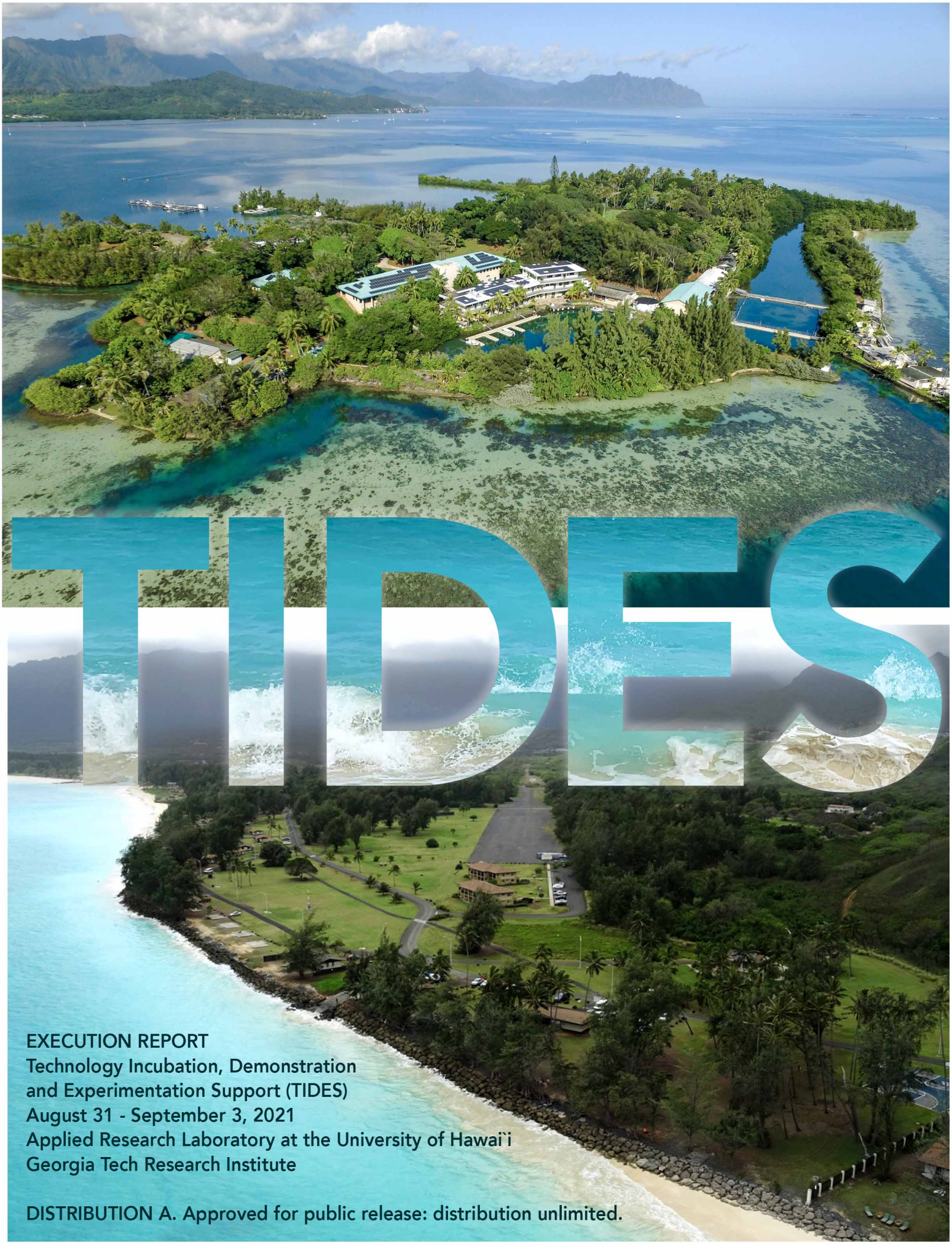

EXECUTION REPORT
Technology Incubation, Demonstration and Experimentation Support (TIDES)

August 31 - September 3, 2021

Applied Research Laboratory at the University of Hawai`i
Georgia Tech Research Institute

This report summarizes the activities, participating organizations, demonstrated technologies, and demonstration locations during the second Technology Incubation, Demonstration, and Experimentation Support (TIDES) event conducted in Honolulu, Hawai'i from August 31 through September 3, 2021.

On behalf of the Applied Research Lab at the University of Hawai'i (ARL at UH), the Georgia Tech Research Institute (GTRI), we thank the TIDES 2021 participants for several days of active demonstrations and discussions to highlight exciting technologies that address important mission needs.

TIDES 2021 focused on technologies that enable rapid capability enhancement for contested logistics, emphasizing emerging capabilities, including manufacturing, robotics, unmanned systems, and power generation.

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Margo Edwards, Director
ARL at UH

Rusty Roberts, Director
Aerospace, Transportation & Advanced Systems Laboratory
GTRI

September 2021

Contents

Acronyms

AAA	Airspace Access Authorization
AAR	After Action Report
ACE	Agile Combat Employment
AI	Artificial Intelligence
ARL at UH	Applied Research Lab at the University of Hawai'i
ATAK	Android Tactical Awareness Kit
ATC	Air Traffic Control
A2/AD	Anti-Access and Aerial Denial
BAFS	Bellows Air Force Station
BDA	Battle Damage Assessment
CENTCOM	Central Command
COIN	Counterinsurgency
DoD	Department of Defense
EABO	Expeditionary Advances Base Operations
EPC	Entry Point Control
FAA	Federal Aviation Administration
FAR	Federal Acquisition Regulation
GTRI	Georgia Tech Research Institute
INDOPACOM	Indo-Pacific Command
ISR	Intelligence, Surveillance, Reconnaissance
JFMCC	Joint Forces Maritime Component Commander
LTE	Long-Term Evolution
MCTAB	Marine Corps Training Area Bellows
NDS	National Defense Strategy
OPFAC	Operational Facility
SNB	SIPR/NIPR in a BOX
STUN	Secure Transmission on Unclean Networks
S&T	Science and Technology
TAOC	Tactical Air Operations Center
TIDES	Technology Incubation, Demonstration and Experimentation Support
T&E	Test and Evaluation
UAS	Unmanned Aircraft System
UAV	Unmanned Aerial Vehicle
UGV	Unmanned Ground Vehicle
UH	University of Hawai'i
USV	Unmanned Surface Vehicle
VTOL	Vertical Take-Off and Landing

Introduction

This report summarizes the 2021 Technology Incubation, Demonstration and Experimentation Support (TIDES) event conducted at Bellows Air Force Station (BAFS) and Moku o Lo'e (colloquially known as Coconut Island) from August 31 through September 3, 2021. TIDES is a test and evaluation (T&E) platform designed to help technologists incubate innovative technologies in diverse, realistic settings, identify and address technical issues, and then test and assess the technologies with direct warfighter involvement in operationally relevant environments.

TIDES provides an opportunity for technology developers to demonstrate and experiment with new and evolving technological capabilities in an operationally relevant environment and obtain insight into federal technology gaps and emerging needs. TIDES aims to enable a collaborative working relationship between government organizations, academia, and industry to identify emerging needs and technology discoveries for the Department of Defense (DoD) and interagency partners.

The TIDES design comprises three parts. The first part (incubation) includes testing of emerging technologies in Hawai'i to assess their readiness in isolated or integrated settings and identify problem areas before introducing the technology to the warfighters. After follow-on development has been conducted to resolve technical issues, the second and third phases of TIDES (demonstration and experimentation) are intended to insert the technologies, with unit sponsorship, into exercises or training events for user-operational military utility assessment.

ARL at UH and GTRI, with support from the Combatant Commands, DoD technology community, and industry, formed a partnership to conduct air, ocean surface, ground, and/or underwater testing in Hawai'i leveraging ARL at UH's proximity to test sites, access to warfighting units, mild climate, and environmental diversity. By expanding this partnership to the DoD technology community, industry, and the warfighting community, ARL at UH and GTRI can assess technology performance holistically, incorporating cultural, environmental, and interoperability factors. TIDES will help enrich collective assessments of technologies to understand better the multiple considerations affecting operational effectiveness. For example, only unscripted field testing can demonstrate the effects of weather, wind, water, blowing sand, radio frequency interference, and communications disruption. TIDES also shows the potential impact of these chaotic elements on the decision chain and human-machine interaction.

Background

The 2018 National Defense Strategy (NDS) has shifted the DoD away from counterinsurgency (COIN) operations and competition with peer adversaries. With the rise of great-power competition and emerging anti-access and aerial denial (A2/AD) capabilities over the last decade, the U.S. military has adopted distributed operations, like U.S. Air Force's Agile Combat Employment (ACE) and U.S. Marine Corp's Expeditionary Advances Base Operations (EABO). While these concepts maintain conventional warfighting advantages against peer adversaries like China and Russia, they place increased demands on logistics support infrastructure, which currently lacks the capacity and resiliency necessary to sustain a prolonged campaign. Fundamentally, this means transitioning from a force optimized for supporting land-based combat operations from fixed positions in a logistically robust theater where naval forces dominated in three domains (land, sea, and air) to maritime and distributed forces designed to support operations in austere and expeditionary environments which will be contested in multiple domains (land, sea, air, cyberspace, space, and the electromagnetic spectrum).

