data acquisition systems and where we think we can go from here with future capabilities.

12:00 p.m. **"Modern High Speed FTI Recorders and Switches Requirements and Use Cases"**
Brandon Rosso, Curtiss- Wright

As Flight Test instrumentation (FTI) architectures increasingly migrate to airborne "network" systems – comprised of distributed sub-systems of data acquisition, processing, and recorders – the role of network switches that form the network switch fabric become critical. Likewise, the FTI recorders – whether a single large or multiple distributed data sinks – is also increasingly critical as it relates to the data formats suitable for ground processing, given the number and types of data sources. This paper discusses the factors influencing the switch and recorder units, for a Distributed FTI (DFTI) System.

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Session 2 **Opening the Door to Digital Engineering**
Chair Eduardo Lucero, KBR

10:30 a.m. **"TBD"**
TBD

11:00 a.m. **"Advancing the State of Software Engineering in the OT&E Ecosystem"**
Ricoh Glover & Melissa Glazener, BrainGu

DoD strategy for realizing highest possible value in warfighting capabilities is being pursued within AFTC via accelerated transformation toward data-centric operations. In a data-centric future, the network is the computer, the browser is the desktop, and web apps are front-end building blocks of trustworthy and continuously evolving T&E software ecosystems. The software development process itself emerges as one of those ecosystems – i.e. a fit-for-purpose cloud environment as described in DoD cloud strategy, tailored in this case toward the purpose of automating the continuous integration and continuous delivery of those trustworthy software-based capabilities for test and evaluation.

In this briefing a managed multi-tenant environment that is a platform on which AFTC can cost-effectively orchestrate software development activities in compliance with applicable DoD and Air Force guidance. We refer to it as "Big Bang as a Service" (BBaaS) in the sense that adapts DoD's accredited software factory paradigm for rapidly building and sustaining applications specific to AFTC's T&E mission.

11:30 a.m **"Utilizing Digital Engineering in the Development of the Navy's MK 48 Torpedo"**
Carlos Godoy, Navy

Description not releasable

12:00 p.m. **"Optimizing Antenna Placement Using Modeling and Simulation"**
*** Virtual Presentation***
Frank Cruz, DAF, Applied Spectrum Technology Research Office (ASTRO)

This report examines how modeling and simulation (M&S) can be used in the initial design phase to optimize telemetry antenna placement on a Rascal Pod. Multiphysics software was used in the modeling of the antenna, placement on the Rascal Pod, and resulting radiation pattern trade-off analysis. Three locations were chosen to analyze optimal placement with a focus given to ground plane. The goal of the simulations was to optimize radiation pattern uniformity coupled with beam angle dependency. The result of this M&S work identified an optimized location for antenna placement, which is resulting in pod modifications to support the new location.

Wednesday, May 18, 2022, 10:30 – 12:30 p.m.

Session 3 **Cellular Telemetry**
Chair Thomas O'Brien, Test Resource Management Center

10:30 a.m. **"TRMC overview"**
Thomas O'Brien, Test Resource Management Center

TBD

11:00 a.m. **"Analysis of the Application of Cellular Wireless Technology for AMT"**
Charles Havasy, Charles Bartlett, Peter Weed, & Hans Miller, The MITRE Corporation

The TRMC is developing a strategic framework for the application of cellular wireless technology to support test missions across the MRTFB locations. The initial focus of this framework was the application of cellular wireless technology to support Aeronautical Mobile Telemetry missions. As part of this framework, MITRE conducted an analysis of different test mission scenarios across multiple use case categories. The analysis looked at the value gained from these technologies and the technical and operational challenges they present as it applies to different use cases over time. A key takeaway the analysis supports is that use of cellular wireless on the range is not a one size fits all migration from existing serial streaming telemetry and that, for the foreseeable future, a hybrid approach of legacy and cellular wireless technology will be necessary depending on the use case. This analysis also highlights that there are several potential trades between components like size, weight and power of an airborne terminal, with the ground station configuration and intersite distances that are essential to understand to most effectively leverage this technology.

11:30 a.m **"5G Telemetry Low SWAP Airborne Transceiver"**
Achilles Kogiantis, PhD, Kiran Rege, PhD, and Eric Beck, Peraton Labs

A novel 5G compliant airborne transceiver is being designed and developed to support 5G cellular-based aeronautical mobile telemetry (AMT). To support operation at speeds likely to be encountered in airborne telemetry, the transceiver implements the Velocite solution for on-board Doppler pre-compensation. The unit is designed for meet the 5G-enhanced Mobile Broadband (eMBB) service objectives. 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. We also describe the planned capabilities of the transceiver and the ground network architecture needed to support cellular telemetry, as well as system-level operation aspects. We conclude with a description of specific design aspects to be considered for AMT, including a ruggedized design for integration with the test airframe to support AMT at the testing range.

12:00 p.m. **"5G Cellular Telemetry using Zero-Trust Architecture Principles"**

Sampath Rangarajan, Achilles Kogiantis, PhD, Giovanni De Crescenzo, & Ta Chen, Peraton Labs

5G Cellular Telemetry data from the on-board transceivers to the ground as well as control data in the reverse direction requires secure transport over the 5G network. We adopt the Zero-Trust Architecture (ZTA) approach as detailed by NIST, which allows us to make no assumptions about the integrity of the underlying network elements. This gives us flexibility in operating across different ground 5G networks. ZTA is an enterprise cybersecurity architecture governed by a set of principles designed to prevent data breaches, both at the network end-points as well as within the network infrastructure. In essence, a ZTA is an enterprise cybersecurity plan that uses zero-trust principles that cover component relationships, workflow, and access policies, among others. At a high-level, a ZTA defines an untrusted zone and implicitly trusted zone. The communication end-points as well as the data transport between them within the untrusted zone are secured using two key components as defined in NIST 800-207, the PDP (Policy Decision Point) and PEP (the Policy Enforcement Point).

