

CRIMSON VIPER 2015

FINAL REPORT



JULY - AUGUST 2015

PRACHUAP KHIRI KHAN, THAILAND

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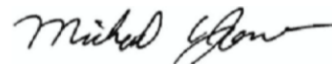
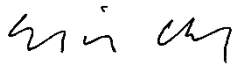
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January 2016

This report provides information on the technologies that were demonstrated and/or assessed during the Crimson Viper 2015 (CV15) Field Experiment as part of the ongoing experimentation engagement and partnership between U.S. Pacific Command (PACOM) and the Royal Thai Ministry of Defence (MOD), Defence Science and Technology Department (DSTD). This document provides a summary of activities, findings, and feedback gathered by the Technology Experimentation Center (TEC) and Office of Naval Research Reserve Component (ONR-RC) and does not represent the formal position of the U.S. Pacific Command or the Department of the Navy.

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ACRONYMS

ADVON	Advanced Party
APCFC	Asia-Pacific Counter-IED Fusion Center
ARDO	Thai Army Research and Development Office
ARL	Army Research Laboratory
C2	Command and Control
C4-ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CDRUSPACOM	Combatant Commands of the United States Armed Forces. Commander, U.S. Pacific Command
C-IED	Counter Improvised Explosive Devices
CONOP	Concepts of Operation
CV	Crimson Viper
EOD	Explosive Ordnance Disposal
DARPA	Defense Advanced Research Projects Agency
DoD	Department of Defense
DSTD	Defence Science and Technology Department
DTIC	Defense Technical Information Center
FSR	Field Site Representative
GCS	Ground Control Station
GPS	Global Positioning System
HA/DR	Humanitarian Assistance Disaster Relief
IAC	Information Analysis Centers
IED	Improvised Explosive Device
IRP	Initial Rally Point
J85	PACOM Science and Technology Office
JIDA	Joint Improvised-Threat Defeat Agency
JIEDDO	Joint IED Defeat Organization
JOC	Joint Operations Center
MDA	Maritime Domain Awareness
MOD	Royal Thai Ministry of Defence
N/A	Not Applicable
NAVAIR	Naval Air Systems Command
NIR	Near Infrared
ORP	Objective Rally Point
ONR-RC	Office of Naval Research Reserve Component
RDECOM	U.S. Army Research Development and Engineering Command
RTA	Royal Thai Army
RTARF	Royal Thai Armed Forces
RTB	Return to Base
S&T	Science and Technology
SME	Subject Matter Expert
TEC	Technology Experimentation Center
TAC	Thai-American Consultations
TTP	Tactics, Techniques, and Procedures
UAS	Unmanned Aerial System
U.S.	United States
USARPAC	U.S. Army Pacific
USPACOM	US Pacific Command

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EXECUTIVE SUMMARY

The Crimson Viper (CV) Field Experiment is conducted annually between the Royal Thai Ministry of Defence (MOD), Defence Science and Technology Department (DSTD), and U.S. Pacific Command Science and Technology Office (USPACOM J85). Crimson Viper 2015 was executed by the Technology Experimentation Center (TEC) under the ambit of the Thai-American Consultations (THAI TAC) Joint Statement. The purpose of experimentation in CV15 was to introduce leading edge technologies and proposed Concepts of Operation (CONOP) to relevant training audiences while assessing candidate technologies and providing operational feedback to the science and technology (S&T) community.

CV15 field experimentation provided a platform to support collaboration and promote interoperability between Royal Thai Armed Forces and U.S. PACOM via S&T partnership with DSTD, assess candidate technologies and provide assessment feedback to the science and technology community, confirm technology maturity prior to introducing to war-fighters, and provide candidate technologies for longer term Royal Thai Armed Forces (RTARF) assessment.

CV15 field experimentation was conducted from July 27- August 7 at Fort Thanarat, Khao Noi, Prachuap Khiri Khan, Thailand. Experimentation, demonstrations, and data collection was conducted on five technology groups. These groups included Unmanned Aerial Systems (UAS) and sensors, Fuel Cell technology, mobile handheld applications, and Counter Improvised Explosive Device (C-IED) handheld detectors. CV15 technologies were demonstrated and assessed utilizing C-IED and boarder security scenarios. These scenarios were designed to mimic the use of these technologies in real world missions.

The CV15 experimentation effort was very successful. The UAS team conducted altitude, platform/sensor optimization, and rapid response testing throughout the event while successfully coordinating airspace, providing demonstrations, and conducting in the field integration and R&D. The biometrics team was able to use each of the four devices in multiple test scenarios including accuracy, throughput, and reachback testing. The TransApps team trained Thai users to operate the TransApps capabilities to support multiple scenario vignettes, while also gaining valuable user feedback on the capabilities from non-tactical users. The C-IED team successfully trained nine Thai users to each use one of the three C-IED handheld detectors. The C-IED users participated in scenario vignettes, the Distinguished Visitors (DV) day Thai and U.S. integrated scenario, and were able to provide teachbacks to one another after they had successfully completed training.

On August 6 the DSTD, USPACOM, and the TEC hosted an S&T DV Day. The purpose of the event was to highlight S&T projects as part of an effort to promote bilateral S&T collaboration between the Royal Thai Armed Forces, the Thai MOD, and U.S. PACOM. The event played a key role in highlighting our joint technology focus areas. The S&T Distinguished Visitors Day consisted of CV15 overview briefs and scenario based technical demonstrations of new and emerging technologies that were currently engaged in CV15.

Overall, CV15 was a successful event for technology insertion and partner nation S&T collaboration efforts. The data collected from each of the experimentation events will help shape continued technology development for our warfighters and future PACOM S&T engagement efforts.

INTRODUCTION

This report provides an account of the Crimson Viper 2015 field experiment conducted with emerging U.S. and Kingdom of Thailand defense technologies, and Thai operating forces, at Fort Thanarat, Thailand, 27 July – 7 August 2015. This report also includes detailed stand-alone annexes (Annexes A-E) for each of the five participating technology groups, complete with findings, feedback, and recommendations where appropriate.

Purpose

The purpose of Crimson Viper 2015 (CV15) was to experiment with leading edge technologies and proposed Concepts of Operations (CONOP) in relevant operational conditions to gather operational feedback. Additionally, CV15 provided engagement opportunities with the Royal Thai Armed Forces (RTARF) and civilian Science & Technology (S&T) partners. This report covers the Technology Experimentation Center (TEC) led activities from July 27-August 7.

Background

The Crimson Viper Field Experiment is conducted annually between the Royal Thai Ministry of Defence (MOD) Defence Science and Technology Department (DSTD) and U.S. Pacific Command Science and Technology Office (USPACOM J85). Crimson Viper is executed under the ambit of the Thai-American Consultations (TAC) Joint Statement. Crimson Viper was discussed during TAC XVI on 9-11 April 2014 under Working Group IV for “Relationship Building, Coordination and Collaboration at All Levels” under subgroup IV.2 for Science and Technology.

Crimson Viper objectives are to experiment with candidate technologies in a field environment to:

- Support collaboration and promote interoperability between Royal Thai Armed Forces and USPACOM via S&T partnership with DSTD
- Assess candidate technologies and provide assessment feedback to the science and technology community
- Confirm technology maturity prior to introducing to warfighters
- Provide candidate technologies for longer term assessment

Each year Crimson Viper provides a new set of operationally relevant scenarios and technology demonstrations. Past events have included themes in Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR), Force Protection, Maritime Domain Awareness (MDA), Humanitarian Assistance/Disaster Relief (HA/DR), and Counter-Improvised Explosive Devices (C-IED). During CV15 concept development and planning the following themes were identified as DSTD/PACOM interest areas:

- **Counter-Insurgency (Counter-Terrorism, Counter-IED, Counter-WMD):** Mobile Ground Penetrating Radar, Checkpoint Security for IED precursors, Aerial Image Change Technology
- **Domestic Defense/Homeland Security:** Maritime Security, Counter-Narcotics, Human Trafficking, and Natural Resource Protection

- **Disaster Response/Search and Rescue:** Renewable Energy, Deployable Communications, and MREs/Food Service
- **Seminar Topic:** Social Media

Five technology groups consisting of three types of C-IED handheld devices, four types of biometrics devices, a suite of mobile applications, fuel cell technology, and two unmanned aerial vehicles with three optional sensor packages participated in CV15. Based on these technology groups, and with consideration for operational relevance in the area of operations (AO), scenarios were developed in C-IED and border security.

Technology Description

The following sections provide a brief description of each of the technologies that participated in CV15.

TransApps

The TransApps Ecosystem were developed as a Defense Advanced Research Projects Agency (DARPA) project focused on providing military end users with timely, relevant and accurate information. This is done via handheld devices loaded with apps, as well as C2 (command and control) software that were all built directly from military service member ideas. TransApps leverages commercially available mobile technology and provides the ability to collect, process, securely disseminate, and holistically display events, places, blue force icons, media and honesty trace data. All in near real-time, overlaid on high resolution imagery, operating on a highly-portable, mobile, lightweight and fully-integrated platform.



VMC1 Mine Detector

This new design Vallon Metal Detector VMC1 is a retractable detector for demining. It is supplied with a soft carrying bag housing the complete mine detecting set. Due to its small packing size it needs extremely little space for transportation and thus facilitates operation in impassable areas. In spite of the compact design Vallon made no compromise with regards to the detection features. The VMC1 is a fully adequate Vallon Metal Detector offering highest detection sensitivity and detection stability. The modern used technology as well as simple and easy to understand operation elements ensure a high demining reliability. The metal alarms are very clear so that the operator can work without a headset and any external cables.

F3Ci by AV Minelabs is More than a mine detector. The system features variable sensitivity through the selection of seven uniquely combined audio and sensitivity configurations, two operating modes to improve target identification, a pin-pointing mode for fast and accurate location of target, preconfigured sensitivity profile to assist in the detection of non-metallic conductive targets, fully enclosed and protected cables, audio and visual indications, a vibrating handle, an adjustable search head, is simple to operate, is waterproof, has a long lasting battery life, and is fully adjustable for operator



CEIA CMD is a very high performance, high-sensitivity Compact Metal Detector designed to detect metal and minimum-metal content targets in conductive and non-conductive soils, including laterite and magnetite. The system provides effective detection of all metal and minimum-metal content targets, a balanced and lightweight design, an one piece retractable design, small packaging size, accurate pin-pointing of the target’s position indicated by acoustic modulation and maskable led display, high discrimination capability for adjacent targets, automatic compensation for mineralized and high natural metal content soil, an integrated battery charger, a long-lasting battery life, an extremely high level of electrical and mechanical reliability, operation monitored by a microcomputer controlled auto diagnostic system, completely digital electronics, with in-field program memory upgrade capability, and is easy to operate and requires minimal training time.