Our logistics enterprise must be capable of providing expeditionary support and sustainment from the greater distances imposed by a future threat environment that is broader and deeper than in past conflicts. The future operating environment will be characterized by complex terrain, technology proliferation, information warfare, the need to shield and exploit signatures, and an increasingly non-permissive or denied environment. Moreover, the rapid evolution and accessibility of technology amongst state and non-state adversaries will pose additional logistics operations risks. These threats will require a proactive cyber defense posture. New technologies include advanced computing, "big data" analytics, artificial intelligence (AI), autonomy, robotics, directed energy, hypersonic weapons, and biotechnology, the very same technologies required to enable U.S. forces to fight and win future battles.

Distributing logistical support through multiple domains contributes to a survivable network that allows the littoral force to persist as a stand-in force. Given the operational environment where ACE and EABO will occur, achieving survivability is mainly dependent on maintaining dispersion, designing the distribution network in light of unique threats, and allocating forces to protect critical logistic capabilities. For example, unmanned aerial systems to resupply widely distributed forces to execute resupply, rearm, refuel, and refit while maneuvering in the littorals contributes to the survivability of the littoral force.

Teaming humans with robots and AI will improve individual and team performance while reducing threats to humans. Augmenting human capabilities offers additional gains in performance and reductions in threats. Robots and AI can improve all institutional and support functions of ground forces. The broad potential applicability of these systems means that ground forces should adopt an enterprise approach to employing human-machine teams. Human-robot teams can be used in training institutions, freeing up personnel to be re-deployed for other operations. Advanced computing and analytical capacity may well be beneficial in human-AI strategic decision-making teams for capability development, resource allocation, and talent management of personnel. Cognitive augmentation may be as helpful for decision-makers. The new and interdisciplinary research areas of AI, complex adaptive systems, and swarm optimization indicates the potential for self-organized robot swarms to be used in a future conflict.

Scenario Descriptions

Day 1

Marines are inserted forward and quickly establish or occupy an existing expeditionary landing field to support rearming and refueling of manned and unmanned aviation assets. This station includes an Operational Facility (OPFAC) and support functions such as Air Traffic Control (ATC), aviation logistics, and force protection. Depending on the mission and the enemy threat, it may also include a Tactical Air Operations Center (TAOC). A collection of emitters (i.e., an antenna farm) is located with appropriate standoff from the OPFAC and remoted in wirelessly. Force protection, including perimeter security and entry point control (ECP) operations, is challenging as EABO operations call for the absolute minimum number of personnel to be deployed. This challenge is mitigated by using a diverse range of high-fidelity, networked sensors around the perimeter, at ECPs, and along likely avenues of approach.

Additional applications of interest include unmanned aircraft system (UAS) management and exfiltration of aircraft sensor data during approach, landing, taxiing, and at the halt to support immediate processing, exploitation, and dissemination of actionable intelligence.

Day 2

A team of Marines is inserted forward to quickly deploy and activate a diverse range of high-fidelity, networked sensors to monitor a specific area or areas of interest to provide early warning and targeting information supporting the Joint Forces Maritime Component Commander (JFMCC) mission. These sensors are monitored and analyzed in real-time to find, fix, and track air and surface targets.

Sensors include radars, cameras, and electromagnetic spectrum analyzers deployed by the intelligence, surveillance, reconnaissance (ISR) team; sensor inputs may come from other platforms (manned and unmanned aircraft and surface vessels) and national assets. Sensors may also include sub-surface monitoring and collection capabilities to support the identification and tracking of undersea threats. The high bandwidth, low latency Long-Term Evolution (LTE) network allows for sensor output to be quickly collected; LTE-connected edge computing facilitates sensor data processing, fusion, analysis, and dissemination – the JFMCC near-real-time intelligence and understanding of the battlespace in support of decision making.

Demonstration Exercises

A top priority of TIDES 2021 was to reduce potential health risks to participants and comply with guidance from host organizations and the State of Hawai'i. Special accommodations at TIDES 2021 in response to COVID-19 included:

- Demonstrators and visitors were required to upload proof of vaccination or display vaccination cards to participate in the event.
- Participants used a mobile app to document whether they had any symptoms of illness and displayed the app confirmation to participate upon arrival each day.
- Demonstration sites on the first and second day of TIDES 2021 were distributed and set up in outdoor locations. Visitors toured demonstration sites in set teams, so there were no more than 25 people at any site at any time.
- Group gatherings on the third and fourth day of TIDES 2021 took place in a covered, open-air pavilion.
- Daily lists of participants were collected in case the need arose for contact tracing.

TIDES 2021 took place in two locations. The four-day event was designed around a human-machine teaming scenario: predictive autonomous cargo delivery supporting contested logistics in an island-hopping small team resupply scenario.

The TIDES 2021 scenario was designed as a hub-and-spoke operation. In this scenario, BAFS served as the hub on the first day. On the second day, Coconut Island served as a forward-deployed spoke. The third day focused on the After Action Review (AAR) at BAFS; the fourth day concluded TIDES 2021 with a discussion of future initiatives and best practices that meet sponsor requirements. On both the third and fourth days, DoD personnel provided guidance to technologists on how to transition the systems that were demonstrated successfully.

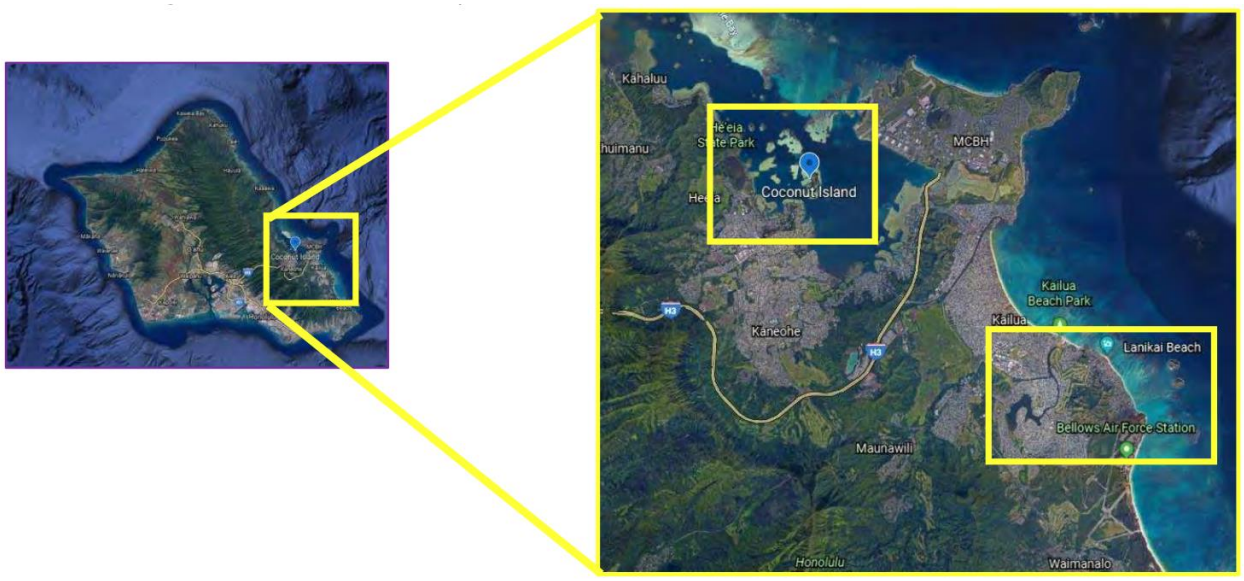


Figure 3: Map of O'ahu, Hawai'i indicating the windward side of the island (left). Detail showing BAFS and Coconut Island (right).

Day 1: Bellows Air Force Station (BAFS)

The first day of TIDES 2021 featured technology demonstrations at BAFS (Figure 3). Located in Waimānalo, O'ahu, BAFS mission is to make resilient warfighters and families through unique recreation and training experiences. ARL at UH regularly conducts T&E operations involving UAS and other emerging technologies in support of the United States Indo-Pacific Command (INDOPACOM) and component services at BAFS, helping expand BAFS's functionality as a T&E and innovation station for emerging military technologies. BAFS presents a superb opportunity for T&E activities from initial concept through pre-deployment training with station access and operational requirements scaled to mitigate risk.

BAFS has multiple terrains, including a former active airfield, unpopulated coastline, open fields, deep forest canopy, abandoned cantonment, freshwater streams, and ocean conditions that range from still water to active surf. BAFS airspace is Federal Aviation Administration (FAA) Class G, enabling ARL at UH and contractor UAS operations under Federal Aviation Regulation (FAR) 107, FAA Educational Interpretation, or Certificate of Authorization. Additionally, government-sponsored UAS operators can be authorized under Airspace Access Authorization (AAA). Coordination of air activities with the adjacent Marine Corps Training Area Bellows (MCTAB) range safety officer ensures that BAFS operations are deconflicted with MCTAB operations.