In this presentation, we discuss a ZTA architecture that we have developed and implemented and the various security features that jointly provide the end-to-end solution and applies to any vertical network implementation. The key features of our architecture are: 1) authentication of the end-point devices, including the IoT devices and the servers, 2) periodic attestation of the software running on these devices to detect any anomalies and malicious behavior, 3) authorization of the devices to communicate with each other, and 4) encryption of the data between the end devices. Novel features of our solution include: a) Remote attestation of software on the IoT devices, b) Implementation of a hybrid-encryption scheme that uses a combination of public key cryptography and shared symmetric keys, that accommodates resource and battery constrained IoT devices, c) Development of a model for periodic rekeying of the shared keys to satisfy the security requirements as determined by the deployment environment, and d) Use of trusted protection modules (TPM) and trust zones to secure our ZTA software. We illustrate our architecture using an implementation tailored towards a private network environment.

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Session 4 **Cybersecurity**
Chair Brandon Hyneman, 412 RANS/ENR

10:30 a.m. **"Coping with Complexity in Security Data"**
Steven Schiavoni

In addition to the enormous quantity of operational and business data, security tools generate their own overhead of data that can be overwhelming. In addition to the raw generation of security data, the planning that goes into placing the tools gathering the data, the enrichment and analysis, and the operationalization of the insights gathered from the data all add complexity to an already complicated endeavor. As humans we tend to simply disregard complexity past a certain point, either out of subconscious bias away from dealing with it or out of a misplaced attempt to cut the Gordian Knot in seeking a solution. This presentation will explore the sources of complexity in security, the pitfalls that come with addressing it, and strategies for trying work within the uncertainty complexity breeds rather than tilting at the windmill of "solving" what is frequently an irreducible problem set.

11:00 a.m. **"Beyond Compliance: Developing a Cyber Defense Mindset"**
Jason Schalow, Chief, Special Missions Flight, 412th Communications Squadron, Edwards AFB

With active adversaries who are constantly adapting their cyber tactics and are intent on leveling the technical playing field, the range of the future will need to be capable detecting and defeating active cyber attacks against its key terrain in order to keep critical test and training data out of enemy hands. This presentation will explore what it takes to move beyond the traditional cyber compliance focus and into the active defense mindset required to counter these threats.

11:30 a.m **"The CMMC 2.0 Reset: Back to NIST 800-171"**
Jeff Kalibjian, Peraton Inc.

The Department of Defense (DOD) introduced the Cybersecurity Maturity Model Certification (CMMC) 1.0 to address the introduction of better cybersecurity practices by federal contractors making up the Defense Industrial Base (DIB). However, the CMMC 1.0 paradigm was daunting---five evaluation levels, mandated third party external audit, with no option for Plan of Action and Milestones (POAMs). Recently the DOD has introduced CMMC 2.0 which attempts to address potential implementation challenges in CMMC 1.0 impacting both Small and Medium Business (SMB) enterprises, as well as large corporations. Evaluation levels have been reduced to three, with a large majority of the DIB now eligible to perform self-assessments. The opportunity to employ POAMs.has also been introduced. While indeed a distinct change from CMMC 1.0, CMMC 2.0 still provides an opportunity for the DOD of achieving its goal of gaining better traction with respect to employing robust cybersecurity practices across the DIB. After

reviewing CMMC 1.0 and the proposed changes for CMMC 2.0, the implications of these changes will be discussed for federal contractors supporting T & E activities, with emphasis on strategies for implementation, audit and self-assessment.

12:00 p.m. **"A Low Cost Data Diode For Cross Administration"**
Greg Uhland, 96th Range Control Squadron

How to build, test and implement a low cost and approvable Data Diode. The concept of a data diode is straightforward; like its semiconductor namesake where current flows in only one direction, a data diode only allows data to flow in one direction. For the application at hand, the data diode will allow data to flow from one classified network into another classified environment at the same classification level, but with different handling caveats. This solution prevents any data flow in the reverse direction. The data diode described in this paper utilizes a pair of IMC Networks Giga-MiniMc Switching Media Converters, specifically connected to produce the desired one-way data flow effect while preventing data flow in the opposite direction.

Wednesday, May 18, 2022, 1:30 – 3:30 p.m.

Session 5 **TmNS Implementation Plans and Lessons**
Chair Thomas Grace, NAVAIR

1:30 p.m. **"Refinement of TmNS Capabilities"**
Thomas Grace, NAVAIR

Efforts are underway in refining TmNS capabilities and working to ease transitions from existing systems such as Common Airborne Instrumentation System (CAIS) and Chapter 10 recording. Within the RCC Telemetry Group, work has been ongoing for an approach to incorporated Chapter 11 data types into the TmNS networking data structures that will be discussed. Furthermore, discuss the refining of the Metadata Descriptive Language (MDL) in describing component capability attributes and advertising those capabilities in a standardized fashion. Lastly, will briefly touch on test results of some the more advance networking capabilities.

2:00 p.m. **"Airborne Network Instrumentation"**
Alfredo Berard, 96th Range Support Squadron

In order to support flight testing of a new aircraft platform, the test team at Eglin Air Force Base would require a robust and sustainable instrumentation system that would be easily interoperable with the exiting test infrastructure. In a departure from traditional practice in which the prime contractor would provide the instrumentation system in support of a new aircraft system or sub-system, the System Program Office (SPO) in cooperation with the Eglin Instrumentation Team from the 96th Range Group (96 RN), took the approach in which the Government would specify and procure the test instrumentation equipment (Group B) and provide to the Prime Contractor as Government Furnished Equipment (GFE). The prime contractor, in turn, in cooperation with the Eglin Team, would design the instrumentation modification and install the wiring and mechanical assemblies (Group A) in support of the Eglin provided Group B.