SEEK II (Secure Electronic Enrollment Kit) is the culmination of bringing core Cross Match technologies together. Combining forensic-quality fingerprint capture, rapid dual iris scan capability and innovative facial capture technology, SEEK II is a comprehensive, multimodal identification and enrollment platform. The compact, portable solution is designed for rugged field use, making it quick and easy for military, border control and U.S. government agencies to identify subjects and verify their identities in the field.



SEEK Avenger is ideally suited for in-field operations, the compact SEEK Avenger is the only fully certified biometric enrollment and credential reading solution purpose-built to perform in the harsh and challenging environments of the military, border security and law enforcement. Combining forensic-quality fingerprint, stand-off dual iris capture, high resolution facial and evidence imaging, and multiple format credential reading, the SEEK Avenger delivers the ideal blend of beauty, brawn and intelligence.

Jump Kit is a multimodal biometric Jump Kit provides compact, highly mobile technology for capturing and transmitting forensic-quality digital fingerprints, iris images, photographs and demographic data for your identity management requirements. It is ideally suited for remote or autonomous enrollment applications. The Jump Kit includes a mug shot camera, iris scanner, and global positioning system (GPS) to log date, time and exact location of enrollment. Optional configurations include a portable handheld fingerprint scanner, a latent image camera, a document scanner and a mobile printer.



SRI Galaxy Pro Identification Tablet

The Galaxy Pro Identification Tablet is a low cost portable biometrics collection and identification system that provides world-class stand-alone iris identification and can serve as a remote collection device that interoperates with the ASTERIA Mobile Biometrics System for performing identifications from iris and face imagery. Utilizing SRI's patented IOM technology, this device provides a multi-function Android tablet with the hardware necessary to collect near infrared (NIR) iris and visible face images.

Talon 120LE is a rugged man-portable Unmanned Aircraft System (UAS) that can be integrated into any situation within minutes. This system were designed for various uses including search and rescue missions, inspection of crops and surveillance of power lines. The modular nose payload section can house a standard EO/IR payload or any experimental payload up to 2.5 lbs. in weight. Equipped with a dual camera, Electro Optical and Thermal Imager Pan and Tilt stabilized gimbal, users can take advantage of both perspectives without the hassle of two separate camera systems.



Phoenix 30 is a VTOL Quad Rotor Unmanned Aircraft System (UAS) that is ideal for military, first responders and civil applications. Ready in minutes, this intelligence, surveillance and reconnaissance platform weighs approximately 10 lbs. The Phoenix 30 carries a pan and tilt electro-optical/infrared (EO/IR) network/IP-based camera for easy video viewing from a UAVS ground control system (GCS), laptop or tablet.



Dragon View EO/IR Pan-Tilt Sensor

The Dragon View offers an array of electro-optical/infrared (EO/IR) Dragon View sensors for integration on air vehicles, antenna towers and other structures. These lightweight, low cost mechanically and digitally stabilized gimbals provide day and thermal imagery, video recording, object tracking and geolocation. Operating at 24 watts, the low power draw enables more efficient use of the battery system for longer duration.

i2-ML

The i2-ML is the smallest and lightest of the Ultra-Light Family. Weighing only 2.0 lbs, the i2-ML provides both IR and EO imagery combined with a high performance mechanically stabilized 4-axis gimbal. Some key features include; mechanical stabilization, embedded tracker, embedded fusion, embedded INS, external INS, local area contrast enhancement, and laser pointer.



Canon S100 for Mosaic Imagery

The Canon PowerShot S100 is a high-end 12.1-megapixel compact digital camera announced and released in 2011. It was designed as the successor to the Canon PowerShot S95 in the S series of the Canon PowerShot line of cameras. The S100 is a similar camera to S90 and S95 with several significant improvements. It has improved noise reduction, white balance and shadow correction. This camera is the first camera in the S series line to use the CMOS Sensor which gives the camera a higher performance and better light sensitivity. The S100 is also the first camera in the series to feature 1080p video recording in 24 frames per second.



D350 Solid Oxide Fuel Cell Power Generator system is a packable 350W Solid Oxide Fuel Cell power generator that is fueled by propane. This system is an ideal replacement for remote batteries and battery chargers, especially in advanced ISR or expeditionary warfare applications. The high specific energy of propane results in a significant tactical advantage for the D350 relative to rechargeable batteries. For example, 25 pounds of carried weight will produce 2.2kWh of energy from BB-2590s (11 batteries) or 5kWh of energy from the D350 (D350 and 5, 1-pound propane tanks).



EXECUTION

This section describes details on the CV15 locations, schedule, participants, data sources, scenarios, vignettes, special events, and lessons learned. Annexes A-E provide detailed information on each technology groups' locations, schedule, data collection, feedback, lessons learned, and results.

Locations

CV15 was conducted at Fort Thanarat, Khao Noi, Prachuap Khiri Khan, Thailand.

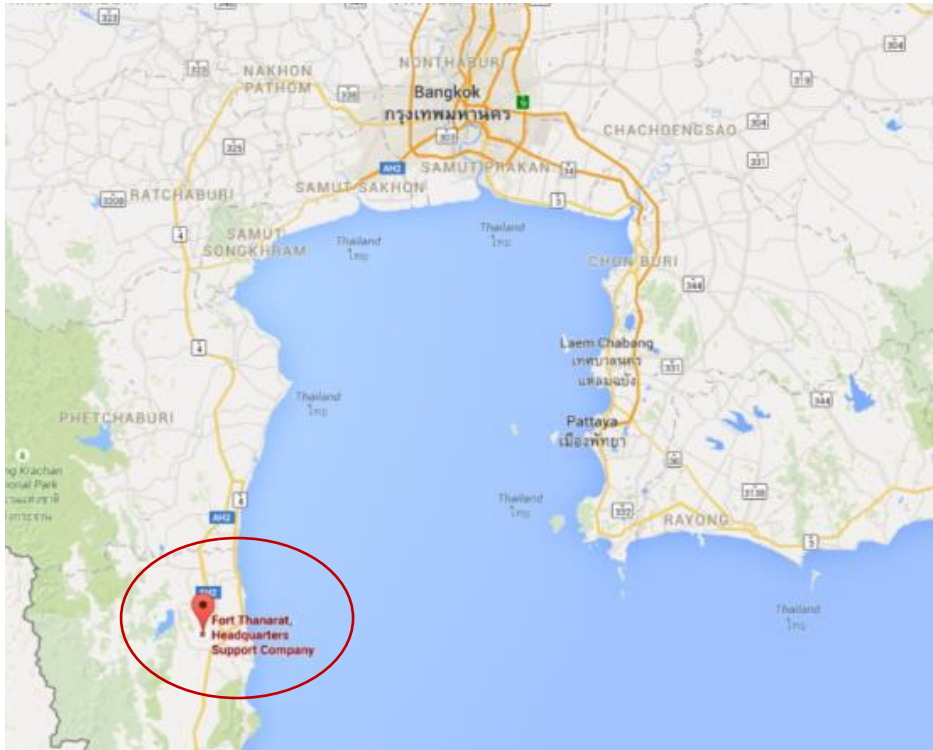


Figure 1: CV15 Locations Summary

Fort Thanarat is based on about 600,000 hectares of land near Pranburi town with the entrance on the western side of Petchakasem Road. The base is home to the Thai Infantry and Armed Forces Preparatory School. Fort Thanarat is home to around 5,000 soldiers and their families.

Two primary areas of operations were used during CV15. The UAS and sensor suite, TransApps, Fuel Cell, and Biometrics teams all operated in the area of the Joint Operations Center (JOC). The UAS runway was located directly outside of the main JOC building. UAS operations were conducted out of a tent located immediately adjacent to the UAS runway. TransApps, Biometrics, and the Fuel Cell all operated in and around the main JOC building, primarily in the technology demonstration and experiment area or the static display area. The geographical coordinates of the JOC was 12° 25' 00" N 99° 52' 21" E.



Figure 2: JOC and UAS Locations

The C-IED handhelds operated approximately two kilometers from the JOC. All daily training, soil testing, and data collection was conducted at this site during CV15.



Figure 3: CIED Training and Scenario Location

Schedule

The following table provides a brief summary of the CV15 schedule of events.

Table 1: CV15 Schedule

Date	Location	Event
7/22/15	BKK	CV15 Logistics Lead arrives in country
7/23-24/15	Customs	Clear customs and coordinate deliveries
7/25/15	BKK	Advanced Party (ADVON) arrives in country
7/26/15	BKK and Bangkok hotel	Rest day for travelers and backup arrival day
7/27/15	Bangkok hotel to Hua Hin	ADVON travel to Hua Hin Site Survey Receive logistics support equipment Scheduled equipment delivery date
7/28/15	Fort Thanarat	Setup day Data collection Actual equipment delivery (End of day)
7/29/15	Fort Thanarat	Setup day Op check and data collection Final coordination with DSTD
7/30-31/15	Fort Thanarat	Op check and data collection Buddhist Holiday
8/1/15	Baan Klang Hotel Various	Maintenance Day Group Activities
8/2/15	Fort Thanarat Baan Klang Hotel	Maintenance Day Additional data collection (Biometrics and UAS) Main Body Arrivals and In Brief Final Execution Brief
8/3/15	Fort Thanarat	DSTD Arrivals and In Brief User Training and Data Collection U.S.-hosted Icebreaker
8/4-5/15	Fort Thanarat	Vignettes and Data Collection Final User Surveys Visitors Day
8/6/15	Fort Thanarat	User After Action Review (AAR) (0900-1100) VIP Day (1300-1600) DSTD-hosted Dinner
8/7/15	Fort Thanarat Hua Hin-Bangkok	Seminar (0900-1200) Ship Equipment PM: Return to Bangkok
8/8/15	BKK-CONUS	Personnel return to Home Station
8/8-10/15	Bangkok hotel	CV15 Quicklook Development
8/11/15	BKK-CONUS	Analysts return to Home Station

Participants

The following section provides information on the CV15 participants.



Figure 4: CV15 Thai and U.S. Team Leads

USPACOM J85

USPACOM Deputy Science Advisor served as the U.S. representative for S&T collaboration with DSTD during CV15. USPACOM is one of six geographic combatant commands of the United States Armed Forces. Commander, U.S. Pacific Command (CDRUSPACOM) is the senior U.S. military authority in the Pacific Command AOR. CDRUSPACOM reports to the President of the United States through the Secretary of Defense and is supported by four service component commands: U.S. Pacific Fleet, U.S. Pacific Air Forces, U.S. Army Pacific and U.S. Marine Corps Forces, Pacific. These commands are headquartered in Hawaii and have forces stationed and deployed throughout the region.