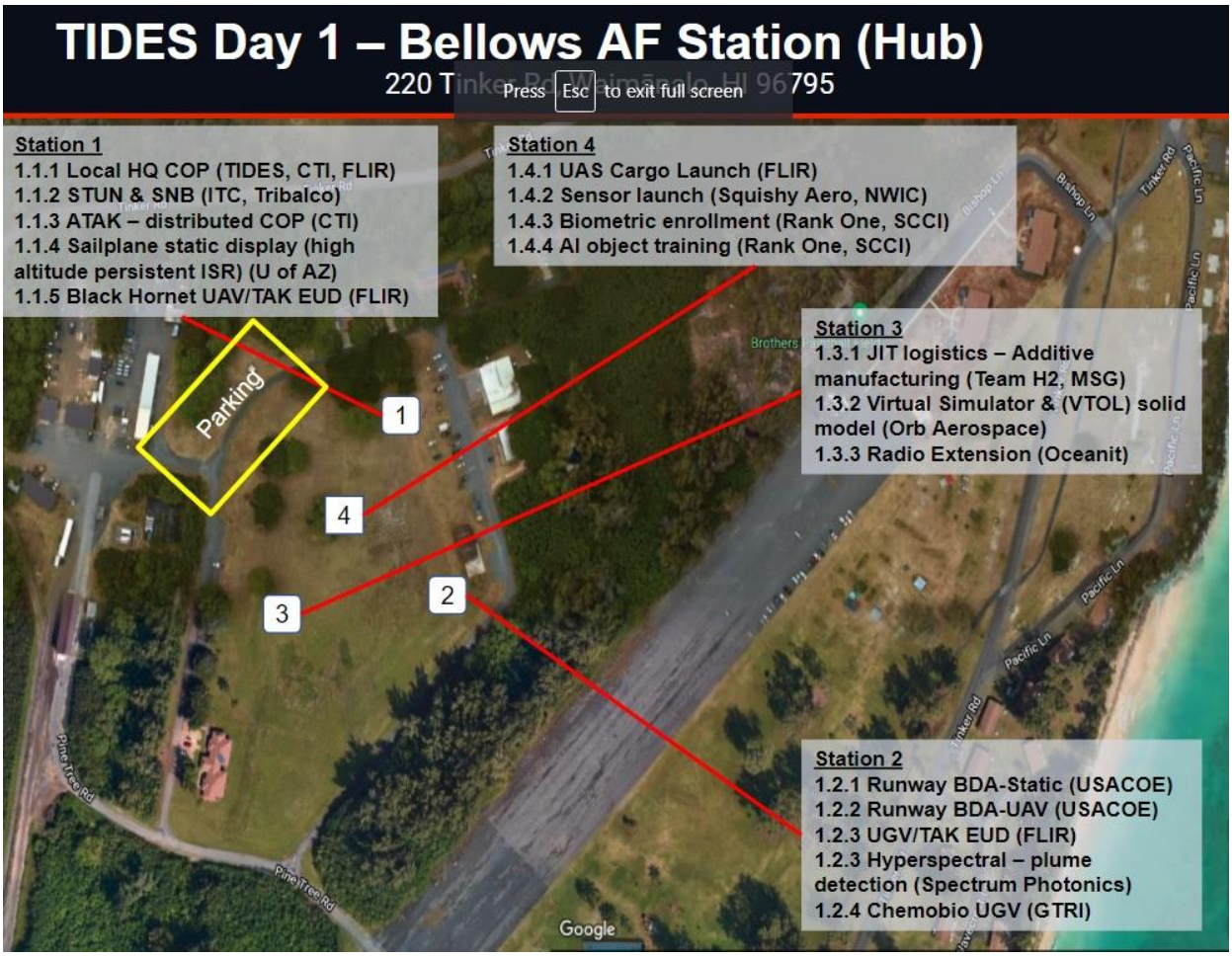


Figure 4: Day 1 demonstration locations at BASF.

BAFS is formally known as Detachment 2, falling under the 18th Force Support Squadron at Kadena Air Base, Japan. The Commander of BAFS is Maj Amanda Pelkowski.

Station 1 (BAFS, Figure 4) served as the Hub headquarters and included a Common Operating Picture providing wide-area and localized situational awareness and connectivity across the base and to the spokes through Android Team Awareness Kit (ATAK). Data transmissions were secured using a "Secure Transmission on Unclean Networks" (STUN) and SIPR/ NIPR in a BOX (SNB), funded by the United States Central Command (CENTCOM) to distribute uplinks to local cellular networks securely. Station 1 included a poster board display of an overwatch sailplane providing high altitude ISR over the hub and spoke. Uplinked video from the black hornet, a small unmanned aerial vehicle (UAV), and wearable blue force tracking technology were also on display at station 1.

Station 2 demonstrated projects to assess and improve battle-damaged runways. This station installed a long-term battle damage assessment (BDA) system and a BDA UAS to provide high-resolution imaging of runway damage. There was also a plume detection sensor, a chem-bio unmanned ground vehicle (UGV) assessing the area, and an additional UGV to investigate any hazardous objects and perform further safety checks.

Station 3 showcased additive manufacturing supporting small team resupply missions to manufacture replacement parts for systems at the spoke location. Once the replacement parts are printed, the expectation is that they would be transported to the launch area by vertical take-off and landing (VTOL) UAS. A virtual simulator was available at station 3 to simulate this capability.

Station 4 was the launch site to ship manufactured components using a small UAS theoretically bound for Coconut Island. Before deployment, intended recipients of the cargo were biometrically enrolled in an authorized person database. When the shipment reached Coconut Island, the UAS would not deliver the load until it had identified an authorized person within the delivery zone. Station 4 demonstrated the biometric enrollment process, a biometrically enabled access control system, the cargo UAS, and a system designed to protect cargo dropped from altitudes of hundreds of feet by UAS.

Day 2: Coconut Island

The second day of TIDES 2021 featured technology demonstrations at Coconut Island (Figure 5), located in Kāne'ohe Bay, O'ahu, and operated by the Hawai'i Institute of Marine Biology (HIMB) of UH. Coconut Island represented the spoke to BAFS's hub.

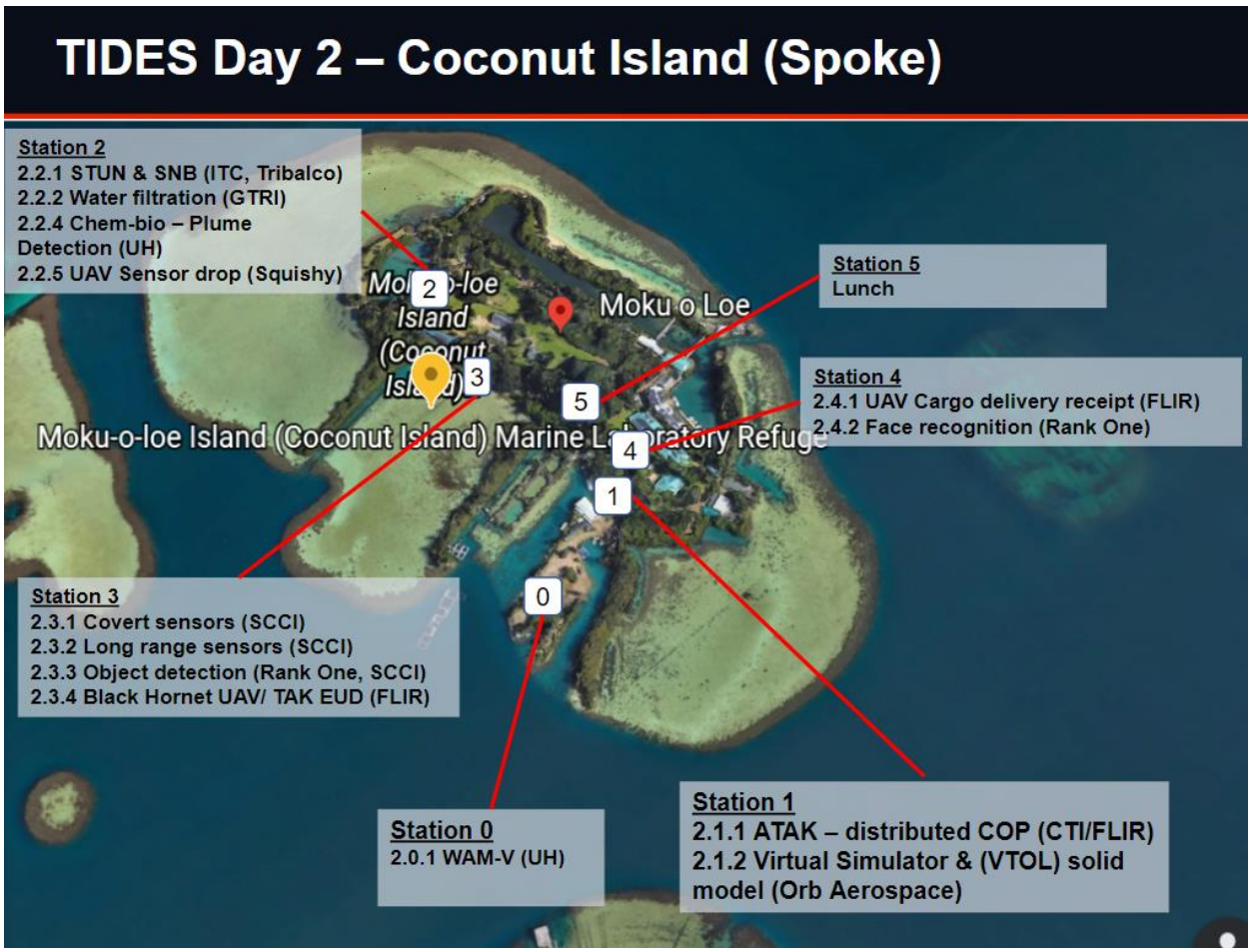


Figure 5: Day 2 demonstration locations at Coconut Island.