This approach would ensure that all instrumentation equipment (recorders, data acquisition systems, transmitters, etc.) would be standard compliant and remain interoperable with the Eglin Test Range Infrastructure. In addition, the instrumentation team, leveraging technology and instrumentation components developed under an I&M program, developed the first sole network-based instrumentation system.

This network instrumentation system completely abandons the traditional Common Airborne Instrumentation System(CAIS) bus connectivity between components, replacing all linkage between instrumentation components with an Ethernet based architecture. Additionally, the data stream used for real-time transmission of Telemetry (TM) data is no longer based on the legacy Pulse Code Modulated (PCM) format; instead the instrumentation system is utilizing the network

publishing format of IRIG 106 Chapter 10 data stream; this allows all real-time data to be received as a network (Ethernet) stream which allows for much more options in terms of bandwidth optimization or data prioritization and reconfiguration for future Command & Control capability.

This briefing will outline the formulation of this instrumentation architecture/design and the lessons learned in implementing and testing this design as well as the benefits of this approach in contrast to previous efforts.

2:30 p.m. **"NASA AFRC Telemetry Network Technology Implementation"**
Bruce Lipe, NASA Armstrong Flight Research Center

Armstrong Flight Research Center performs aeronautical research for the National Aeronautics and Space Administration at Edwards Air Force California. This presentation will provide an overview of efforts at AFRC to implement telemetry network technology in research aircraft, support aircraft and at the Dryden Aeronautical Test Range.

3:00 p.m. **"What is the Future of Telemetry at Armstrong Flight Research Center?"**
Tom Young, Deputy Director Mission Operations, Code 600, NASA Armstrong Flight Research Center

Armstrong Flight Research Center executes aeronautical research and development for NASA. Telemetry is a key data component used to validate the R&D process and more importantly provide a critical safety element. This presentation will offer information that supports efforts to investigate the Future of Telemetry at a Test Range, specifically AFRC.

Wednesday, May 18, 2022, 1:30 – 3:30 p.m.

Session 6 **Range Instrumentation**
Chair Douglas H. Nelson, Teknicare, Inc.

1:30 p.m. **"LASER T&E Status at the PMSR"** *** Virtual Presentation* CUI CAC REQUIRED**
Robi Garcia, NAWCWD

The Point Mugu Sea Range (PMSR) has been directed to develop a robust capability to support Navy High Energy LASER (HEL) testing in a realistic environment. The long distances of the LASER hazard patterns, the evaluation of the LASER beam quality, and characterizing the atmosphere have been the major challenges. This presentation outlines how the PMSR has leveraged ongoing Test Resource Management Center (TRMC) investments in developing solutions to known gaps in HEL testing, nationwide. In addition some internal Naval Air Warfare-funded initiatives will be highlighted, describing upgrades to the TRMC initiatives for maritime conditions, fire control cueing improvements and remote scoring capability.

2:00 p.m. **"DELAMBRA-I Initial Results" "** *** Virtual Presentation* CUI CAC REQUIRED**
Justin Lee, NAWCWD

The Directed Energy Low Altitude Maritime Baseline Research and Analysis (DELAMBRA) is an internally funded initiative by Naval Air Warfare Center, Weapons Division (NAWC-WD). In 2014 some initial measurements of optical turbulence by the Navy Post Graduate School at San Nicolas Island on the Point Mugu Sea Range indicated that there is a significant increase in optical turbulence in the lower Maritime Atomospheric Surface Layer (MASL). This feature was confirmed to be non-Kolmogorov in its intensity by NAWC-WD in 2016. The DELAMBRA-1 campaign was designed to further research this MASL feature and evaluate sensors appropriate for use on an open-ocean test range. This presentation will provide the overview of the DELAMBRA-1 campaigns and some initial findings.

2:30 p.m. **"ATMOBUOY Development for the PMSR"** *** Virtual Presentation***
Kyle Edwards, NAWCWD

The Point Mugu Sea Range (PMSR) sponsored a $1.5M Small Business Innovative Research (SBIR) Project to develop a comprehensive deep-ocean buoy that can provide all necessary atmospheric and oceanographic measurements to conduct live-fire testing in open-ocean arenas. This presentation is an overview and development report of the Atmospheric Turbulence, Meteorological and Oceanographic Buoy (ATMOBuoy) initiated in 2019 and completed in 2021. The ATMOBuoy has leveraged small tactical weather station technologies to provide a modular, scaleable, and easily deployed system for use on the PMSR. The design

is still going through improvements, but the basic capability has been demonstrated during three prototype deployements at sea and a number of shoreline deployments. Sensor accuracy and the future roadmap of improvements will be described in detail.

3:00 p.m. **"Directed Energy Test Range Support Instrumentation from Test Resource Management Center (TRMC)"**
Jeffrey S. Schleher, American Systems

TRMC acting through PEO STRI (Army) provides various test ranges with sensors, data acquisition systems, and sources (threat representative or to develop US system) to US ranges to support developmental or rapid acquisition testing. This presentation addresses advanced sensors and associated data acquisition systems developed either through S&T projects or acquisition programs. In addition, this presentation is limited to addressing radio frequency test equipment, although we also acquire equipment supporting laser and nuclear effects testing. Advanced Electro-Optical and Magneto-optical sensors for observing high very and low Electrical-Fields (MV/m), and Magnetic-Fields (KA/m) without intruding on those fields are the presentations focus. With directed energy weapons not contributing to the effects on the target as metal probes do is also an important characteristic of these probes. In wide area tests such as counter-Improvised Explosive Devices or counter-Unmanned Arial Vehicle test activities portable highly shielded data acquisition systems are also required, and it is always good to give the test director instant information on how well (or poorly) the system under test is performing; the presentation also addresses how that is accomplished.

Wednesday, May 18, 2022, 1:30 – 3:30 p.m.