Technology Experimentation Center (TEC)

During CV15, the TEC served as the PACOM J85 executive agent responsible for coordinating and executing all aspects of CV15 to include logistics, scenario development and operational feedback of the technologies demonstrated. The TEC representatives assisted with visitor briefs, data collection plans, logistics, and overall project management. The TEC is a U.S. Government consortium of technology and operational community subject matter experts working together to enable the warfighter by conducting technology demonstrations, experiments, and assessments in relevant operational venues and environments. For CV15, Naval Air Systems Command and Space and Naval Warfare (SPAWAR) Systems Center Pacific provided the subject matter experts to the TEC.

Royal Thai Army (RTA) Infantry Center

The RTA Infantry Center at Fort Thanarat provided users for the technology demonstrations and assessments. The technology users worked daily with the participating technologies and provided valuable feedback during the demonstration period.

Defence Science and Technology Department (DSTD)

DSTD is a department of the Thai Ministry of Defence that focuses on Science and Technology initiatives. During CV15, DSTD and its co-host, the Thai Army Research and Development Office (ARDO) provided coordination support for the execution location, facilities, airspace and frequency management, RTARF users, and VIP Day.

Naval Air Systems Command (NAVAIR)

NAVAIR Special Surveillance Program sponsored and led the CV15 demonstrations of unmanned aircraft systems (UAS) and Biometrics technologies. NAVAIR also sponsored CV15 staff support. NAVAIR's mission is to provide full life-cycle support of naval aviation aircraft, weapons and systems operated by Sailors and Marines. This support includes research, design, development and systems engineering; acquisition; test and evaluation; training facilities and equipment; repair and modification; and in-service engineering and logistics support. NAVAIR contractor support included Navmar Applied Sciences Corporation, UAS Solutions, Neany Inc., and SRI International.



Figure 5: NAVAIR Projects Team

Office of Naval Research Reserve Component (ONR-RC)

The ONR-RC provided personnel to support demonstration and data collection efforts during CV15. ONR-RC provided Subject Matter Expert (SME) knowledge during demonstration briefings, trained users on participating technologies as appropriate, and collected feedback from users and distinguished visitors throughout the event.

Department of Defense (DoD) Information Analysis Centers (IAC)

The DoD IACs provided field service representatives (FSR) from PACOM and STRATCOM to observe CV15 operations. Additionally, the FSRs supported CV15 by assisting in scenario execution, data collection, and by conducting VIP Day briefings. The DoD IACs are research and analysis organizations chartered by the DoD and operated by the Defense Technical

Information Center (DTIC). IAC experts help researchers, engineers, scientists, and program managers get the information they need, when they need it.

U.S. Department of Defense Joint Improvised-Threat Defeat Agency (JIDA)

JIDA, formerly known as the Joint IED Defeat Organization (JIEDDO), provided SME guidance during CV15 planning and data collection, and served as the technology sponsor for the C-IED technologies. JIEDDO was a jointly operated military organization of the Department of Defense established in February 2006 to deal with IEDs. In March 2015, JIEDDO became the newest defense agency, designated a combat support agency, and nested it within the Office of the Undersecretary of Defense for Acquisition, Technology & Logistics. In the process, the new unit was renamed JIDA. Doing so made it a permanent part of the Department of Defense. JIDA's mission is to enable the Department of Defense actions to counter improvised threats with tactical responsiveness and anticipatory acquisition in support of Combatant Commanders' efforts to prepare for, and react to, battlefield surprise in support of counter-terrorism, counter-insurgency, and other related mission areas including counter-IED.



Figure 6: JIDA, ARL, APCFC team with Thai Interpreter

U.S. Army Research Laboratory (ARL) Sensors and Electron Devices Directorate

ARL is a U.S. technology provider, deploying the C-IED handhelds and the TransApps technologies. ARL of the U.S. Army Research Development and Engineering Command (RDECOM) is the Army's corporate, or central, laboratory. Its diverse assortment of unique facilities and dedicated workforce of government and private sector partners make up the largest source of world-class integrated research and analysis in the Army. ARL's mission is to discover, innovate, and transition science and technology to ensure dominant strategic land power.

U.S. Army Pacific (USARPAC) Asia-Pacific Counter-IED Fusion Center (APCFC)

USARPAC APCFC provided a C-IED SME to help support the C-IED technologies during CV15. The SME also participated in the CV15 seminar as a speaker addressing C-IED technologies. USARPAC APCFC's mission is to conduct USPACOM C-IED and irregular warfare analysis; develop and synchronize C-IED and explosive ordnance disposal (EOD)

programs and regional engagements; and resource USARPAC C-IED training in order to ensure U.S., Allied, and Partner Nation personnel can effectively counter IED threats and are prepared to operate in an IED threat environment, and to minimize the strategic, operational and tactical impact of IEDs.

Data Sources

The TEC team used the following data sources to collect data and feedback during CV15.

Questionnaires/Surveys

CV15 user groups completed questionnaires/surveys designed primarily to gather feedback on the CV15 technologies. The majority of questions used a six-point rating scale ranging from Completely Disagree to Completely Agree and provided space for comments to allow users to explain their ratings, or to comment further. In addition, a Not Applicable (N/A) choice was available to those users who feel a particular question does not apply to them. Demographic information was collected separately.

Interviews

When appropriate, CV15 user group participants and SMEs were asked to participate in round table discussions with data collectors. Questions were designed to collect feedback on the CV15 technologies in relations to relevant functional areas and objectives.

Event Logs

Event Logs were used to capture subjective and objective data during CV15 data collection. The data captured included performance data, timeline, user impressions, SME observations, and the data collectors' independent view.

Photographs

Data collectors captured photographs of CV15 events throughout the setup and execution periods. Data collectors ensured that photographs remained unclassified and are approved for release by the appropriate agencies.

CV15 Scenarios

The TEC, as the CV15 executive agent for PACOM J85, DSTD and technology providers, developed C-IED and border security scenarios within the defined themes and objectives identified for CV15. The Integrated C-IED scenario was demonstrated in two vignettes that incorporated multiple technologies, exposing users to the technologies in an operational context, and providing data collection opportunities that would not be available if technologies were demonstrated separately. The border security scenario was demonstrated in two vignettes, allowing the biometrics team to collect data on identified metrics, while providing users more experience operating the various biometrics systems. The following is a breakdown of each of the scenarios, with related vignettes and associated technologies.

Integrated C-IED Scenario

Insurgents have been using IEDs as weapons against police checkpoints, schools, and roads, for both their tactical and strategic/political value. Intelligence from tactical UAS assets indicates that insurgent groups may have emplaced IEDs along a road near the province police

headquarters. Engineer/Infantry teams equipped with handheld ground IED detectors (C-IED handheld devices), mobile phone jammers, TransApps smart phones, and biometrics handhelds have been dispatched to survey the area and identify buried IEDs so that Explosive Ordnance Disposal (EOD) teams can come disarm them. Tactical UAS imagery have traced the IEDs back to an insurgent safe house. An infantry team equipped with TransApps smart phones is dispatched to raid the safe house, capture insurgents, and conduct tactical site exploitation including biometrics evidence.

Integrated C-IED Scenario

- Patrol Vignette (TransApps, Electric UAS Suite, Biometrics)
- IED Lanes Vignette (C-IED handhelds, TransApps, Electric UAS Suite, Biometrics)

Border Security Scenario

Along the Thai border, Road A is known to be an entry point into Thailand where vehicles smuggle drugs or people for human trafficking. The Thai military has established a checkpoint where guards check identification cards and inspect suspicious vehicles. Identification card fraud is rampant and the guards need better information in order to narrow down the number of suspicious vehicles and increase the likelihood of uncovering smugglers. The biometrics system has been in use for the last year and the Thai police have been enrolling convicted traffickers, wanted criminals, and missing persons into the system for an established database of 50,000 records on the regional server. A sub-database along with watch lists for ALLOW, DENY, VIP, and TRACK have been established and installed on the biometrics handheld systems. The guards are now using the handheld systems to scan all drivers, passengers, and pedestrians crossing the checkpoint.

Border Security Scenario (Biometrics only)

- Throughput Vignette
- Checkpoint Vignette

CV15 Scenario Vignettes

The following sections provide detailed information on the vignettes used to support CV15 scenarios. Two integrated vignettes, the patrol and IED lanes, were used to demonstrate the combined capabilities of CV15 technologies. The biometrics technologies, in addition to participating in the integrated vignettes, conducted mini vignettes using only the biometrics technologies.

Patrol Vignette

The focus of the patrol vignette was to demonstrate the UAS suite, TransApps applications, and biometrics technologies in a tactical C-IED scenario context that would provide the TransApps users exposure to the applications, the biometrics users an opportunity to identify/enroll TransApps users, and the UAS team the opportunity to demonstrate various platform and sensor combinations using TransApps and Biometrics users as ISR targets of interest.