Station 0 demonstrated the use of unmanned surface vehicles (USV) for developing underwater test ranges. A group of three USVs autonomously steered to specific locations, deployed objects meant to serve as surrogates for sea-disposed munitions, and generated sonar maps of the seabed.

Station 1 connected ATAK devices to a secure network and provided an overview of Coconut Island, including locations where the person was positioned. Wearable devices allowed personnel around the island to be monitored. In addition, the virtual VTOL simulator was rapidly deployed at station 1 to simulate flight over Coconut Island.

Station 2 demonstrated technologies critical to ensure safe island operations, including a communications uplink and the STUN and SNB operating and transmitting data securely between sites. Water purification technology was also demonstrated at Station 2, along with a chem-bio plume detection capability. Not far from Station 2, a UAV repeatedly dropped packages onto the ground to illustrate the performance of a cargo protection system.

Station 3 demonstrated layered security options for the forward-deployed station with cameras providing perimeter surveillance, infrared sensing, object detection and alerting, concealed sensing, and watchlist-based biometric security. In addition, long-range sensors searched for objects such as aircraft, boats, people, or vehicles.

Station 4 was the hypothetical receiving point for the replacement parts shipped from BAFS the previous day. Again, tactical facial recognition to authenticate that the shipment was delivered to authorized personnel was demonstrated.

Day 3 & 4: BAFS (After Action Review, Opportunities, Best Practices)

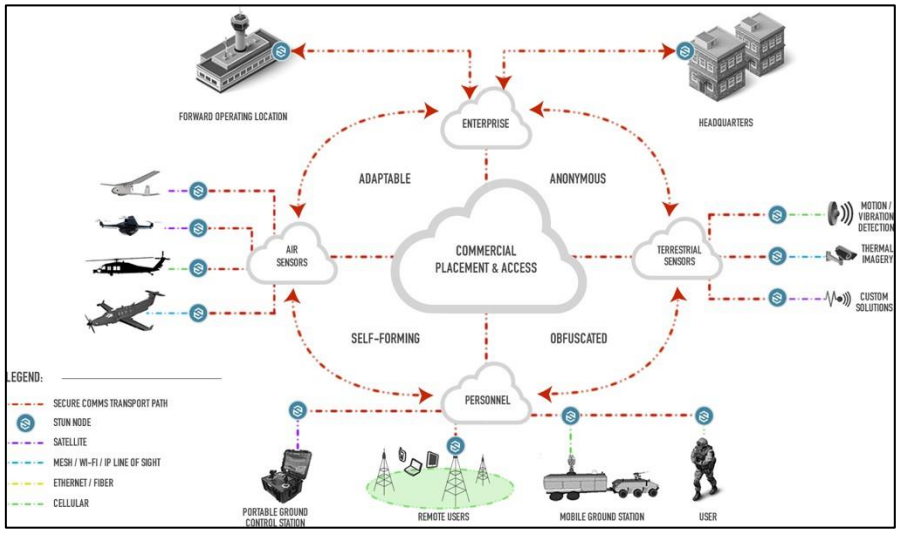
The third day of TIDES 2021, which returned the participants to BAFS, focused on the AAR. Technology providers presented detailed descriptions of the systems they had demonstrated on the previous days and answered questions from other participants. In addition, science and Technology (S&T) advisors from various combatant commands and DoD service branches discussed objectives and opportunities and guided demonstrators to transition technology successfully. TIDES 2021 concluded on the fourth day by discussing future initiatives and best practices to meet sponsor requirements. To foster collaboration, Day 4 participants were broken into teams to brainstorm collaborative solutions to existing challenges.

Technology Descriptions

Following is a brief description of all technologies presented at TIDES 2021. The listing approximates the order in which the technologies were introduced on Day 1 at BAFS.

Secure Transit through Untrusted Networks (STUN)

The STUN is hardware and virtualized capability that provides a secure communications software layer that interfaces with corresponding radio frequency links and networks. These communication paths can be military tactical as well as commercial networks. However, the STUN platform creates a computational problem for our adversaries by obfuscation of the network endpoints. This is further exacerbated by distributing portions of the communications stream across all communication paths. In addition, STUN enhances existing security and encryption standards employed by the COCOMs and Services.



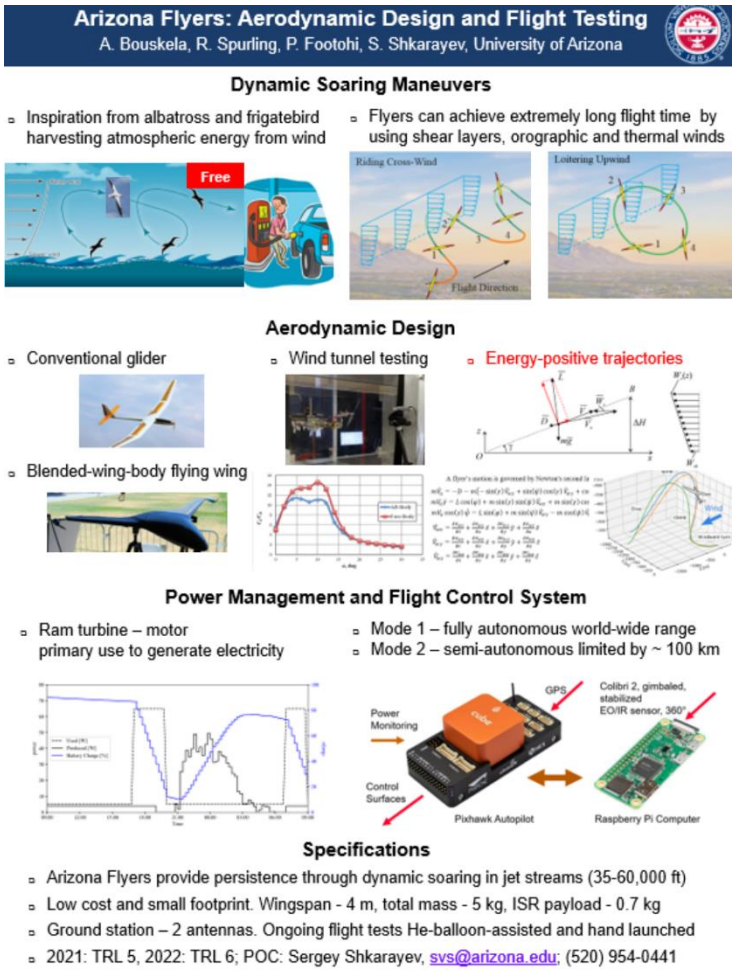
Signal Fusion Platform – with STUN integration

Signal Fusion Platform (SFP) is a Tribalco patented multi-service communications gateway system. SFP connects diverse application waveforms including radio, cellular, RF, IP, laser, and SATCOM; the integrates and transports voice, video & data signals, leveraging VPN, CSfC, complex-waveforms & blockchain elements. The SIPR/NIPR in a Box (SNB)/SFP is a deployed TRL 9 system with the US Marines and Army C5ISR.

This demonstration integrates the SFP with Secure Transport through Untrusted Networks (STUN) technology to recharacterize the data transport across commercial backhaul.

RavenX/ArizonaSwarm

Remote Autonomous Vehicle-Enabled Networks – via Xperimentation (RavenX) is a USARPAC-sponsored multi-year MDO designed to inform the future through field testing technologies that meet operational mission requirements. Therefore, TIDES can be seen as a technology feed into RavenX.



ArizonaFlyer (AF) UAS and its group/ network configuration, ArizonaSwarm (AS), are potential candidates for RavenX. AF is a persistent, durable, extremely long-duration high-aero-performance UAS operating continuously in the stratosphere, using wind shear in the jet stream as its 'power source.' Flying an onboard-calculated Energy Positive Trajectory, or Dynamic Soaring track, AF operates without chemical fuel or propulsion & batteries as long as it has access to the jet stream. Additionally, AF can carry Sensors or Radio Relays over the battlefield and uses gimbals to keep sensors or antennas oriented correctly while maneuvering to achieve the Positive Energy Trajectory.

An unstructured group of AFs working together and serving a unitary objective is called ArizonaSwarm (AS). AS provides a high-altitude backbone of distributed sensors and radio relays for direct support of TIC and/or TOC. AF can fly indefinitely (for months at a time) by exploiting jet streams for dynamic soaring. In addition, AF provides persistent EO/IR and mesh network data links while traveling for hundreds of miles as needed to remain close to the action. The system is a low-cost and small footprint solution designed for autonomous multi-AZ Flyers supporting multi-target missions.

Balloon-launched and parachute-recovered, AF/AS is runway independent. The AF is managed by ground control stations that allow operators to communicate with and control the AF/AS and its payloads. Flight navigation, aircraft operations, and energy management are autonomous, focusing on the ISR or radio relay mission requirements. Radio link from the Ground Station into the RavenX comms network brings AF/AS into the RavenX Ecosystem, where cloud computing supports highly informed PED and the decision-making process.

The project aims to develop and demonstrate the Arizona Flyer system at a high altitude (30,000-70,000 ft). In the context of TIDES, AS would be employed as persistent overwatch and as an intel contributor to the Ecosystem.