Session 7 **TM Phased Array Antennas: Interfaces, Architectures, and Test Results**
Chair Dan Skelley, Perrygo Consulting Group

1:30 p.m. **"Framework for a TM Phased Array Antenna Interface Control Document (ICD)"**
Dan Skelley, Perrygo Consulting Group

This presentation will describe a set of Interface Control Documents (ICDs) for a Telemetry Phased Array Antenna. The ICDs were created in partnership with the leading developers of Telemetry Phased Array Antennas. As a result, the ICDs are vendor and architecture agnostic. Current and emergent Telemetry Phased Array Antennas, from the major developers, are compatible with the ICDs. While focused on a specific example, mounting a TM Phased Array Antenna on a Gulfstream business jet, the interfaces can be easily adapted to any platform (cargo aircraft, drone, and terrestrial based antenna pedestals, etc.)

2:00 p.m. **"Advanced Phased Array Technology for Telemetry Operations"**
Satya Ponnaluri, Intelligent Automation Incorporated (IAI)

Major range test facility bases across the country use large and small parabolic dishes to track test articles conducting flight tests. The use of dishes however limits performance in terms of portability, efficiency, and number of targets one dish can track across frequency bands. Phased array antenna systems alleviate some of these problems by providing a wider field of regard, while simultaneously tracking multiple targets. Today we see technological breakthroughs in digital technologies such as Xilinx RFSoCs that integrate multiple high-speed ADC/DAC channels and powerful processors such as FPGA in a single chip of size 40 mm x 40 mm. These devices can support sampling rates as high as 5 Gsps with analog bandwidths reaching 6 GHz or more. This has now brought the dream of a truly digital phased array antenna system in a small package to reality. In this talk, we will present an overview of one such all-digital phased array technology, the benefits, challenges and the current state of development and test. This talk will show how a single phased array antenna can replace and provide the function of more than half a dozen legacy parabolic dishes, with improved flexibility, future adaptability, and logistics support.

2:30 p.m. **"Applications of Universal Beamforming Technology"**
Anand Kelkar, Creative Digital Systems Integration (CDSI)

Universal Beamforming Technology (UBT) has been developed and matured by TRMC through the Spectrum Efficient Technologies (SET) office at Edwards AFB as a lightweight, flexible Telemetry (TM) resource for the Range of the Future. The 'shape shift' capability of the antenna technology conformally adapts to the physical shape of the installation and allows focusing G/T to where it is most needed within the field of view. UBT demonstrator versions have been installed and flown on UAS craft to successfully support remote Sband TM collection at a

fraction of the cost of conventional methods. A second generation of the UBT antenna is coming into existence and is targeted for demonstration in late 2022, and will be capable of acquiring and tracking several very dynamic sources in the L, S and Cband TM spectrum. The first multi-band application will be a groundbased antenna system using physical shaping to distribute G/T to coincide with specific classes of missions.
Technical challenges, successes (and myths) encountered during the development phases are presented for consideration along with the and integration and test methodology.

3:00 p.m. **"Raven Advanced Phased Array Telemetry Resource (RAPTR)"**
Chris Patscheck, Raven Defense

This presentation provides an overview of the design, implementation, testing, and transition to operations of the Raven Advanced Phased Array Telemetry Resource (RAPTR) antenna system to support ongoing telemetry collection requirements at the Atlantic Test Range on board the unique BT-67 airborne test and evaluation platform. The session addresses the importance requirements definition to support rapid acquisition program requirements as delivery schedule becomes a more prominent feature of DoD acquisition strategy. Details of the system characterization and test approach are discussed, showing the incremental confidence building progression of test events leading to the system's first operational use as a test resource. .

Wednesday, May 18, 2022, 1:30 – 3:30 p.m.

Session 8 **Spectrally Efficient TM**
Chair Mike Cook, 412th Communications Squadron

1:30 p.m. **"Initial Results on Forward Error Correction for PCM/FM and ARTM CPM"**
Erik Perrins, University of Kansas

Forward Error Correction (FEC) codes have demonstrated their effectiveness on serial streaming telemetry (SST) links with SOQPSK-TG. This has motivated an expansion of FEC use cases into SST links with PCM/FM and ARTM CPM. However, these additional use cases require FEC codes that are explicitly designed to work with the characteristics of continuous phase modulation (CPM). This presentation outlines the general problem formulation and gives preliminary results on capacity-approaching FEC codes for these use cases.

2:00 p.m. **"Observations of 16-APSK C-Band Aeronautical Telemetry System Performance"**
Daniel DePardo, & Erik Perrins, University of Kansas

The implementation of more advanced modulation formats, such as Amplitude Phase Shift Keying (APSK), would increase aeronautical telemetry system spectral efficiency and offer more robust adjacent channel interference performance, in comparison current modulation schemes. This presentation will detail laboratory measurements of 16-APSK telemetry transmitter and receiver prototypes and observations of 16-APSK modulation performance in comparison to SOQPSK-TG and Multi-h CPM.

2:30 p.m. **"Optimizing PCM Bandwidth Usage in Flight Test by Real-time Data Analysis During Flight"**
Pat Quinn, Curtiss-Wright Defense Systems, Dublin, Ireland

There is an ever-increasing demand for more data to be captured during flight test, 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 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 paper discusses data analysis methods, specifically Fast Fourier Transform (FFT) analysis on accelerometer data in real-time during flight, that can be used without additional flight test instrumentation hardware onboard the aircraft.

3:00 p.m. **"TBD"**
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TBD

Thursday, May 19, 2022, 10:00 – 12:00 p.m.