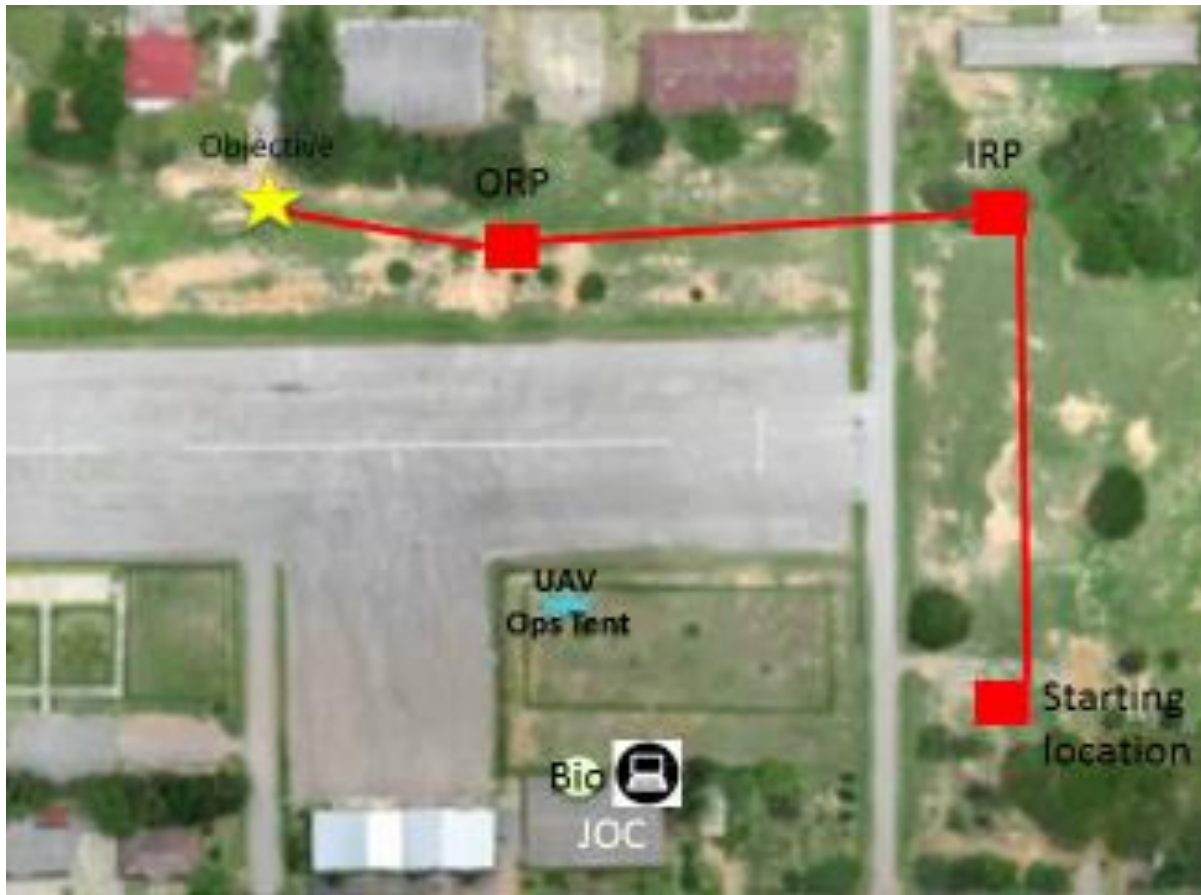


Figure 7: Patrol Vignette Diagram

Mission Planning: The Talon 120 along with the mosaicking sensor and software provided mosaicked imagery Intel of the transit and target areas to the JOC to help support mission planning. A TransApps user positioned at the JOC developed a route plan and marked buildings and landmarks in the area as safe or unsafe using the Spots feature.

Patrol: The TransApps squad used the identified route developed by the JOC to navigate to rally points and the objective, blue force tracking to track team members, and chat for communications throughout the patrol. The UAS provided objective location confirmation and tracking of the TransApps users throughout the vignette.

Tactical Site Exploitation: TransApps users collected imagery using Collect after securing the target location.

Biometrics: The biometrics team identified/enrolled POIs (persons of interest) at the objective location while collecting throughput and accuracy data.

Table 2: Patrol Vignette Checklist

Mission Planning		
TransApp	UAS	X
Scenario Prep: Clear route and spots in TransApp applications. Position van support. TransApp Team Setup: 1 user remains at JOC, one user remains with UAS team Raid team A recon at Objective Rally Point (ORP), Raid team B joins raid after recon (one user is Squad Leader) UAS Prep: UAS surveys raid area with mosaic capability to support mission planning		
Input route planning for Initial Rally Point, Objective Rally Point, and planned Objective Routes and Spots	Coordinate waypoints for raid with TransApp route planning team	
JOC user Chat to UAS user: <i>Deploy UAS x with payload z to track assault team</i>	UAS team receives orders from TransApp UAS user	
UAS user Chat: <i>UAS Launched</i>	UAS launch	
Teams depart JOC for Initial Rally Point (IRP) Squad Leader Chat to JOC: <i>Arrived at IRP position</i>	UAS surveys Objective and identifies new objective	
JOC user identifies new objective based on UAS data. Passes intel using Collect (Screen capture of objective from UAS feed) and Chat: <i>New target identified, access Collect, UAS move to team</i>	UAS surveys Objective and identifies new objective	
<ul style="list-style-type: none"> Raid team A recon at ORP Raid team B tracks team A using Maps blue force tracking 	UAS tracks team movements	
Squad Leader adjusts Route for new objective.	UAS tracks team movements	
Raid team A Chat to team B: <i>Proceed to ORP</i>	UAS tracks TransApp team movements	
Raid Team A and B assault target	UAS tracks Raid teams	
Raid Team A and B detain suspects	UAS tracks Raid team	
Raid Team Chat: <i>objective secure</i>	UAS tracks Raid team	
	UAS return to base (RTB)	
TransApp	Biometrics	X
Raid Team uses Collect to acquire data on IED devices, scene, etc.		
TransApps team gets scanned by biometrics	Biometrics identifies and enrolls detainees (TransApps Team)	

Run 1: Once route planning by the JOC and TransApps users was complete the Talon 120LE UAS was launched to support the patrol vignette with aerial surveillance. TransApps users proceeded through the vignette, utilizing the TransApps features along the way to support vignette requirements. The initial route change introduced, due to the team observing a new target, did not upload to users. SMEs concluded that this was likely due to the new route not being saved by the user. The SMEs also observed that their user group was not composed of the tactical groups they were accustomed to training. This was viewed as a positive new opportunity to train and expose a new type of user, but as a result minor vignette modifications were made to support the demonstration. The UAS and biometrics systems all operated as expected and supported the vignette successfully.

Run 2: For Run 2 a new squad leader was identified for the TransApps team, but the JOC and UAS users remained the same. Due to possible inclement weather the Talon 120LE was landed prior to the run. The Talon 120LE is not waterproof and therefore not able to support ops during rain. As a result the UAS portion of the vignette was simulated. Run 2 was timed, with a start time of 1400 and an end time of 1442. This time included the processing of all suspects with the biometrics equipment at the end of the vignette. All technologies operated as expected during run 2 and successfully completed the vignette.

Run 3: In an effort to eliminate some of the excess time needed to transition from each location a new starting location, IRP, and ORP were identified for the final run of the patrol vignette. Additionally, the VTOL UAS platform with the I2Tech sensor was flown to provide a more detailed view of the biometrics processing portion of the vignette. The TransApps team used a new user in the JOC for mission planning and communications. Run 3 started at 1505 and was concluded at 1541. All technologies operated as expected during Run 2 and successfully completed the vignette.



Figure 8: Run 3 Locations Layout



Figure 9: UAS Launch (Left) and GCS (Right)



Figure 10: TransApp Users Move to Target (Left) and Site Exploration with Collet (Right)



Figure 11: Biometrics Processing at Target Site

IED Lanes Vignette

The focus of the IED Lanes vignette was to demonstrate C-IED handheld technologies, the UAS suite, TransApps applications, and Biometrics technologies in an IED lane clearing context that would pair C-IED handheld users with TransApps users and provide the Biometrics team an opportunity to identify/enroll additional TransApps users. The UAS team demonstrated various platform and sensor combinations in a different operating environment than the Patrol vignette and collected additional data on rapid deployment of the UAS away from their UAS operations tent. The vignette also included POI tracking incorporating both NAVAIR technologies, the Electric UAS Suite and Biometrics.



Figure 12: IED Lanes Vignette User Training and UAS Test Flights

Mission Planning: UASs provided mosaic imagery of the target area for future mission planning.

Checkpoint: The POI was scanned at a checkpoint location using the biometrics technologies. His profile identified him as a POI who should be tracked for the purposes of identifying HVTs (high value targets) in the area. When the POI was released from the checkpoint he was tracked by a UAS.

Suspicious Activity: The POI was tracked by the UAS and observed burying an IED. The POI then exited the area and was tracked to a hideout where known HVTs were meeting.

IED Clearing: Engineering and EOD C-IED handheld users, partnered with TransApp users, were dispatched to the area where the POI planted an IED. Their responsibilities were to locate the possible IEDs, tag the locations in TransApps, and clear the area of threats.

Raid and Biometrics: The hideout identified by the UAS tracking the POI was raided and all HVTs detained and identified/enrolled in the biometrics system.



Figure 13: IED Lanes Vignette Diagram

Table 3: IED Lanes Vignette Checklist

<p>Introduction: A person of interest (POI) has been identified at a checkpoint using biometric data. The suspect was released and is being tracked by a UAS with the goal of catching his rendezvous with high value targets (HTVs). He is observed potentially emplacing an IED in the area.</p> <p>Scenario Prep: Clear spots in TransApp applications.</p> <p>Biometrics Prep: Enroll initial suspect in system</p> <p>TransApp Team Setup: Actor with shovel at IED Lanes. 1 user remains at JOC, 1 user with Biometrics team, 1 user with UAS team, 3 users as engineer team to accompany C-IED HHD users, 3 users and EOD team.</p> <ul style="list-style-type: none"> Use Scenario Lane with 3 types of devices; use Spots to indicate detections by device or type of detection <p>UAS Prep: UAS surveys area with mosaic capability to support mission planning</p>			
UAS Surveillance			
Biometrics	TransApp	UAS	X
Biometrics scans suspect	Biometrics user uses Collect to take photo of POI profile and sends info to JOC and UAS team		
	JOC receives intel from Biometrics user that there is a POI flagged as “track” identified at the checkpoint		
	JOC user to TransApp user Chat: <i>POI profile image in Collect, deploy UAS x to image location to observe POI</i>	UAS deploys and tracks POI	
	POI: possible IED placement in scenario lane UAS TransApp user observes UAS feed, uses Spots to mark location of possible IED and sends Chat to JOC	Observe POI on IED Scenario Lane	

	JOC receives Chat from UAS user and sends a Chat to IED team to <i>deploy to investigate/defuse possible IED</i>	Observe POI on IED Scenario Lane	
POI: leaves area to rendezvous with HVTs at hideout			
IED Clearing and Disarming			
Biometrics	TransApps	UAS	
Raid team watches UAS feed and prepares for raid (HVT hideout/Training tent)	Engineer Team deploys with TransApp to clear lanes	UAS observes POI rendezvous with HVTs	
Raid team raids target and detains HVTs	Engineer team uses Spots to tag and Collect to GPS suspected IED sites	UAS observes, RTB if needed	
Raid team identifies HVTs into biometrics	EOD team deploys to disarm IEDs		
Raid team identifies HVTs into biometrics	EOD team uses Spots and Collect info collected by the Engineer team to help confirm target locations		
	<ul style="list-style-type: none"> • EOD teams to JOC Chat: Mission complete, IEDs disarmed • Biometrics user to JOC Chat: Mission Complete, HVTs captured 		

Practice Run: The initial attempt at the IED lanes vignette consisted of a dry run by the TransApps users to help ensure successful execution of all aspects of the IED lanes vignette. After preliminary classroom review of the IED lanes vignette checklist, the biometrics and TransApps users were asked to go step by step through the vignette checklist with the aid of the TransApps trainers and TEC leads to provide a hands-on review of the checklist process. The practice run was conducted without the aid of the VTOL UAS to help conserve battery life for full runs of the vignettes.