Black Hornet Personal Reconnaissance System (PRS)

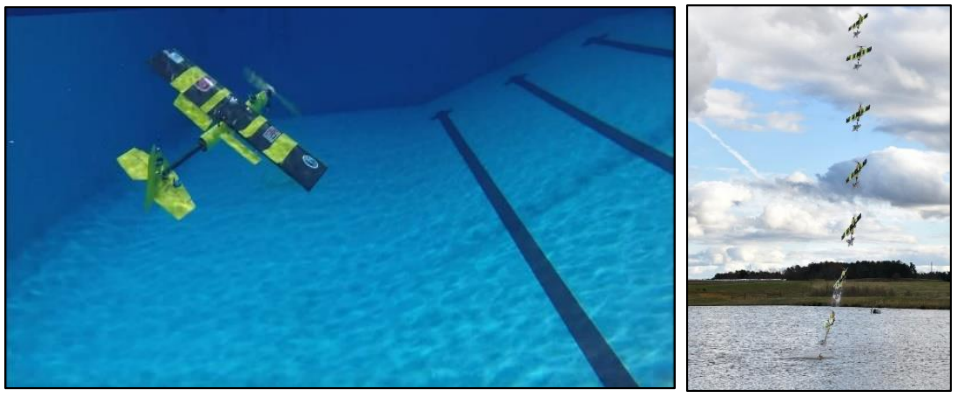
The Black Hornet is the world's smallest operational intelligence, surveillance, and reconnaissance platform. Available as a PRS for dismounted warfighters or a vehicle-based system, the platform's game-changing electro-optical (EO) and infra-red (IR) technology bridge the gap between aerial and ground-based sensors.

The Black Hornet PRS equips the non-specialist dismounted soldier with immediate covert situational awareness (SA). Incredibly light, nearly silent, and with a flight time up to 25 minutes, the combat-proven, pocket-sized Black Hornet PRS transmits live video, and high- definition still images back to the operator and the ATAK ecosystem.

R80D SkyRaider sUAS

R80D SkyRaider delivers a range of versatile Group 2-3 payload capabilities with the agility and single-operator deployment footprint of a proven Group 1 aircraft. With its ability to carry and deliver multiple payloads up to 7.7 lbs, an open architecture, and one of the most powerful embedded AI computing devices available on an sUAS, SkyRaider is redefining what's possible with a man-packable UAS. Integration with the UAS Tool allows end-users on ATAK's network native ability for tasking, targeting, and data exploitation from the aircraft in prosecuting various missions. In addition, the SkyRaider's expanded carrying capacity, open payload architecture, and dynamic flight control provide an unprecedented level of flexibility in an sUAS.

EagleRay Cross-XAV (Remote Demo)



EagleRay is a cross-domain amphibious vehicle specifically designed to facilitate covert littoral ISR missions. It can be capable of being deployed and recovered covertly as a sub-surface vehicle, loitering as a surface vehicle, or conducting aerial, fixed-wing surveillance. Additionally, it can start and end its mission in the water without a runway.

PackBot 525 UGV

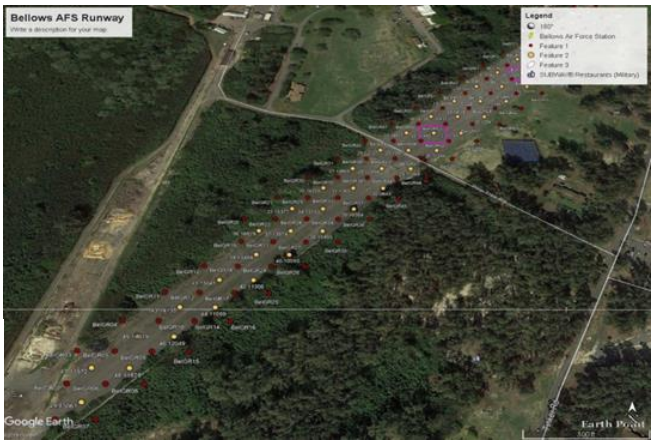
PackBot 525 builds on the heritage of the legacy PackBot system, which has 4,000+ systems deployed worldwide. The PackBot 525 is purpose-built for multiple missions, including surveillance, reconnaissance, CBRN detection, and EOD. Additionally, PackBot 525 natively supports broadcasting its position and video into the ATAK ecosystem.

FirstLook Gen3 UGV

FirstLook is a throwable, rugged, and expandable robot that provides immediate SA while operating where other robots can't go. This lightweight robot can be inserted into structures and provides operators with sensor feedback before entry. In addition, the robot climbs can overcome curbs, turns in place, and self-rights when flipped over.

Battle Damage Assessment

U.S. Army Corps of Engineers (USACOE) has been developing a satellite-based, thermal-response method to assess runway physical condition rapidly. While more R&D is necessary, the system gives strong indications of being useful for real-time orbital assessment of pavement condition.



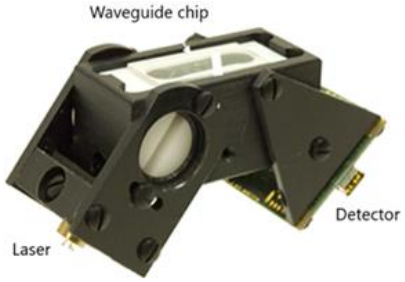
USAF Civil Engineering has developed a Rapid Airfield Damage Assessment (RADAS) method of runways and built infrastructure. RADAS uses Small Unmanned Aircraft Systems (SUAS) to locate, classify, and analyze airfield damage and the minimum airfield operating surfaces. As a result, it equips combat engineers with an expedited process for analyzing battle or environmental damage without putting them in harm's way.

Salvus Detection System – The world's first interferometric chem-bio detection platform

The Salvus detection system can simultaneously detect chemical and biological threats with previously achievable sensitivities in labs staffed by scientists. This gives military personnel the ability to identify and protect themselves from unseen threats in real-time. In addition, it is both lightweight and robust. This allows for deployment by whatever vector is best suited to the mission.

The Salvus technology platform can deploy detection at scale for entirely new targets in weeks from their first isolation – giving a strategic and tactical advantage. For example, it can detect threats or be deployed to look for chemical or biological markers of interest.

Waveguide Interferometry based Optical sensor for Rapid Chemical and Biological Detection

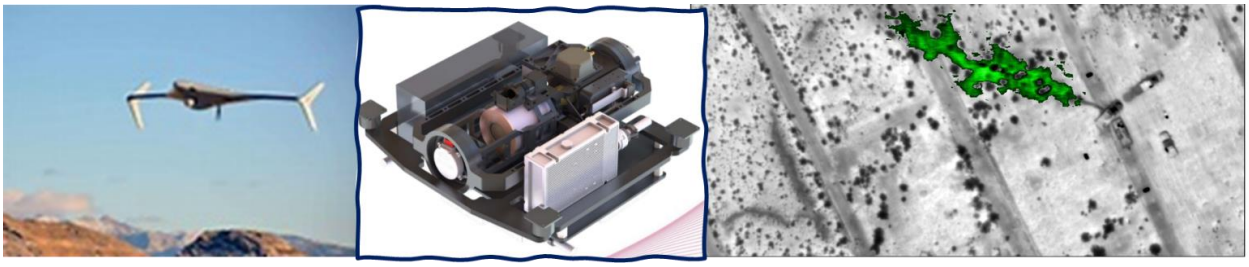


GTRI has researched, designed, and developed an optical sensing system for chemical and biological detections over the last 20 years. The GTRI sensing platform based on an integrated optic planar waveguide interferometer combines two very sensitive methods, the waveguiding and the interferometry techniques, into the next generation of sensors for rapid chemical and biological detection field. The current chip design contains four independent interferometers, so four separate detections can be conducted simultaneously. Furthermore, as this is a platform technology, either chemicals or biologicals can be detected by changing the surface sensing chemistries.

The analysis time from sample to results can be less than a minute. The detection limits range from ppb to ppm for vapor and liquid phase organic analytes, pg/ml for biomolecules, and $<10^4$ cells/ml for bacteria. Applications include ground-based, remote, unattended sensing with data logging and uplink, hand-held use by hazardous materials response teams, airborne sensing, online process control, and personal or clinical monitoring devices. Recently, the GTRI sensing platform has been developed for rapid COVID detection in clinical samples and licensed by Salvus LLC for commercialization.

HyCARS

Spectrum Photonics of Honolulu has developed an Ultra-compact Hyperspectral Imaging System. This sensor system and its companion on-board processor produce real-time map-based pictorial early-warning intelligence graphic expression of chemical operations, chemical threats, and post-release visuals of chem plumes. The game-changing ultra-compact form factor, low weight, and low power consumption allow HyCARS to operate in Group 3 and 2 UAS and aircraft and ground systems. HyCARS enables wide-area rapid detection, rapid re-deployment, basis for integrating HIS into the battlefield PED cycle, extended persistence, and direct participation in dynamic IEW. In addition, HyCARS dramatically increases the area of regard and operational agility over point sensors.