Session 9 **WSMR Instrumentation**
Chair Zoe Aguirre, White Sands Missile Range

10:00 a.m. **"Emerging Photo-Optical Instrumentation Capabilities"**
Rocio Rangel, ATEC-WSMR-Range Operations, Process Engineer

The new operational paradigm of the photo-optical instrumentation systems integrates modern digital imaging sensors with enhanced networking capabilities through the use of automation and remote functionality for data collection. Critical areas affected by this pivotal shift is the area support non-tracking systems and the precision optical tracking systems. The next generation of area support non-tracking systems requires improved operational concepts and technologies for precision timing, amplification and synchronization across networks and GPS denied environments that extend to the last mile of a digital sensor's position at a test site. The next generation of precision optical tracking systems is the Multispectral Imaging and Tracking System comprised of the Fly-Out Systems for providing long range tracking and the Close-In System for providing short range tracking. With modern imaging subsystems such as Short Wavelength Infrared, Medium Wavelength Infrared, High Speed Visible cameras and Visible Metric Zoom Lenses, motion imagery, phenomenology data and associated metadata will significantly improve the functional performance characterization of the system under test. Collectively, this will provide the Department of Defense Test Ranges with a common set of remotely-operated photo-optical instrumentation systems as evolving interoperable capabilities are enhanced for conducting future operations.

10:30 a.m. **"Switched Optical Transport Networks"**
Alejandro Salazar, White Sands Missile Range/Electronics Engineer

In recent years, range modernization efforts have been undertaken to provide a transition away from legacy time division multiplexing (TDM) and synchronous optical networks (SONET) technology to more packet centric services and optical multiplexing technology. Dense Wave Division Multiplexing (DWDM) has provided a solution to increase the effective capacity of the existing fiber plant and also provide fast and dynamic provisioning of network connections. Intelligent Switched Optical Transport Networks (OTN) has provided a platform that combines the flexible network architecture of an OTN and the high capacity of DWDM. Packet protocols such as IP, MPLS and Ethernet are well supported on a Switched OTN while offering a transition platform away from legacy SONET. The integration of packet services, OTN services and wavelengths will provide a solution that enables the creation of multiple independent overlay networks into a single joint network platform service while increasing bandwidth, performance and security.

11:00 a.m. **"White Sands Missile Range (WSMR) Telemetry Capabilities Overview"**
Jesus Nevarez, White Sands Missile Range/Electronics Engineer

The Department of Defense (DoD) anticipated the eventual sell off of a portion of the Aeronautical Mobile Telemetry (AMT) frequency spectrum (from 1755-1780 and 2155-2180 MHz), prompting the telemetry (TM) community to develop systems with higher spectral efficiency as well as augmented frequency band capabilities. Through the Advance Wireless Systems 3 (AWS-3) funding, White Sands Missile Range (WSMR) augmented legacy telemetry capabilities with systems capable of operating in a portion of the C-Band spectrum (4400-4940 MHz and 5091-5150 MHz) and addressed spectrum efficiency by integrating Tier I and Tier II modulation schemes into the telemetry system architecture. Although these advancements have solved several gaps in telemetry support at WSMR, other gaps created by more complex mission scenarios and a reduced personnel footprint need to be addressed. This brief presents the current telemetry system architecture at White Sands Missile Range and highlights path forwards that will address capability gaps.

11:30 a.m. **"WSTC – Radar Branch TSPI Solutions"**
Brian Johns & Raymond Guerra, TEWS-ROD-R (WSTC)

The Radar Branch at White Sands Test Center (WSTC) collects Real-Time Time Space Position Information (TSPI) from various types of instrumentation radars and Global Positioning System (GPS) equipment. There is a growing need to track smaller and faster targets, more simultaneous targets, and all at an increased accuracy and precision. To accomplish these requirements a US Army Major acquisition program was setup to replace WSTC's 1960-1980 aged radars. A Central Test and Evaluation Investment Program (CTEIP) funded effort was also recently completed to provide WSTC with Common Range Integrated Instrumentation System (CRIIS) that will help solve GPS instrumentation deficiencies. Efforts have also been made locally to come up with solutions to track small drones with Marshall Radio Telemetry systems. The Radar Branch is now poised to expand its capabilities with modern instrumentation and satisfy data requirements for Flight Safety and WSTC's various customers.

Thursday, May 19, 2022, 10:00 – 12:00 p.m.

Session 10 **Mission Control Room / Distributed Test Operations**
Chair Sean Conway, 412th Test Wing

10:00 a.m. **"Edwards AFB Mission Control Rooms Modernization Upgrades"**
Steven Price, 412th Range Squadron

The modernization of current Mission Control Rooms (MCR) at Edwards Air Force Base (AFB) is a multifaceted effort and an ever evolving path that the next generation MCRs will take. One aspect of this modernization is the reduction of the multiple data types utilized (telemetry, timing, video, and audio) in the MCR into network Internet Protocol (IP) infrastructure. An additional avenue of approach to the modernization is the use of emerging technologies. Some of these technologies that are getting implemented into Mission Control Rooms will be IEEE-1588 Precision Timing Protocol to enable nanosecond resolution to ensure synchronization of the system. Virtualized disk drives will be utilized to enhance the security of the system through the reduction of physical drives and reduce data contamination. Through the deployment of Network Device Interface (NDI) software solution for video switching, this will enable extreme cost savings and bring what was completed in hardware to the realm of software. Transitioning to a network based IP packet infrastructure within the MCR will ensure that the current interface implementation is significantly streamlined and reduced. This brings about the benefit of making the MCRs operational and maintenance support easier for the current and next generation workforce. Some of the challenges that need to be overcome with this multifaceted modernization efforts are, new equipment required that exclusively has network IP interfaces and the security aspects of having bi-directional network connections while traversing classification levels. Once these challenges have been addressed and the Edwards AFB MCR is running with this new IP based infrastructure, these MCRs will evolve to implement some of the new telemetered data streaming technologies such as, Telemetry Network Standards (TmNS) to allow initial capabilities of configuring the telemetry acquisition equipment present on the aircraft direct from the MCR, and PROTN which will combine telemetry and satellite technology into the testing MCR atmosphere here at Edwards AFB.