Figure 14: Practice Run Walkthrough with TransApps and Biometrics

Run 1: In preparation for run 1, 1 each of the three C-IED handhelds was identified for use during the vignette, and the JOC user and UAS users remained the same to take advantage of familiarization gained during the practice run. Run 1 started at 1113 at the Biometrics

checkpoint area. Once the POI was processed the vignette proceeded smoothly with the VTOL 30 launching immediately after POI processing. The UAS observed the POI movements while the TransApps users collected and relayed information to and from the JOC. Once the POI reached the HVTs hideout location the UAS returned to base (RTB) and relaunched within seconds to monitor activities in the field. The IED teams, along with their TransApps partners, deployed and relayed information on detections, including specifying carbon rod detections to the JOC. The biometrics raid team moved in on the HVT hideout location and detains the HVTs. Upon completion of the mission at 1205 all HVTs had been processed though the biometrics team and the IED teams had identified and marked all potential IED locations.

Run 2: Run 2 of the IED lanes vignette started at 1437 after a short break due to visitor demonstration at the vignette site. All aspects of the vignette worked as expected. The technology teams were able to make observations on how their technology would operate given the environmental, user, and operational elements of the vignette. The second run concluded at 1525, slightly faster than the first full run of the vignette.

Observation: When users take a photo in Collect, the geotagged photo is only displayed on the users map, not on the maps of the other users within the group.



Figure 15: POI Biometrics Processing (Left) and UAS GCS (Right)



Figure 16: C-IED Handhelds and TransApps Vignette Detections



Figure 17: HVTs Biometrics Processing

Biometrics Vignettes

The biometrics team conducted two vignettes to help collect specific data on the biometrics technologies. The throughput vignette was designed to measure throughput; time to collect, time to match locally, and time to match from regional server. The accuracy vignette was designed to measure correctness; track number of match attempts versus correctness.

Throughput Vignette Characteristics

- Set up checkpoint stations
- Enroll 20 people in Jump Kit
- Load 20-person watch list from Jump Kit onto devices via thumb drive; upload watch list to Regional Server via Wi-Fi
- Throughput/Accuracy Measurements (30 min/run)
 - Run 1: Fingerprint (Avengers and SEEK II) and face (Galaxy Tab)
 - Run 2: Iris scan (All Devices)

- Single queue feeding 4 stations (tables); estimated 30 sec/person
 - Table 1: Avenger1 (fingerprint, iris)
 - Table 2: Avenger2 (fingerprint, iris)
 - Table 3: SEEK II (fingerprint, iris)
 - Table 4: Galaxy Tab (face, iris only)

Checkpoint Vignette Characteristics

- Enroll all CV15 U.S. and Thai personnel
- Position devices at entrances to the JOC
- Each device will have a watchlist
 - If ALLOW, allow access to JOC
 - If VIP, notify OIC
 - If DENY, “deny access” to JOC
 - If UNKNOWN, go to Enrollment Station
- Update local watchlists at end of day
- Monitor biometrics situation on Toughbook



Figure 18: Biometrics Vignettes

Distinguished Visitors Day

DSTD hosted a Distinguished Visitors (DV) Day on August 7, on Fort Thanarat, Thailand. The purpose of the event was to highlight S&T projects and to promote bilateral S&T collaboration between the Thai MOD, and USPACOM. This event played a key role in highlighting the MOD and PACOM collaboration on technology experimentation. The VIP Day consisted of an introductory brief, static displays, and scenario based technical demonstrations of new and emerging technologies that were demonstrated during CV15.

DV Day Visitors

- GEN. Patsorn Itsarangoon Na Ayuthaya, MOD Chief of S&T
- LTG Takerngkarn Sri-Am-Pai, DSTD Director-General
- MG Sirasak Yuttapawet, DSTD Deputy-General
- LtCol Fisher, Deputy USPACOM Deputy Science Advisor
- Mr. Shujie Chang, Director, Technology Experimentation Center (TEC)
- Fort Thanarat Infantry Center SNCO officer candidates
- Thai Military S&T personnel
- U.S. CV15 participants



Figure 19: Thai and US Introductions DV Day



Figure 20: UAS Team Brief on DV Day (Left) UAS Launch Prep DV Day (Right)



Figure 21: UAS DV Day Demonstration



Figure 22: CV15 DV Day TransApps (Left) and UAS (Right) Static Displays



Figure 23: CV15 DV Day Fuel Cell Static Display



Figure 24: CV15 DV Day Biometrics Static Display



Figure 25: DV Day Scenario Field Demonstration

CV15 Seminar

On June 7th a technology seminar was held in the city of Hua Hin, Thailand as the final major event of CV15. Thai and U.S. presenters provided briefs focused on strategy, specific technology needs, R&D, and information sharing. The following is a summary of the presenters and topics that comprised the CV15 seminar:

U.S. Speakers

- *PACOM S&T Strategy*: Lt Col Ken Fisher, Deputy S&T Advisor, USPACOM J85
- *Partnership Efforts in Counter-IED*: SSG Jesse Holewinski, Asia-Pacific Counter-IED Fusion Center (APCFC)
- *Social Media: Overview, Trends, and Opportunities*: Mr. Jawad Rachami, DoD Information Analysis Centers

Thai Speakers – Organization R&D Focus Areas

- Military Research and Development Center (MRDC)
- Royal Thai Army Research and Development Office (ARDO)
- Panel:
 - Defense Science and Technology Department (DSTD)
 - Air Force Research and Development Office

- Royal Thai Naval Research and Development Office (NRDO)

CV15 Execution Feedback and Lessons Learned

As part of the learning process associated with field experimentation, the CV15 execution team collected feedback on what elements should be sustained, and what elements need to be improved. The following is a summary of that feedback.

Lessons Learned: Sustain

- Interpreters + translated material was very effective
 - Having the interpreters was crucial
 - The quality of the interpreters was above and beyond, experienced, knowledgeable
 - Every team that participated in CV15 mentioned the value added by the interpreters. The interpreters provided a level of communication with Thai users that had never been accomplished in previous CV15. The idea to use interpreters was a direct result of implementing a previous lesson learned.



Figure 26: CV15 Thai Interpreters

- Sitreps were very effective for when we need to complete reports at the end of the event
- Site was great, runway, tent, etc.
- Having technology interfaces translated into Thai will increase efficiency of training. Make sure materials are translated, it was very helpful for training.
- At least 1 week for setup
- Morning meeting and After Action Reviews (AAR) conducted on site were good
 - Good to do individually so teams are not waiting on each other to input
 - Good when lead analyst came to visit teams individually
 - Assign times for AAR to technology teams; or flexible

- Impressed with the involvement of the Thai chain of command
- Dedicated van for each team was good for supporting each team schedule
- Thais were very helpful supporting team requirements

Lesson Learned: Improve

- Always bring or acquire additional comms support, i.e. walkie talkies that work. They inevitably are used to support scenarios and vignettes
- Create an Admin Support Kit and/or List that can be acquired if needed at the beginning of the event
- People who are going to participate in the final event need to be present during the planning meetings and visits to have eyes on the physical locations, and to develop a good understanding of the area, logistics, and requirements.
- Lengthen timeline between IPR 1 and shipping
- Make sure users are dedicated to the technology, understand their requirements, and are available for the entire agreed upon execution period
- Duty officer on both sides to oversee the JOC
- Bring support material for software in case of failures
- Functioning and fairly fast admin supplies are crucial. Often new versions of materials must be printed quickly, having a functioning, fast printer is key to more efficient work.
- Don't plan the event during the holidays
- COMRELS would be good
- Make sure the right users are identified for the data collection needs for each technology
- Observers interfering with training
- Make sure that airspace is planned and organized and that each side understands the requirements and have confirmation that those requirements have been met.
- Deconflicting all signals. Have a person assigned as a frequency manager

CV15 Conclusion

The Thai MOD, DSTD, USPACOM J85, with support of the TEC successfully conducted CV15 July 27-August 7 at Fort Thanarat, Khao Noi, Prachuap Khiri Khan, Thailand. CV15 introduced leading edge technologies and proposed CONOP to relevant training audiences while assessing candidate technologies and providing operational feedback. CV15 participants were able to demonstrate and assess technologies in a complex OCONUS environment that encouraged them to consider cultural, logistical, technical, environmental, interoperability, and commercialization factors. These six key factors are crucial to encouraging the development process and for effective transition of technologies to the warfighter in both OCONUS and CONUS environments.

Experimentations, demonstrations, and data collection was conducted on five technology groups including; UAS and sensors, Fuel Cell technology, mobile handheld applications, and C-IED handheld detectors. CV15 technologies were demonstrated and assessed utilizing C-IED and boarder security scenarios designed to mimic the use of these technologies in real world missions.

The experimentation effort was very successful during CV15. Each team gained valuable knowledge about how their technologies and how they aligned with the six key assessment

factors. All teams were impacted by the logistical requirements and nuances of shipping and receiving gear in an OCONUS environment. Teams were able to execute tailored assessment plans in order to gain technical and environmental knowledge about how their system(s) performed in a tropical climate. Integrated scenarios and vignettes allowed technologies, decision makers, and operators to gain an understanding how their technology might interoperate with other technologies. CV15 provided multiple opportunities to identify cultural factors that can be approved upon during future events including; some that might affect future training due to a better understanding of how the host population learns and trains, how to better work with the host nation to manage airspace and visitors, and cultural every day dos and don'ts. Finally, user surveys and round table discussions provided technologist valuable feedback on how their technology might meet commercial requirements by designing to the population and fulfilling user identified capability gaps in an individual or joint/coalition setting.

Each of the five technology groups conducted testing based on their requirements and goals. The UAS team conducted altitude, platform/sensor optimization, and rapid response testing throughout the event. The biometrics team conducted multiple test scenarios including accuracy, throughput, and reachback testing. The TransApps team quickly trained Thai users and also gained valuable user feedback from surveys and discussions. The C-IED team conducted soil and environmental testing, in addition to training users to successfully participate in scenario vignettes, using their own TTPs and CONOPS.

On August 6 the DSTD, USPACOM, and the TEC hosted an S&T DV Day. The S&T Distinguished Visitors Day consisted of CV15 overview briefs and scenario based technical demonstrations of new and emerging technologies that were currently engaged in CV15. Overall, CV15 was a successful event for technology insertion and partner nation S&T collaboration efforts. The data collected from each of the experimentation events will help shape continued technology development for our warfighters and future PACOM S&T engagement effort.