State of the art CL1720 3D Printing System

Team H2's 3D Printing System offers significant capability at a fraction of the price of leading competitors. We are focused on providing Additive Manufacturing (AM) solutions that provide functional end-use parts through our knowledge and expertise. Strong fiber reinforced thermoplastics are leveraged with our easy-to-use 3D printer to produce robust, high-quality, and consistent parts. The filament is carbon fiber-filled and made in the USA. Our systems are built using aircraft-grade aluminum and industrial-grade linear drive components suitable for semiconductor manufacturing. Each plan includes closed-loop motor control for every axis and extruder. Systems allow users to choose any material that can be extruded under +400ºC or +752ºF —including PEEK, Ultem™, and several other unique materials.

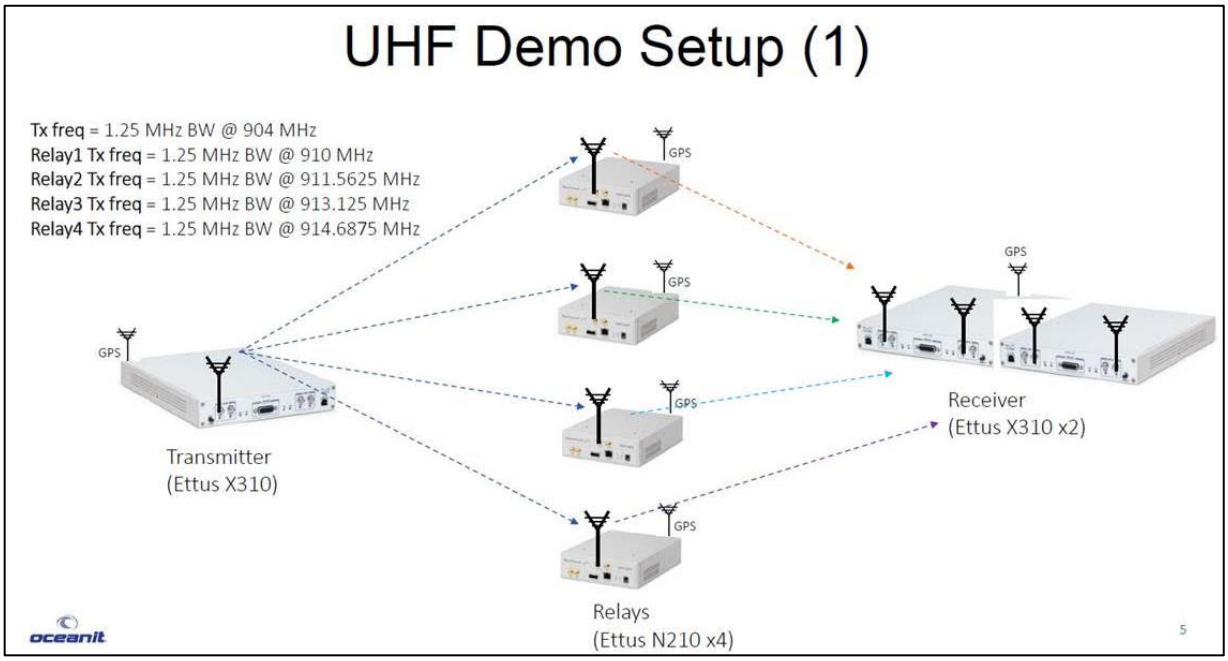
Orb Nomad – The Second Generation of Electric VTOL

The Nomad is a vehicle the size of a Humvee, with the cost of an "attributable," designed to exceed the range and speed of every available rotorcraft while providing the vertical lift missing in fixed-wing platforms. Able to team with manned, unmanned, and remotely controlled counterparts, flights of between six and twenty-four Nomads can seamlessly stand-up forward operating bases,

provide exfil for austere units, and self-deploy within a range of 1,000 Nautical Miles while carrying a 500-pound payload. The Nomad boasts modular wings that offer superior flexibility for logistics and provide max range or max endurance payloads, including passengers, cargo, and reconnaissance platforms. In addition, Expeditionary maintenance hubs will be capable of expeditionary payload changes and additive part manufacturing with a minimal sustainment footprint.

While delivering supplies to the warfighter, Nomads become a flying sensor on the network, map enemy positions, provide coms, EW, and overwatch. Nomads provide the Integrated functions of a drone, medium-lift helicopter, and reconnaissance aircraft into a swarm-able EVTOL the size of a class 3 UAV.

Oceanit Expanded SO Task Force Radio Net



Oceanit Expanded SO Task Force Radio Net Operational Enhancement via MIMO: Oceanit will demonstrate an enhanced airborne network (tested on the ground) communication system using a UHF MIMO (Multi Input – Multi Output) network. In this demo, we will be using four relay nodes that create multiple transmission paths, which will be combined coherently at the receiver. Furthermore, we will show real-time BER (Bit Error Rate, a QOS term) and constellation plots at the receiver with and without the MIMO technique to show the performance enhancement. MIMO capability fits well with the need for agility in operations under the future expeditionary concept (such as ACE), as reliable comms underlies everything.

Squishy Robotics Air-Droppable Sensor & Communications Platform

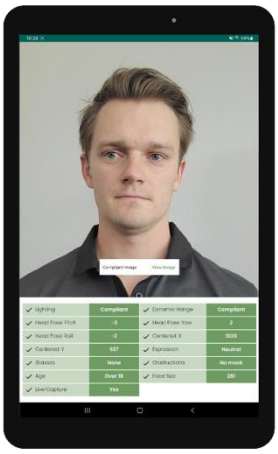
Squishy Robotics, Inc. has developed a solution to enable the deployment and operation of diverse payloads in austere or dangerous locations. Typically dropped from drones or other aircraft, these payloads can be rapidly deployed to provide persistent intelligence, surveillance, reconnaissance (ISR), and situational awareness (SA), enabling faster, better informed, data-driven decisions. The payloads can also be customizable—rapidly redesigned and retooled to carry and deliver an assorted range of items, such as radios to rebuild a damaged communication infrastructure or blood and plasma for emergency medical aid.




The Squishy Robotics, Inc. stationary robot is a multi-modal sensor optimized for situational awareness in emergency and security operations. The ability to deploy the sensor by air eliminates the need for personnel to physically hand-carry sensors into dangerous environments. Payloads are dropped without parachutes and thus require no additional setup to ensure sensor operation after deployment.

Our scalable and reconfigurable platform can carry customized, third-party equipment of up to 5 lb. One capability is to deploy a Mobile Ad-Hoc Network (MANET) radio via drones to provide dependable communications infrastructure through mesh networking and other robust topologies.

Live Scan Mobile Capture Application



The Live Scan mobile capture application leverages the mobile phone's internal camera to capture quality face images for enrollment and verification. The application provides ICAO compliance and real-time feedback during image acquisition. The application receives and displays full-motion video with reactive feedback on which compliance metrics are being met. The application will automatically capture the raw, uncompressed jpeg that meets all compliance metrics or automatically capture the best raw, uncompressed jpeg image of the person even if it is non-compliant. The application can generate ANSI / NIST files for use in external applications. In addition, the application can access and apply Rank One's patented single image passive liveness solution to ensure the face being captured is not an image of a look. Facial recognition quality metrics can also be displayed to confirm the captured image is usable for facial recognition purposes. All features included in this application are embedded in the core ROC SDK, which can be deployed on multiple operating systems and integrated via various programming languages.

ROC Watch

ROC Watch is an HTML application that offers a flexible environment for real-time video analytics. This solution provides easy and flexible deployments that can scale from a headless NVIDIA ARM device to a centralized, distributed framework with hundreds of IP camera inputs. This application provides a searchable analytics log, including face detections, face recognition, license plate recognition (LPR), and vehicle and object detections. Thirty-second video clips, thumbnails, timestamps, and other metadata are captured with each event. Triggers can be configured to send an alert via SMS or email when an analytics event occurs, such as people from a specified watchlist are seen by specific cameras.

Naval Information Warfare Center – Pacific (NIWC PAC)

NIWC PAC will showcase an array of UAS systems used in service of IPACOM. NIWC PAC Indo-Pacific Department delivers Command, Control, Computers, Communications, Cyber, Intelligence, Surveillance, and Reconnaissance (C5ISR) capabilities to mitigate emerging and future capability gaps. Recent development efforts have focused on ISR sensors, unmanned system platforms, energy and power, and logistics. In addition, NIWC PAC serves as a one-stop-shop for the transition of technologies to the Warfighter for capability and limitation and military utility assessments.

TAKwatch with WEAVR Wearable application for Situational Awareness

The TAKwatch API is the first, created to allow developers to relay data to a wearable solution securely. It leverages a 256-bit encrypted BLE connection that is device and platform agnostic. CTI, in partnership with the TAK Product Center, developed this Government Owned, Open Source Solution. Its purpose is to leverage proven, commercially available Wearable solutions to meet the immediate needs of Operators. Garmin was the chosen platform for the first implementation of the API. Their Fenix 6 and Tactix Delta series of Ruggedized Smartwatches are battle-tested and already the wearable of choice for many Operators. However, the API is designed to support other platforms that may be better suited for other applications such as Human Performance, etc. If the data is in TAK, it can work with TAKwatch.