10:30 a.m. **"Using UDP Multicast for Telemetry Data Distribution"**
Gary Thom, Delta Information Systems

With the rapid growth of Telemetry over Internet Protocol (TMoIP) for distributing telemetry data on flight test and launch ranges, it is important to understand the benefits of and requirements for using UDP multicast on range networks. While multicast provides many benefits for the efficient distribution of telemetry data, it also imposes some requirements on the network systems for the successful distribution of that data. This paper explores these benefits and discusses the resulting network requirements.

11:00 a.m. **"Eos – A New Approach to Telemetry Decommutation"**
Kevin Tacke & Robert Brainerd, 96th Range Control Squadron

Telemetry decommutation has historically been approached as a hardware solution to process Pulse Code Modulation (PCM) serial data streams. IRIG-106 standards including Chapter 7, Chapter 10, and Chapter 11 have transitioned away from traditional Chapter 4 telemetry to TM-over-IP (TMoIP) solutions, and there is an urgent need to support the multitude of data stream configurations. Eos is a government developed and owned TRL-6 100% software decommutation solution that addresses telemetry from an IP first approach. Eos is designed to adhere to open architecture principles with extensive modularity, allowing rapid implementation and integration of new data processing modules. This product allows easy configuration to process a myriad of IRIG-106 compliant data stream arrangements consisting of various formats, such as, Chapter 4, Chapter 7, Chapter 8, Chapter 10, and Chapter 11. Eos delivers payloads of Engineering Unit (EU) converted parameterized data, digital video frames, audio, or MIL-STD-1553 values to a variety of different output feeds. While Eos is still in development, it is currently employed at the Eglin Test and Training Range (ETTR) to support various TMoIP feeds from the F-15, F-18, and A-10 platforms, demonstrating the core functionality for telemetry decommutation. As this software reaches maturity, it will be a viable option for integration into T&E range architectures that require telemetry processing. Eos only accepts Ethernet input; serial streams can be packetized via commercially available serial-to-IP solutions. The 96th Range Control Squadron at Eglin has committed to adopting Eos as the squadron's telemetry decommutation solution during the transition away from the existing hardware solution.

11:30 a.m. **"Implementing TMNS Data on Demand"**
Rocco Docimo, Ben Kupferschmidt, & Kathy Rodittis, 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.

One of the longest-standing problems with traditional telemetry has been data dropouts. These gaps in the flight test data can occur at any point in a test flight, and they can prevent the ground controllers from knowing if a test was successfully completed. TmNS offers a solution to this problem by allowing the ground to request a PCM backfill to re-send the section of the data that was lost. This paper explores a fully functional demonstration system that Curtiss-Wright has created to show an end-to-end PCM backfill operation using a TmNS compliant recorder, two TmNS radios, and the IADS real-time visualization and analysis software.

Thursday, May 19, 2022, 10:00 – 12:00 p.m.

Session 11 **Current /Future Secure Telemetry Directions (CUI CAC REQUIRED)**
Chair Ron Pozmantier, Chief Engineer, 812 AITS/ENI

10:00 a.m. **CHECK IN**

This session will contained Controlled Unclassified Information (CUI). Attendance is limited to DoD civilians and DoD contractors only. DoD common access cards (CAC) will be required to be presented and attendees will sign a register at the door.

10:30 a.m. **"Commercial Encryption to Secure your Telemetry Data" (CUI)**
Paul Cook, Curtiss Wright Corporation Defense Solutions

In the United States, the telemetry industry has traditionally relied on the National Security Agency (NSA) to provide leadership and/or solutions to encrypt telemetry data for streaming applications. However, with the current heightened concern to protect data for programs with short development cycles, encryption solutions based on the commercial Advanced Encryption Standard (AES) algorithms offer options that augment the NSA solutions. This presentation describes the development of an encryption – decryption module, and the attendant trades in using (AES) block-cipher based encryption algorithm for streaming applications, resulting link performance, and the certification choices and requirements.

11:00 a.m. **"Type 1 HAIPE Encryption for Securing Current and Future Telemetry Data Distribution and Transmission" (CUI)**
Jason Forte, 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 TMoIP mission space. Latest features such as advanced zeroization techniques, heartbeat signaling, and modern remote management will be discussed. We will also address the use of HAIPE secure encryption of TMoIP data as related to TMNS. Presentation will conclude with future capabilities for next generation HAIPE.

11:30 a.m. **"Current and Future Secure Telemetry Bulk Encryption Solutions for Serial Streaming Telemetry (SST)and Telemetry Over IP (TMoIP)" (CUI)**
Ronald Pozmantier, 812 AITS/ENI, DAF

Current SST and TMoIP Solutions will be presented. Current Unified TMoIP Secure Telemetry Program will be presented. Capability and status of the UTMOST Ground Unit will be discussed. Proposed developments UTMOST Airborne Equipment will be presented. Limitations, Flexibilities and Use Cases will be presented for discussion.

Thursday, May 19, 2022, 10:00 – 12:00 p.m.

Session 12 **Airborne Instrumentation**
Chair Larry R. Dale, Director, 812th AITS/ENI

10:00 a.m. **"Wireless Techniques to Instrument a Tailhook"**
David Hodack, Naval Air Warfare Center, Aircraft Instrumentation Division

In the aircraft instrumentation world there is always a push to minimize down time during the installation of the instrumentation system. Advances in technology allow the Aircraft Instrumentation Division (AID) to instrument aircraft in a more effective and efficient manner and collect the data in less intrusive ways. There is now a move toward the use of wireless instrumentation technologies to help shorten the instrumentation installation downtime. This presentation will cover the possibility of using a wireless transmission between instrumentation data acquisition unit nodes to eliminate running physical wiring the length of the aircraft. In particular it will look at an AID project that focused on using these wireless techniques for instrumenting a tailhook.