ANNEX A: UAS CV15 FINAL REPORT

Introduction

This report includes the relevant event details, feedback, observations, and recommendations collected during CV15 as part of the UAS demonstration and data collection effort. The TEC, under the direction of the USPACOM J85, conducted a data collection and demonstration effort of the TALON 120 LE, Phoenix 30, Dragon View, i2-ML, and Canon S100 for mosaicking under field experimentation conditions, and as part of the HADR scenario, during the annual Crimson Viper Field Experiment (CV15) in the Kingdom of Thailand from 27 July-7 August 2015. CV15 was conducted at Fort Thanarat, Khao Noi, Prachuap Khiri Khan, Thailand. The first week of operations focused on setup and initial data collection. The following week will consist of daily demonstrations and data collection within the identified scenarios.

UAS Platform Descriptions

The following section provides brief description of each of the participating UAS platforms. Additional details can be found in the technical specification section of this report.



Figure 27: Talon 120LE (Left) and Phoenix 30 (Center and Right)

Talon 120LE is a rugged man-portable Unmanned Aircraft System (UAS) that can be integrated into any situation within minutes. This system was designed for various uses including search and rescue missions, inspection of crops and surveillance of power lines. The modular nose payload section can house a standard EO/IR payload or any experimental payload up to 2.5 lbs. in weight. Equipped with a dual camera, Electro Optical and Thermal Imager Pan and Tilt stabilized gimbal, users can take advantage of both perspectives without the hassle of two separate camera systems.

The **Phoenix 30** is a VTOL Quad Rotor Unmanned Aircraft System (UAS) that is ideal for military, first responders and civil applications. Ready in minutes, this intelligence, surveillance and reconnaissance platform weighs approximately 10 lbs. The Phoenix 30 carries a pan and tilt electro-optical/infrared (EO/IR) network/IP-based camera for easy video viewing from a UASV ground control system (GCS), laptop or tablet.

UAS Sensor Descriptions

The following section provides brief description of each of the participating UAS sensors. Additional details can be found in the technical specification section of this report.



Figure 28: Dragon View (Left) Canon S100 (Center) i2-ML (Right)

Dragon View

The Dragon View Sensor is an electro-optical/ infrared (EO/IR), pan-tilt- zoom, mechanically and digitally stabilized gimbal sensor; providing day and thermal imagery, video recording, object tracking and geolocation data. It is ideal for integration on air vehicles, antenna towers, and other structures. For optimal imagery, the sensor comes equipped with high resolution of 336×256 (4x digital zoom), or 640×512 (8x digital zoom). It also features a Slow Frame Rate of < 9Hz or a Fast Frame Rate of 30Hz. Operating at 10.6 watts, the low power draw enables more efficient use of the battery system for longer duration. Off-the-shelf system comes standard with 25mm lens; options are available for a 13mm lens or a 19mm lens.

i2-ML

The i2-ML is the smallest and lightest of the Ultra-Light Family. Weighing only 2.0 lbs, the i2-ML provides both IR and EO imagery combined with a high performance mechanically stabilized 4-axis gimbal. Some key features include; mechanical stabilization, embedded tracker, embedded fusion, embedded INS, external INS, local area contrast enhancement, and laser pointer.

Canon S100 for Mosaic Imagery

The Canon PowerShot S100 is a high-end 12.1-megapixel compact digital camera announced and released in 2011. It was designed as the successor to the Canon PowerShot S95 in the S series of the Canon PowerShot line of cameras. The S100 is a similar camera to S90 and S95 with several significant improvements. It has improved noise reduction, white balance and shadow correction. This camera is the first camera in the S series line to use the CMOS Sensor which gives the camera a higher performance and better light sensitivity. The S100 is also the first camera in the series to feature 1080p video recording in 24 frames per second. During CV15 the Canon S100 was used in combination with mosaicking software to produce imagery for scenario and vignette support.

Pix4DMapper Pro

Pix4Dmapper software automatically converts images taken by hand, by drone, or by plane, and delivers highly precise, georeferenced maps, mosaics, and 3D models. They're customizable, timely, and compliment a wide range of applications and software.

UAS Technology Specifications

The following section provides more detailed technical specification for each of the C-IEDs technologies. The information provided includes system specifications and benefits.

Table 4: UAS Platforms Technology Specifications

Talon 120LE	Phoenix 30 VTOL Platform
<ul style="list-style-type: none"> • Max Takeoff Weigh: 16 lbs. • Endurance 2.5 Hours on low cost rechargeable batteries, Solar Technology and Fuel Cells being tested • Hand Launch and Belly Recovery (integrated safety chute) Possible Ship Board operation • Communication Range: 3 miles Omni to Omni (can be increased to 15 - 20 miles (amplifiers, directional antennas or military radios) • 900 MHz C2, 2.4 GHz DDL for Video and payload communications (configurable) • Payloads: EO/IR ISR Gimbal, Multispectral, Hi Res. SLR Camera, Coms. Relay • Multiple GCS options: Laptop with Communication Module, or Tactical GCS with integrated monitors & solid state computer • Modes: Fully and Semi-Autonomous modes, full waypoint navigation • Personnel: 1-2 operators • Training: 2 Days • Non-Itar/ Exportable • IP Based Open Architecture Solution • Low-Cost Organic Solution 	<ul style="list-style-type: none"> • Length: 20" Width: 20" • MGTOW: 10 lbs • Range: 2 miles • Payload Capacity: 2 lbs. • Endurance: 25 – 30 minutes • Typical operating altitudes: 50-500 ft AGL; MSL to 10,000 ft • C2 and video communications combined on single encrypted digital data link • Foldable booms for easy transport and storage • Set-up in less than 5 minutes • Ground launch • Low cost solution • Instant actionable intelligence • View video from UAVS GCS, laptop or tablet • Microhard digital data link • Non-Itar/ Exportable

Table 5: UAS Sensor Technology Specifications

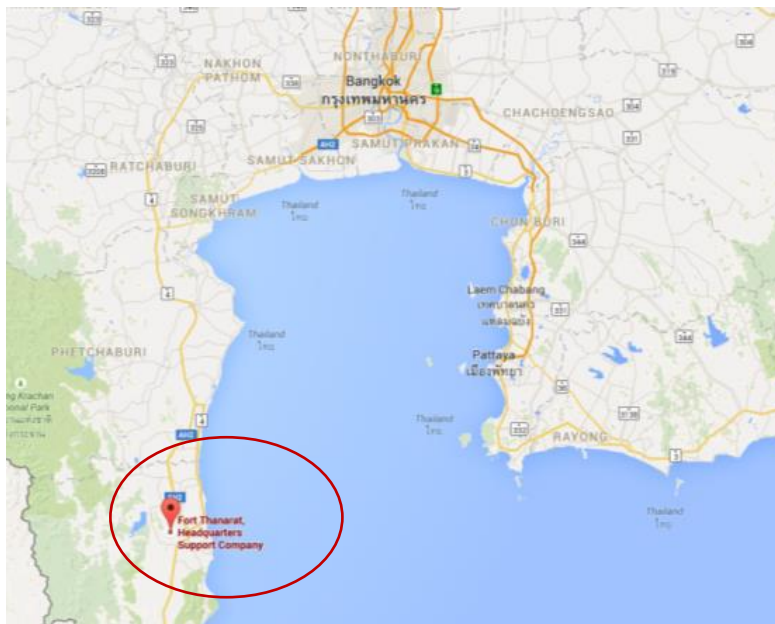
Dragon View
<ul style="list-style-type: none"> • Combined Electro-optic/Infrared; Pan-Tilt-Zoom • Can be Integrated on Air Vehicles, Towers and Other Infrastructure • Mechanically and Digitally Stabilized • Video Processing and Object Tracking • Operating at 24 Watts • Weight: 1.40 lbs.; VIN: 24V • Standard Ethernet Interface • Digitally Compressed Video Output – H.264 • Onboard Video Recording to Micro SD Card • Video Stabilization • In-frame Object Tracking • Integrated Inertial Measurement Unit (IMU) for Rate Feedback • Non-ITAR Controlled • Configurable to Your Application • Default payload for Talon 120LE & Phoenix 60 VTOL
I2-ML

- EO Sensor: 720 x 480 Color CCD Camera, 37.5 to 3.9 Optical 1.9 Digital
- Night Sensor: 640 x 480 LWIR FLIR 12.4 Optical to 6.2 Digital
- Turret Dimensions: 4.1” Diameter x 7” Height (including isolator)
- System Weight: < 3 lbs. with Isolation System
- Input Power: 12 Volts, < 10 Watts
- Video and Comms: NTSC, RS170 or H.264 Ethernet, R5-232 or Ethernet
- Field of Regard: 220 Elevation 350 Continuous Azimuth
- Gyro Stabilization: 4-Axis
- Embedded Tracker: Centroid and Correlation
- Image Processing: Image Fusion, Local Area Contrast Enhancement
- INS Interface: Slew to Cue and Geo-Point Capabilities with North Pointing Arrow
- Environmental: Weatherized housing for harsh environments

Canon S100

- Geo-Referenced orthomosaics
- Point cloud 3-D rendering
- Mechanical stabilized or fixed in nadir position
- Operating at 12 Watts
- Weight: 8 oz.
- Resolution: 2.0 cm/pixel
- Capture rate: 1/sec.
- Typical operating altitude of 200’-400’ AGL
- Interface directly to autopilot for navigation data
- Stand-alone GPS possible
- On-board snapshot recording to SD card
- Non-Itar/ Exportable
- Configurable to Your Application

UAS Operating Location



CV15 field experimentation was conducted at Fort Thanarat, Khao Noi, Prachuap Khiri Khan, Thailand.

Fort Thanarat is based on about 600,000 hectares of land near Pranburi town with the entrance on the western side of Petchakasem Road. The base is home to the Thai Infantry and Armed Forces Preparatory School. Fort Thanarat is home to around 5,000 soldiers and their families.

Figure 29: Fort Thanarat Location

Two primary areas of operations were used during CV15. The UASs, TransApps, Fuel Cell, and Biometrics all operated in the area of the JOC. The UAS runway was located directly outside of the main JOC building. UAS operations were conducted out of a tent located immediately adjacent to the UAS runway.



Figure 30: UAS Operations Tent (Left) and CV15 Major Operations Area (Left)

UAS Demonstration Daily Schedule

The following table is a summary of the daily schedule and evolutions by day followed by the UASs team.