Leveraging the TAKwatch API, CTI created the first wearable application for TAK, the Wearable Awareness Viewer - WEAVR - application. The application was designed with one primary purpose: to provide an Operator Maximum Situational Awareness with a glance to their wrist. Up to this point, for an Operator to obtain relevant mission data from an ATAK EUD, they had to look at the device, which was typically secured to their chest plate. This is a risky endeavor in any environment as it compromises their line of sight, thus their immediate situational awareness. The WEAVR application relays important mission data such as the location

of priority Points of Interest (POIs), Friendly Forces (BlueForce Nodes), and Planned routes. This data is relayed directly from a paired ATAK EUD, managed through an intuitive panel, and presented to the Operator through several views on the wearable. The app supports a Connected mode, where it maintains a live feed of updates from the EUD. Additionally, it can work in Standalone mode for environments where BLE communications are restricted or help extend the watch's battery.

TAKwatch is not only a flexible and scalable platform that meets the immediate needs of Operators, but it's a solution built on proven technology, ready for immediate deployment.

Covert/Overt Video Surveillance Systems, RAPTOR Analytic Software, and Mobile Access

SCCI will demonstrate various video surveillance systems, including a minor, affordable utility box concealment, 5-gallon bucket camera concealment, Rapidly Deployable (RAD) tripod mounted overt long-range camera deployment, a tactical video management system, and ATAK video integration.

We will demonstrate the RAPTOR (Rapid Tactical Operations and Reconnaissance Platform). The RAPTOR is designed to be a single pane of glass interface with a variety of third-party analytics. The RAPTOR platform is intended to be a force-multiplier tool. The suite of analytics RAPTOR supports allows live video streams to be processed rapidly, on the edge and provides highly accurate searchable data. In addition, the RAPTOR platform gleans the pertinent information from



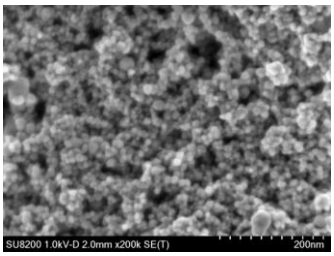


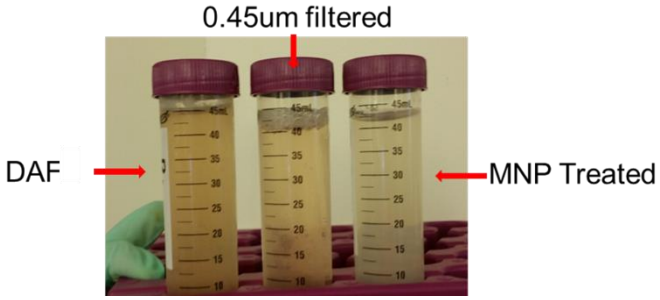
the video to speed up the investigative process; Instead of watching days, or even weeks of footage, the information is needed.

Our demo will also include the Gallagher Access control kit, embedded in a Pelican case, with an external laptop running the Gallagher Management software allowing user enrollment and management. This will also be integrated with an Axis I8016-LVE Network Video Intercom, combined with the Rank One SDK for Face Authentication for the 2nd factor, after the PIV card Authentication. The 5MP sensor allows enough pixels at close distances for face image capture. With Gallagher, you can have Audio Messages output from the Intercom to tell the user to look straight into the camera or to try again if the initial face capture is not of sufficient quality. This sensor could be fed into a VMS or run with Object Detection analytics (person, color, etc.). For TIDES 2021, we would have this kit available at one of the stations to demonstrate the 2-factor workflow of PIV Card and Face.

Functionalized Magnetic Nanoparticle for Rapid Water Treatment

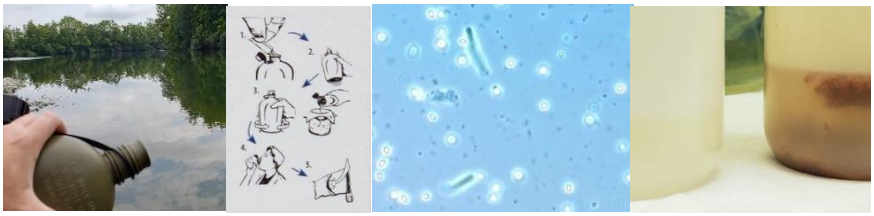
GTRI has developed a patented water treatment technology based on the functionalized magnetic nanoparticles. Magnetic nanomaterial-based adsorbents are very attractive due to their high surface area and easy separation of solid/liquid via an external magnet. The diameter of our functionalized superparamagnetic nanoparticle is about 10 nm, and the synthesis method is simple, scalable. The prepared material has an excellent adsorption capacity for suspended solids, odor, taste (COD), heavy metals, microorganisms. The removal efficacy is not influenced by pH, temperature, other common anions, and organic matters. Additionally, the contamination removal can be achieved quickly (within a few minutes) by adding the magnetic nanoparticle into the water sample, shaking for 3 minutes, pushing the treated water sample through a magnetic filter into a collecting container.





Our functionalized MNPs have been tested in water samples collected from local ponds and creeks. The collected water samples were spiked with arsenate, selenite, and *E. coli* for removal efficiency study. The heavy metal levels, microorganisms, suspended solids, odor, and COD were determined before and after the MNP treatment. It was discovered that all the contaminates were reduced significant enough, so the treated water is safe to drink or use after a single-step MNP treatment.

Oxi-Floc: Broad-Spectrum Halogen-Free Individual Water Purification



Military operations, humanitarian assistance, and disaster relief often occur in environments with limited access to safe drinking water. Traditional halogenated water purification products can impart offensive chemical flavors to the water and pose secondary health risks by forming harmful disinfection byproducts, primarily halogenated organics.

Oxi-Floc (TDA Research, Inc.) is a halogen-free purification product that clarifies and disinfects to provide clean drinking water to the individual warfighter. Dry powders packaged in stable pouches are added to the water and, following mixing and settling periods, the disinfected water is poured off for use. As a broad-spectrum disinfectant, Oxi-Floc has been shown to remove viral and bacterial microorganisms, chemical warfare agents, toxic metals, and organic matter.

Participating Organizations

Table 1 provides a brief description of organizations participating in TIDES 2021.

Org	Org Description	Technology
ARL at UH	The Applied Research Laboratory at the University of Hawai'i (ARL at UH) is youngest of five U.S. Navy-sponsored University Affiliated Research Center (UARCs). ARL at UH was founded in 2008 has grown rapidly past decade, undertaking $40 million in research for government and industry in FY21. ARL at UH leverages our proximity to test sites, access to warfighting units, Hawai'i's mild climate and environmental diversity to imagine and develop agile, innovative and cost-effective solutions to problems impacting our stakeholders, our community and our planet. ARL at UH has partnered with the UH College of Engineering to use unmanned surface vehicles to deploy objects on the seabed and map the objects' locations shortly after deployment to rapidly install and reconfigure underwater test ranges.	Unmanned Surface Vehicle installation of underwater test ranges
Battelle Memorial Institute	Battelle Memorial Institute is a non-profit, charitable trust formed in 1925. Battelle's mission is as relevant as ever. We solve global challenges through contract research, laboratory operations, STEM education, and philanthropy and volunteerism. The active chemical and biological research laboratories within Battelle's CBRNE Defense Bioscience Center contain multimillion-dollar analytical instrumentation and ancillary supporting laboratory equipment. Highly experienced scientists and state-of-the-art, regulatory-compliant biological facilities operate under a quality management system. Battelle serves more than 200,000 square feet of laboratory space dedicated to biological and chemical research, development, testing, and evaluation; this includes extensive BSL-1 and BSL-2 laboratories in Columbus, OH, and multiple BSL-3 laboratories at West Jefferson, OH. Battelle provides independent laboratory test and developmental prototype demonstration support to TDA Research through an OSD Rapid Innovation Fund Project.	Oxi-Floc: Broad-Spectrum Halogen-Free Individual Water Purification
CTI	CTI is a mid-sized defense technology and services company with a mission to create government open platforms and applications addressing Defense and Intelligence customer requirements. We are liberal in sharing our Intellectual Property (IP) rights with the U.S. Government; we build (and use) open platforms that are available, accessible, extensible, and flexible; and we create loosely coupled application environments that allow for collaboration of functionalities without requiring explicit knowledge of one component by another. CTI deploys a variety of open source and open, government-owned geo-visualization tools (such as TAK and Raptor), software-defined radio frameworks (such as GNU Radio and Redhawk), and Apache tools (such as Hadoop and Spark) for extensive data analysis and machine learning. CTI is composed of individuals with subject matter expertise within all aspects of spectrum-dependent operations, including signals intelligence (SIGINT) and Radio Frequency (RF) sensors, Electromagnetic Warfare (EW), communications, navigation warfare (NAVWAR), and Directed Energy (DE). CTI has unique knowledge within the "Spectrum Domain," our key business area. The Spectrum Domain covers all aspects of spectrum-dependent operations.	TAKwatch with WEAVR Wearable application for Situational Awareness
Georgia Tech Research Institute (GTRI)	The Georgia Tech Research Institute (GTRI) is the non-profit, applied research division of the Georgia Institute of Technology (Georgia Tech). Founded in 1934 as the Engineering Experiment Station, GTRI has grown to more than 2,800 employees supporting eight laboratories in over 20 locations around the country and performs more than $782 million of problem-solving research annually for government and industry. Each day, GTRI's science and engineering expertise is used to turn ideas into workable solutions for our customers. We take the best ideas, often co-developed with	Waveguide Interferometry based Optical sensor for Rapid Chemical and Biological Detection