The initial phase of this project was to research use cases for wireless on aircraft instrumentation. In order to keep the scope of the project manageable, the single use case – retrieving tailhook data from an instrumented tailhook without installing wires back to the main instrumentation package was selected. This use case was well suited for this project as it is a measurement we do regularly. It normally requires removing panels and equipment down the length of the aircraft to connect the data system to the tail hook sensors, and the data rate is high enough to stress the throughput of the wireless technology.

After that, the hardware was selected that would meet this set of requirements. Once this hardware was purchased and received, AID performed functionality testing because this was the first time using some of the hardware selected. Once all the bugs had been worked out, AID integrated the various pieces of hardware to build a complete demonstration system in our lab. Using this system, data comparisons and ground test were performed to help prove the new wireless system would meet the requirements for trap testing. These tests along with an on aircraft wireless line of site evaluation all proved promising. AID is currently looking to the next stage of the project. This is to test the wireless system during traps to ensure data integrity while the aircraft is approaching the trap. AID is looking for an asset to perform this testing on and looks forward to updating instrumentation/flight test professionals in the near future with our results.

10:30 a.m. **"Telemetry Re-radiation Upgrades for the Raptor" 4614220082126073**
Nathan John B. Ferrer, 812 AITS/ENIC (Edwards AFB, CA)

Basic function, configuration and technical performance information on the current telemetry re-radiation (TTC/CW RTAS-2000) system will be presented. Recent, new mission support requirements and weapons TM signal changes will be discussed, as to how they drove RTAS upgrade requirements. Upgrades to the RTAS

TM receivers and TM transmitters that form the system (to support higher TM bit rates, greater link margin, while also supporting on-board recording) will be presented. Impacts of using Low Density Parity Check (LDPC) coding (per IRIG-106-20, chapter 2, appendix 2-D) will be introduced; data quality and spectrum utilization effects will be discussed. Resulting RTAS system performance improvements, that support increased slant range between the test article and the TM acquisition sites will be summarized.

11:00 a.m. **"Water-proofed Microphone Environmental Test"**
Sid Jones, Naval Air Warfare Center, Aircraft Instrumentation Division

Water-proofed conventional (covered with a hydrophobic membrane) and fiber optic microphones were provided by the Wet Aircraft Sound Pressure (WASP) project for testing. The WASP project was developed by the TRMC T&E/S&T Program. The Environmental Testing Lab at Patuxent River ran the sensors through a number of simulated flight test profiles. The Environmental Lab has the ability to simultaneously change temperature, humidity, and pressure altitude (vacuum). So while we can simulate a flight profile, there is no ability to exercise the sensors with a dynamic pressure during the test. The purpose of this test is to see that the sensors can survive a freezing, moisture induced flight profile at altitude, not whether they can operate while frozen.

11:30 a.m. **"Expanding Versatility with Wireless Instrumentation Systems"**
Grecia Roman and Clinton Mazone, 812th AITS/ENIE

The 812th AITS/ENIE is researching the effectiveness of using wireless communication in an intra-plane instrumentation system. Motivations are to provide capability to overcome the limitations of wired connections; and to reduce the amount of orange wire in aircraft, aircraft down time, and material cost & weight. Test objectives are to characterize timing over wireless links, prove RF link performance and reliability, and demonstrate functionality in an operationally relevant environment.

Thursday, May 19, 2022, 10:00 – 12:00 p.m.

Session 13 **Special Topics**
Chair Mark Radke,

10:00 a.m. **"Overcoming Challenges in Telemetry in the Hypersonic Environment"**
Jean Paul Santos, PhD, Airborne Instrumentation Division, NAWCWD

The relevant emergence of Hypersonic systems has presented pressing challenges in Test and Evaluation (T&E), specifically data connectivity through sustained wireless Telemetry during flight. Vehicles enduring atmospheric re-entry induce sheaths of plasma, a function of aerodynamic velocity, resulting in reflected and attenuated Electromagnetic (EM) signals caused by hot ionized gasses. An investigation is presented on telemetry communication challenges presented in hypersonic environments. A quantitative analysis of an EM wave is performed on attenuation factors and antenna radiation efficiencies in the presence of plasma. Finally, possible solutions and alternatives such as assisted radiation in higher frequency, utilizing plasma as an antenna matched layer, and a novel approach of utilizing plasma as a source of an EM wave are presented.

10:30 a.m. **"A Modular Ultrawide Band Radar in Radar Cross Section Range Measurements"**
Maxim Apalboym, Airborne Instrumentation Division, NAWCWD

The Radar Reflectivity Laboratory (RRL) of Naval Air Warfare Center Weapons Division (NAWCWD) Point Mugu has been at the forefront of Test and Evaluation (T&E) missions by providing mono and bi-static Radar Cross Section (RCS) measurement capabilities to various Department of Defense and partnering entities. RCS measurements are vital in adequately characterizing, modeling, and validating vehicular performance across a variety of spectral needs. A modular ultra-wideband (100 MHz – 100 GHz) radar system designed for robust and accurate signal measurements is presented through a scalable and modular design, permitting evolution as new testing requirements emerge. The aforementioned radar system, developed by engineers at Airborne Instrumentation Division (AID), could also be retrofitted for various other applications including EW and COMMS, enabling robust measurements across the T&E environment.

11:00 a.m. **"Open Air Battle Shaping (OABS)"**
Capt. Andrew Haug, USAF

The term "open air battle shaping" is used to define a family of capabilities that tie in virtual and constructive elements into a live test. This capability is in use today in the operational test of fifth-generation fighter aircraft platforms, and development continues to ensure that open air battle shaping meets the future test and training needs of military aviation. While initially developed for operational test of fighter aircraft, this technology is becoming increasingly important for training and an important aspect of integrated developmental and operational test of all military aircraft. In this presentation, the current state of open air battle shaping will be discussed, and on-going efforts to align the services

into a system with ties into test and training range facilities across the United States will be detailed.