Table 6: Daily CV15 Evolutions

Daily Schedule			
Date	Event(s)	Date	Event(s)
7/28/15	UAS Cargo arrived	8/3/15	Rapid response testing Mosaicking
7/29/15	Unpacked Cargo Ops check and flight testing on the Talon120LE Troubleshoot network issues	8/4/15	Patrol Vignette Visitor Day
7/30/15	Continued troubleshooting network issues Continued flight testing on both platforms Sensor integration	8/5/15	IED Lanes Vignette Visitor Day
7/31/15	Sensor integration Visitor demonstrations Altitude and sensor/platform combination testing Sensor integration	8/6/15	VIP Day
8/2/15	Continued altitude and sensor/platform testing Mosaicking		



Figure 31: UAS Demonstration Team

UAS Demonstration Support

The UAS team optimized their time at CV15 by conducting a number of activities including first time integrations, attitude testing, platform/sensor performance testing, and information exchange with Thai counterparts, and numerous flight demonstrations for civilian and military visitors. The UAS team conducted data collection and testing primarily during the first week of CV15, but continued throughout the second week on a limited basis while supporting the integrated vignettes. Once all cargo was received the team conducted flight operations daily. Flight operations focused on collecting data on ideal operating altitudes for the various platforms and sensor combinations, as well as optimal platform/sensor combinations for various scenarios and vignette support. Two of the sensors tested had never been integrated into the two UAS platforms, but the team was able to rapidly integrate the sensors in the field, with limited resources, on a compressed schedule. Additionally, the team successfully mitigated airspace issues with a local Radio Controlled (RC) hobby group, daily base activities, helicopter fly overs, and even a damaged helicopter that was forced to land on the runway during one of the UAS flight tests.



Figure 32: Local RC Club (Left) and Helicopter Landing (Right)

The UAS team used both the Talon 120 LE and the Phoenix 30 platforms to collect mosaic imagery on the patrol and IED lane vignette locations. The team also seamlessly provided support as outlined in each of the vignette runs during the execution period of CV15. The Talon 120LE was identified as the best platform for the patrol vignette due to its longer flight duration time, ability to provide less noticeable situational awareness at various altitudes, identify persons in detail at 800ft, and a better tracking capability at higher altitudes. Although the UAS team did not have users to train on the systems, they were able to provide numerous demonstrations to visitors, including the Thai UAS teams that were also participating in CV15.



Figure 33: Sensor Integration (Top Left) Talon 120LE Launch (Top Right)



Figure 34: Flight Demo (Bottom Left) IED Lane Vignette Support (Bottom Right)

The UAS team and their technologies were integral to the successful execution of the CV15 field experimentation event. The efforts of the team, and the visual demonstrations they provided, offered a collaboration and experimentation opportunity unique to the CV15 venue and valuable for continued theater engagement.

UAS Data Collection Approach

The following information provides the data collection approach for each of the identified focus areas.

The following focus areas were identified for data collection during CV15:

- **Most Effective Altitude**
- **Best Payload/Platform Combination for Scenario Support**
- **Rapid Response Time**

Most Effective Altitude

Each UAS was outfitted with each of the offered sensors to determine the most effective altitude for that sensor using that particular system.

Data Collection Method: Objective and subjective data was collected to help support recommendations/conclusion regarding the most effective altitude. SMEs utilized supporting base station capabilities and common operating picture to provide objective data points on the clarity, accuracy, and/or other relevant information. SMEs were asked after each altitude test run to provide their findings. The minimum information required for each run during effective altitude testing was the name of person recording data, sensor type, platform, altitude, date, time, SME observations, and justification for recommendations on effectiveness at altitude.

Best Payload/Platform Combination for Scenario Support

Each UAS was outfitted with each of the offered sensors to determine the combination that best supported the Cv15 scenarios.

Data Collection Method: Objective and subjective data was collected to help support recommendations/conclusion regarding the best sensor/platform combination to support the CV15 scenarios. SMEs utilized supporting base station capabilities and common operating picture to provide objective data points on the altitude, clarity, accuracy, and/or other relevant information. SMEs were asked after each test run to provide their findings. The minimum information required for each run during scenario testing was the name of person recording data, sensor type, platform, date, time, SME observations, and justification for recommendations on the sensor/platform combo for scenario support.

Rapid Response Time

The UAS teams were asked to perform timed recovery and relaunch tests to help identify an average recovery/relaunch time under field conditions.

Data Collection Method: Primarily objective data was collected on the recovery and relaunch of systems. Data collectors recorded the amount of time each recovery and relaunch system took, and identify any notable factors as they pertain to each instance. SMEs were asked after each test run to provide their observations. The minimum information required for each run during rapid response testing was the name of person recording data, date, start time, end time, person recovering and relaunching the system, sensor, platform, and what was changed on the system.

UAS Flight Tests Observations and Results

As part of the CV15 field experiment the UAS team conducted altitude, platform sensor combination, and rapid response time testing. In some cases the UAS team was integrating sensor for the first time and under field conditions. This section provides the detailed results of that testing, including data collector and SME observations. Flight tests are listed in the order of occurrence.

Table 7: Flight Test Summary

Test	Test Focus	Date	Time	Platform	Sensor	Altitude
1	Most Effective Altitude	7/30	1150	Talon 120LE	Old Dragon View	1000ft And 1500ft
2	Ops Check	7/30	1300-1430	Talon 120LE	New Dragon View	600-3000ft
3	Sensor/ Platform Performance	7/30	1445-1500	VTOL 30	i2-ML	80ft
4	Sensor Range and Sensor/ Platform Performance	7/31	0945-1045	Talon 120LE	New, Updated, Dragon View	600-800ft
5	Most Effective Altitude	7/31	1100-1220	Talon 120LE	New, Updated, Dragon View	2000ft
6	Most Effective Altitude	7/31	1100-1220	Talon 120LE	New, Updated, Dragon View	1500ft
6	Most Effective Altitude	7/31	1100-1220	Talon 120LE	New, Updated, Dragon View	1200ft
6	Most Effective Altitude	7/31	1100-1220	Talon 120LE	New, Updated, Dragon View	1000ft
6	Most Effective Altitude	7/31	1100-1220	Talon 120LE	New, Updated, Dragon View	800ft
6	Most Effective Altitude	7/31	1100-1220	Talon 120LE	New, Updated, Dragon View	600ft
6	Most Effective Altitude	7/31	1100-1220	Talon 120LE	New, Updated, Dragon View	400ft
7	Sensor Integration and Performance	7/31	1637-1655	Talon 120 LE	Canon S100	260ft
8	Sensor/ Platform Performance	7/31	1820-1827	VTOL 30	UAS Vision CM100	200ft
9	Sensor/ Platform Performance	8/2	0900-0925	Talon 120LE	Canon S100	200ft
10	Sensor/ Platform Performance	8/2	1002-1014	VTOL 30	UAS Vision #1	700ft
11	Sensor/ Platform Performance	8/2	1040-1049	VTOL 30	UAS Vision #1	600ft
12	Sensor/ Platform Performance	8/2	1050-1057	VTOL 30	UAS Vision #1	Not recorded
13	Sensor/ Platform Performance	8/2	1104-1114	VTOL 30	UAS Vision#1	600ft
14	Sensor/ Platform Performance	8/2	1200-1215	VTOL 30	i2-ML	300ft
14	Sensor/ Platform Performance	8/2	1200-1215	VTOL 30	i2-ML	200ft
14	Sensor/ Platform Performance	8/2	1200-1215	VTOL 30	i2-ML	100ft
14	Sensor/ Platform	8/2	1200-	VTOL 30	i2-ML	50ft

	Performance		1215			
15	Sensor/ Platform Performance	8/2	1233-1239	VTOL 30	UAS Vision #2	300ft
16	Sensor/ Platform Performance	8/2	1313-?	VTOL 30	UAS Vision #2	300ft
17	Sensor/ Platform Performance	8/2	1401-1414	VTOL 30	Dragon View	300ft
17	Sensor/ Platform Performance	8/2	1401-1414	VTOL 30	Dragon View	200ft
17	Sensor/ Platform Performance	8/2	1401-1414	VTOL 30	Dragon View	100ft
17	Sensor/ Platform Performance	8/2	1401-1414	VTOL 30	Dragon View	50ft
18	Sensor/ Platform Performance and Optimization	8/2	1525-1531	VTOL 30	Canon S100	40m
19	Sensor/ Platform Performance and Optimization	8/2	1541-1545	VTOL 30	Canon S100	40m
20	Sensor/ Platform Performance and Optimization	8/2	1546-1548	VTOL 30	Canon S100	40m
21	Sensor/ Platform Performance and Optimization	8/2	1550-1600	VTOL 30	Canon S100	40m
22	Altitude Test for Scenario	8/3	0835-0945	Talon 120LE	Dragon View	600-2000ft
23	Rapid Response	8/3	1138-1145	Talon 120LE	Dragon View	N/A
24	Rapid Response	8/3	1157-1207	Talon 120LE	Dragon View	N/A
25	Rapid Response	8/3	1351-1357	VTOL 30	Canon S100	N/A
26	Rapid Response	8/3	1409-1418	Talon 120LE	Canon S100	N/A

Test Focus: Most Effective Altitude

Date: 7/30/15		Time: 1150	
UAS Platform: Talon 120LE Fixed Wing	Sensor Type: Dragon View	Altitude: 1000ft and 1500ft	

Altitude Observations: The UAS team concluded that 1000ft was a good altitude for using this platform and sensor combination. The pilot flew the platform from the UAS launch site to the C-IED training area and observed targets in the area. The UAS SMEs concluded that 1000ft was a safe attitude, free from obstructions, and provided enough time to land the system. The system climbed to 1500ft where it was observed that the image quality was very similar to at 1000ft, making this altitude a good working altitude as well. Towards the end of the test inclement weather threatened the system so the Talon 120 LE was safely landed back at the airfield.

Communications Observations: Intermittent drops in the 2.4 link were observed once the platform reached the C-IED area.

Sensor Observations: UAS SMEs realized that the Dragon View sensor that was being used was actually an older model and expressed a desire to try out the updated model that should have more gains and more stable picture.

Test Focus: Operations check resulting from the 2.4 link drop in first test

Date: 7/30/15		Time: 1300-1430
UAS Platform: Talon 120LE Fixed Wing	Sensor Type: New Dragon View	Altitude: 600-3000ft

Communications Observations: The system experienced repeated drops in the link. This made the video basically unusable. The team tried three different frequencies, noting that the link seemed to be better at high altitudes, but still not good. Drops occurred as close as the end of the runway and half of a circular pattern loiter dropped. The team continued to troubleshoot the link issue.

Sensor Observations: The team observed that the Dragon View sensor was making tracking targets difficult. When the operator zoomed in on a target the sensor would not hold the track and the gimbal would drift.