	our Georgia Tech academic partners, and turn them into systems applications that provide a significant technological advantage over other approaches. As a University Affiliated Research Center (UARC), GTRI's renowned researchers combine science, engineering, economics, policy, and technical expertise to solve complex problems for the U.S. federal government, state, and industry. We develop highly effective, practical solutions that we put into action. As a non-profit research institute, we are an objective partner who delivers workable solutions and manufacturable products. Our highly specialized laboratories and interdisciplinary research centers allow us to bring the right mix of talent, experience, and creativity to every project.	Functionalized Magnetic Nanoparticle for Rapid Water Treatment
IT Consulting Partners (ITC)	IT Consulting Partners (ITC) is an information technology firm focusing on delivering integrated software, hardware, and cloud services to warfighters within the national defense and intelligence communities. For the last 12 years, ITC has provided state of the art capabilities to US Special Operations Command (USSOCOM), US Central Command (USCENTCOM), and the joint warfighter. ITC is a privately held company known for providing a unified, mission-level view across the entire DoD enterprise, analyzing joint missions and addressing technology gaps critical to military readiness. ITC's program management and engineering team draw on decades of experience in research, development, and manufacturing. ITC also specializes in delivering defense, national security, space systems, and commercial product solutions. Leveraging a robust Government customer base and extensive network of transition partners within and external to the DoD, ITC has mitigated capability gaps through accelerated prototyping, demonstration, and fielding, with the ultimate goal of operational sustainment.	Secure Transit through Untrusted Networks (STUN)
MSG, Team H2	Team H2 (Hui Huliau, KAIROS, and Mission Solutions Group (MSG)) designs, develops, manufactures, markets, and distributes technologies that enhance the warfighters perception and awareness. Team H2 brings an innovative understanding that leads to actionable Intelligence and provides the ability to derive knowledge from raw data and information – Our goal of applying intelligence to embrace Perfect Information Exchange is to leverage technology and related AI/ML techniques to enhance the human ability to derive a more thorough understanding of each mission. Our team provides sophisticated cybersecurity analysis and implementation within Commercial, Federal, and DoD/Military environments by integrating governance and compliance with operational security threat avoidance activities. Additionally, Team H2's combination of Cybersecurity and IT management Services allows our clients to plan, maintain, enhance and protect the technology required to improve the efficiency and effectiveness of their mission objectives.	3D Printing System
NIWC-PAC	The Naval Information Warfare Center Pacific (NIWC PAC) Indo-Pacific Department strives to resolve current issues related to Naval Forces Command, Control, Computers, Communications, Cyber, Intelligence, Surveillance, and Reconnaissance (C5ISR) needs and diligently works to develop new technologies to mitigate emerging and future C5ISR capability gaps. Recent development efforts have focused on ISR sensors, unmanned system platforms, energy and power, and logistics. In addition, NIWC PAC serves as a one-stop-shop for the transition of technologies to the Warfighter for capability and limitation and military utility assessments. The results of these assessments inform the further development of new technology and systems.	Indo-PACOM UAS Systems
Oceanit	Oceanit is a Mind-to-Market company founded in Hawaii in 1985. Resting on our core values of Curiosity, Community, and Ohana, we have built a world-class reputation for developing and migrating fundamental science to real-world applications. Oceanit has deep expertise and a long history of aeronautical, aerospace, and defense projects in both government and private sectors. Our background, facilities, and capabilities allow us to design, simulate, fabricate,	Oceanit Expanded SO Task Force Radio Net

	characterize, and test award-winning materials, sensors, and systems for the Department of Defense and commercial customers in our state-of-the-art laboratories. In addition, Oceanit's rapid prototyping lab, Engineering Design Center (where optical and mechanical design occurs), and fabrication/scale-up facilities allow us to work across a spectrum of advanced aerospace projects with diverse scopes and applications.	
Orb Aerospace	Orb Aerospace is pioneering autonomous multi-mission aircraft for node-based logistics, personnel transport, and reconnaissance. Orb engineers emphasized utility and modularity to make their hybrid EVTOL the most multi-mission capable vehicle on the future battlefield.	Orb Nomad – The Second Generation of Electric VTOL
Rank One Computing (ROC)	Rank One Computing (ROC) provides the only top-tier, U.S.-developed solutions for facial recognition and object detection that meet the rigorous needs of U.S. military operations and high-profile commercial applications. Our AI/ML algorithms deliver the industry's most efficient and fastest algorithms, popular for embedded, mobile, and on-edge applications.	Biometric Enrollment AI Object Detection Facial Recognition
SCCI	Sandoval Custom Creations, Inc. (SCCI) is a premier designer and supplier of covert and overt surveillance equipment and components to Federal, State, and Local law enforcement and military organizations. SCCI designers and technicians, along with their elite fabrication partners and a complete graphic and print shop, can design and manufacture almost any covert concealment or overt surveillance system. Design, assembly, testing, component 3D printing, packing, and shipping occur at their production facility in Palmer Lake, CO. SCCI is the largest supplier of Canon Internet Protocol (IP) cameras to Law Enforcement. All video management and analytic software used in SCCI products are from US partners/companies. All SCCI employees are U.S. citizens. All work is completed at our facilities in the US.	Covert/Overt Video Surveillance Systems, RAPTOR Analytic Software, and Mobile Access Control System
Spectrum Photonics	Spectrum Photonics is a Honolulu-based small business focused on developing lightweight, ultra-compact hyperspectral imaging system (UCHIS) technologies for remote and standoff applications. Infrared UCHIS sensors can support ISR missions to identify chemicals, UXO, and IED emplacements at the range, defeat camouflage and identify dismounts in cluttered scenes. UAV- and ground vehicle-mounted UCHIS sensors have been developed for several DoD and US Government agencies.	HYCARS
Squishy Robotics, Inc.	Squishy Robotics, Inc. provides lifesaving and cost-saving information in real-time through our rapidly deployable mobile sensor robots. Squishy Robots, a spinoff of research at UC Berkeley with NASA to develop planetary probes for space exploration, is a technology that allows for the dropping of sensors, communications equipment, and other sensitive payloads into a remote or austere environment to collect critical situational awareness information. Squishy Robotics offers several customizable platforms tailored to several applications: Hazardous Materials (HazMat) response in municipal fire departments, payload delivery for government customers, and industrial monitoring for commercial markets.	Air-Droppable Sensor & Communications Platform
Teledyne FLIR	**TELEDYNE FLIR** designs, develops, manufactures, markets, and distributes technologies that enhance perception and awareness. TELEDYNE FLIR brings innovative sensing solutions into daily life through thermal imaging, visible-light imaging, video analytics, measurement, diagnostic, and advanced threat detection systems. TELEDYNE FLIR offers a diversified portfolio that serves several applications in government, defense, industrial, and commercial markets. TELEDYNE FLIR products help first responders and military personnel protect and save lives, promote efficiency within the trades, and innovate consumer-facing technologies. In addition, TELEDYNE FLIR strives to strengthen public safety and well-being, increase energy and time efficiency, and contribute to healthy and intelligent communities.	Black Hornet Personal Reconnaissance System (PRS) R80D SkyRaider sUAS EagleRay Cross-XAV (Remote Demo) PackBot 525 UGV FirstLook Gen3 UGV

Tribalco, LLC	Tribalco, LLC is a global C6ISR systems integrator providing mission-critical information technology (IT) and telecommunications solutions worldwide to Government and commercial customers. Our diverse portfolio of integrated services and solutions spans the entire technology lifecycle from design and engineering to procurement and systems integration through follow-on operations and sustainment. Our performance-based culture emphasizes quality delivery, customer satisfaction, and operational excellence. Tribalco's capabilities and expertise comprise a multitude of disciplines across the technology spectrum, including: • Land Mobile Radio (LMR) • Telecommunications Design and Procurement • Terrestrial-based Communications • Video Teleconferencing Solution Design • Microwave and Satellite Communications • IT Integration, Installation, and Equipment Procurement • Secure Wireless Infrastructure Design • Training and Technical Assistance • Spectrum Management • Program Management and Consulting Services	Signal Fusion Platform – with STUN integration

Summary and Conclusions

The basic tenet of TIDES is that there is no substitute for field experimentation. No matter how effectively a technology performs in simulation or a laboratory, it must be tested in an unpredictable environment to be honestly evaluated. Field experimentation that brings together sponsors, technology development, and the user community in a realistic environment serves as an accelerator for transitioning technology to support the warfighter. TIDES was created to provide a realistic, uncontrolled setting to develop and enhance technology from incubation to operations.

Working together with support from DoD and industry partners, ARL at UH and GTRI successfully executed the second TIDES event, adapting activities over periods as short as 1-2 days to accommodate rapidly changing situations resulting from the COVID-19 pandemic – a true test of agility in unpredictable circumstances for all of the TIDES 2021 participants! As a result, TIDES 2021 fulfilled its foundational objective "to act as a catalyst to strengthen relationships between technology and operational user communities, leverage DoD S&T resources, promote collaboration among the operational forces, strengthen partnerships and relationships with allies and promote an environment in which different organizations complement each other's efforts."

ARL at UH and GTRI wish to thank the TIDES 2021 attendees for their participation and collaboration. We look forward to expanding our partnership to serve the user community by leading the progressive development of TIDES.