11:30 a.m. **"Data Infrastructure in Pursuit of Big Data Analytics"**
Louis Dube, DAF

In today's Agile acquisition world, geographical separation of data stakeholders is becoming standard while the volume of data collection on test assets and ranges is increasing at a rapid rate. Efficient data governance is required to ensure timely and complete access of data to stakeholders to enable accelerated development cycles and advanced data exploration and analysis. In this presentation, the F-35 test enterprise data infrastructure will be used as a case study to demonstrate key tenets of data governance as they pertain to flight test: connectivity between test sites, labs and ranges; opportunities for test ranges to augment and enable next-gen data analysis; and efforts to converge data sources to enable big data analytics, machine learning and artificial intelligence.

Thursday, May 19, 2022, 1:00 – 3:00 p.m.

Session 14 **Tomorrow's Airpower…Vision to Victory**
Chair Dr. Roderick Davis, Air Force Production Facility, Plant 42

1:00 p.m. **"The Truth About $30,000 Toilet Seats and Extraterrestrials in America's Industrial-Military Complex: A New Way of Doing Business in the 21st Century"**
Dr. Roderick Davis,412th Test Wing Operating Location Air Force Plant 42

In the 1996 movie "Independence Day," Julius Levinson (played by Judd Hirsch) stated, while trying to explain how the-much-speculated Area 51 was funded, "You don't actually think they spend $20,000 on a hammer, $30,000 on a toilet seat, do you?" Of course, then there's that "whole extraterrestrial-thing." You've seen it, usually on late night TV. It hypnotizes stealth technology and other aeronautical advancements are products of reverse engineering, garnered from other-worldly craft that crashed on our blue-green oasis from the Milky Way galaxy. The reality is found at the heart of America's Industrial-Military complex; and how government, industry, and out-of-this-world innovation comes together. Dr. Roderick Davis, the Deputy Director of Air Force Plant 42 in Palmdale, California will provide a guided tour of the past, present, and future of this rarely-seen realm. Come see … "The truth is out there."

1:30 p.m. **"Air Force Plant 42 … Enterprise … Where No Man Has Gone Before"**
Sandra Stapleton, 412th Test Wing Operating Location Air Force Plant 42

Got a commercial or military "cool thing" to build, test and fly? We have two 12,000-foot runways and the human capital pool in the Antelope Valley, aka Aerospace Valley, situated in a 5,700-acre industrial production secure landscape for new and emerging programs. We are excited to showcase our Enterprise to support and promote a Total Force integration. We have a mission to explore new opportunities to gain efficiency and effectiveness. Come and learn how we can "do things better together." It all starts at Plant 42!

2:00 p.m. **"Exploration of Assimilated Cybersecurity T&E Resources"**
Steven Nastally, 412th Test Wing Operating Location Air Force Plant 42

Testing and evaluating complex software driven weapons systems against Advanced Persistent Threats (APT) within the cyber terrain requires a T&E program and project manager to overcome the challenge of structuring, integrating, and implementing cyber talent in each of the six cybersecurity T&E phases. The evolving terminology and concepts of cybersecurity may be overwhelming to program and project managers with limited or no knowledge of software or hardware development. Models reduce the fog of cyber-techno jargon and provide clarity to a program or project leader who must have a working knowledge of general cybersecurity requirements and the system under test to leverage talent effectively. This talk will review the DOD cyber T&E model which drives the need for specific cybersecurity professionals throughout the acquisition

lifecycle. Next, it will examine the information security color wheel which may be used to organize cyber professionals into proficient and effective teams suitable to each cyber T&E phase. Finally, it will explore cybersecurity T&E resources for the audience to further explore and equip themselves with critical knowledge and situational awareness necessary to ensure cybersecurity is integrated throughout a weapon system's lifecycle.

2:30 p.m. **"Enhancing Community Partnership - "I love my job, but ...""**
Chad Morris, 412th Test Wing Operating Location Air Force Plant 42

For thousands of years military leaders have struggled with the Mission verses People question. Most leaders have adopted the catch phrase "take care of the people, and they will take care of the mission." What does taking care of the people mean? For all the efforts to build family focused installations, there is only so much that can be done inside the fence line and the world's most advanced Test and Evaluation industrial plant. This presentation will explore what one "Great American Defense Community" has done to live long and prosper.

Thursday, May 19, 2022, 1:00 – 3:00 p.m.

Session 15 **Hypersonic Range Readiness & Gaps ** Special Session** (CUI) CAC REQUIRED**
Chair Geoff Wilson, T&E/S&T PM, TRMC

Do you have questions surrounding hypersonic testing? Do you stay up at night wondering, "Will current Range capabilities adequately support the upcoming hypersonic tests?" Or perhaps you see some gaps in current or future capabilities. If so, please join us in this interactive three part special session.

This session begins with a comprehensive review of T&E investments made by TRMC in support of hypersonic testing. Following the investment review, we will review use cases/scenarios for hypersonic tests. Finally, we will transition into roundtable discussion—bring your questions and be prepared for open discussions. Don't forget your CAC as this session will be CUI.

Thursday, May 19, 2022, 1:00 – 3:00 p.m.

Session 16 **Artificial Intelligence/Machine Learning**
Chair Allen Hagopian, 412 TW

1:00 p.m. **"Advanced Multi-Variate Time Series Analytic Techniques on DoD Datasets Using AI and ML"**
Kathy Smith, GBL Systems

Abstract description not releasable.

1:30 p.m. **"Advanced Visualization Techniques for DoD Dataset using AI"**
Ben Baysinger, GBL Systems

Abstract description not releasable.

2:00 p.m. **"Anomaly Detection on US Army OTC Level 1 and Level 2 Data from Structured and Unstructured Data Sources**
Kent Picket, MITRE

Abstract description not releasable.

2:30 p.m. **"The Utilization of AI & ML in Analyzing Helicopter Data for RTC"**
Kenny Sanchez, Test Resource Management Center (TRMC)

Abstract description not releasable.