Figure 35: Talon 120LE Assembly and Preflight checks (Left and Center) and Talon 120LE Hand Launch (Right)

Test Focus: Sensor/Platform Performance

Date: 7/30/15		Time: 1445-1500
UAS Platform: VTOL 30 Quadcopter	Sensor Type: i2-ML	Altitude: 80ft

Altitude Observations: This platform/sensor combination was flown at only 80ft because the SMEs noted that the i2-ML would be the heaviest payload ever flown on the VTOL 30. The flight time was reduced due to the weight of the sensor.

Sensor Observations: The control on the gimbal felt much easier than on the Dragon View. The picture quality was good and only limited by the link. Ground clearance for this sensor on the fixed wing might be an issue with this combination because the i2-ML hangs a bit low. Other than the flight time constraints this platform sensor combination would be a good option. Additionally, the Dragon View would not be a good option for the scenarios given the better quality and control they observed with the i2-ML.

Test Focus: Sensor Range and Sensor/Platform Performance		
Date: 7/31/15		Time: 0945-1045
UAS Platform: Talon 120LE Fixed Wing	Sensor Type: New, Updated, Dragon View	Altitude: 600-800ft

Test Characteristics: To help identify the issue with the 2.4 link the team decided to test the link while the local Wi-Fi, setup to support other technologies, was down. Before the test the UAS team updated the pan and tilt speed ration in hopes of improving the control of the Dragon View.

Communications Observations (no Wi-Fi): There was a noticeable improvement with connectivity with the Wi-Fi down. The sensor image remained stable.

Sensor Observations: The users were able to identify buildings, roads, and dogs over the C-IED training area. At 2 nautical miles out the image was a bit unstable, but good at 800ft. The SMEs observed that with the updates to the sensor the camera is now usable. A safe altitude for viewing people and vehicles with this sensor is about 600-800ft. Targeting is a bit difficult but it can track. The sensor is easier to control with the mouse than with the Logitech controller.

Communications Observations (with Wi-Fi): The UAS team immediately noticed a negative impact on the link. The Wi-Fi was identified as the cause of the issues with the previous day's testing. As a result of this test, the Wi-Fi was switched to channel 1, as to not interfere with UAS operations.

Test Focus: Most Effective Altitude		
Date: 7/31/15		Time: 1100-1220
UAS Platform: Talon 120LE Fixed Wing	Sensor Type: New, Updated, Dragon View	Altitude: 400-2000ft

Test Characteristics: Thai soldiers were asked to walk along the runway on the airfield to provide the UAS team targets to provide feedback on image quality and sensor performance.

2000ft Observations: The winds picked up a bit since the morning so the camera was shaky at full zoom. User identified the number of people, including arms and legs, but not if they are carrying anything when the camera is fully zoomed. Nothing when zoomed out. *IR: User identified the targets maybe but could not distinguish if they were people.*

1500ft Observations: When zoomed in you might be able to make out a large weapon, and could see that a target is kneeling. The user was also able to make out general details about vehicles. Nothing when zoomed out. *IR: zoomed out, not able to distinguish people, and could see vehicle but not describe it. Zoomed in user couldn't distinguish if the targets are not moving and not if it is a person or animal.*

1200ft Observations: Started to see targets at 1/2 zoom. At full zoom the user was able to make out crouching and a motorcycle. The image was still jumpy due to wind conditions. *IR: It was still difficult to distinguish targets without movement. With movement it was still difficult to distinguish a person from an animal.*

1000ft Observations: Zoomed out the user was still not able to get a clear image. At 1/2 zoom you started to see targets, and at full zoom you could distinguish clothing color. The sensor seemed to lose tracking often when at full zoom and the user was required to zoom out completely in order to reestablish a track. *IR: Zoomed out you could see moving pixels but still not able to discern targets from animals. The tracking was still difficult when zoomed in and targets just appeared as pixelated bushes.*

800ft Observations: Zoomed out it was easier to see targets but still couldn't tell that they were human. Zoomed in you could see that they were jogging. At this point the system lost tracking and both screens in the GCS. The system was restarted and the image returned. Once the image returned the user was able to spot the targets from fully zoomed out and once zoomed could distinguish larger firearms, and provide details on vehicle type and color.

Sensor Observations: The sensor when switched from EO to IR does not return the user to the target when calibrating. SMEs suggested that a calibration button be added that calibrates and returns to the target to at least close to the target. The SMEs concluded that tracking at full zoom would likely not improve with altitude.

600ft Observations: Zoomed out you could distinguish a person better, but difficult. Zoomed in the user was able to make out more details on the targets clothing, including stripes. User could distinguish head, arms, legs, but not shoes. *IR: When zoomed out the user was able to see movement but not distinguish a person. When zoomed in the image was pixelated, at just the right angle you have been able to tell it was a person.*

Sensor Observations: The tracking continued to drop making it more difficult for the users to make out details.

400ft Observations: When zoomed out it was easier to distinguish a person because the pixels appeared to be vertical. When zoomed in the picture quality was much better. The user was able to make out hands are and describe clothing. *IR: When zoomed out the user was able to tell the target was a person, and when zoomed in the target appeared as a torso with legs, possibly with a blanket over their head.*

Sensor Observations: Unfortunately at full zoom the users kept losing tracking so they determined that keeping it at 1/2 or 3/4 zoom was the only way for the sensor to be useful.

Test Focus: Sensor Integration and Performance		
Date: 7/31/15		Time: 1637-1655
UAS Platform: Talon 120 LE Fixed Wing	Sensor Type: Canon S100	Altitude: 260ft

Test Characteristics: A short duration flight with a small area mosaicked to test the integration of the S100 sensor.

Integration Observations: With the initial mount the camera was not functioning so the UAS team altered the mount by adding a servo that manually pushed the button to capture photos.

Platform Observations: The servo in one of the tail pieces was not operating properly so the part was cannibalized from another tail that was damaged in shipping.

Sensor Performance Observations: The sensor seemed to function as expected. Imagery was processed through the mosaicking software.



Figure 36: Talon 120LE Altitude Testing (Left) and Sensor Integration (Center and Right)

Test Focus: Sensor/Platform Performance		
Date: 7/31/15		Time: 1820-1827
UAS Platform: VTOL 30 Quadcopter	Sensor Type: UAS Vision CM100	Altitude: 200-300ft

200ft Observations: When zoomed out the user was able to make out arms, legs, head, and torso.

300ft Observations: Camera dropped, software failure

Sensor Observations: This setup could benefit from a soft mount.

Test Focus: Sensor/Platform Performance		
Date: 8/2/15		Time: 0900-0925
UAS Platform: Talon 120LE Fixed Wing	Sensor Type: Canon S100	Altitude: 200ft

Sensor/Platform Observations: This is the lowest comfortable altitude that can be flown with this combination. The platform flew as expected, and the integration of the sensor was successful. However, the test resulted in too many images. The software was unable to process.

SME Observations: This platform can easily carry a DSLR or other camera to collect better imagery.

Test Focus: Sensor/Platform Performance		
Date: 8/2/15		Time: 1002-1014
UAS Platform: VTOL 30 Quadcopter	Sensor Type: UAS Vision	Altitude: 700ft

Sensor/Platform Observations: When zoomed out the image would not focus. There appeared to be issues with the auto and the manual focus when zoomed. The UAS team decided to end the test to troubleshoot the issue on the ground.

Test Focus: Sensor/Platform Performance		
Date: 8/2/15		Time: 1040-1049
UAS Platform: VTOL 30 Quadcopter	Sensor Type: UAS Vision	Altitude: 600ft

Test Characteristics: After the previous test the gimbal was reinitialized, Network and IP settings checked, and focused tested on the ground. Everything appeared to be working correctly after the initialization. The UAS team decided to change the altitude to 600ft because they felt that 700ft was too high given the battery life of the platform.

Sensor/Platform Observations: Once the platform reached altitude it appeared that there might be a frequency issue. The users had no control of the sensor after launch. There was a local RC club flying in the area so it is possible the interference was a result of their operations. The team restarted the GUI, pulled the joystick, replaced the joystick, and decreased the altitude but nothing correct the issue.

Test Focus: Sensor/Platform Performance		
Date: 8/2/15		Time: 1050-1057
UAS Platform: VTOL 30 Quadcopter	Sensor Type: UAS Vision	Altitude: Not recorded

Test Characteristics: The power was cycled on the VTOL 30 and the sensor was reinitialized on the ground.

Sensor/Platform Observations: The sensor worked on the ground and in the air. The UAS SMEs concluded the issues are likely a problem with the software.

Additional SME Observations: With this platform it is best to position the vehicle in such a way to make a 45 degree angle with the target. Cameras don't like to look straight down. Also, every time the power is cycled you must reset and enable the network and IP address of the host. This is not desirable and hopefully can be updated in the future.

Test Focus: Sensor/Platform Performance		
Date: 8/2/15		Time: 1104-1114
UAS Platform: VTOL 30 Quadcopter	Sensor Type: UAS Vision	Altitude: 600ft

Sensor/Platform Observations: There was a lag in the signal and the sensor kept losing focus. The team concluded that there was likely a problem with the sensor so they ended the test and decided to switch to a different sensor until the issues with the UAS Vision can be resolved.

Test Focus: Sensor/Platform Performance		
Date: 8/2/15		Time: 1200-1215
UAS Platform: VTOL 30 Quadcopter	Sensor Type: i2-ML	Altitude: 50-300ft

Test Characteristics: The UAS team used the people working in the UAS area as the targets for measuring image quality. In each instance, to maintain an azimuth of 25 degrees, an altitude and distance from GCS is provided. The maximum altitude was limited to 300ft due to the wind and weight of the sensor payload.

300ft Altitude/820ft Distance to GCS: When zoomed out the image was pixelated. When zoomed in it was easy to see people, colors of clothing, hand movements. *IR: When zoomed out there was a vibrant change. It was easy to see targets zoomed in or zoomed out.*

200ft Altitude/600ft from GCS: People were still difficult to make out, but zoomed in you could make a detailed ID, distinction from others, and even imagery on clothing. *IR: The IR imagery was excellent.*

100ft Altitude/400ft from GCS: When zoomed out the user is almost able to confidently identify the target as a person. At half zoom it is easy to identify people, and at full zoom you can see many small details, including sunglasses. *IR: The IR quality is really nice and matches the EO field of view.*

50ft Altitude/250ft from GCS: When zoomed out the user is able to identify people.

SME Observations: The stabilization of this sensor was awesome. Also, the controls were preferable to other sensors. The SMEs determined that pixilation was caused by the link, not the sensor. Finally, the users noted that the screen for the software does not maximize and should have that option.

Test Focus: Sensor/Platform Performance		
Date: 8/2/15		Time: 1233-1239
UAS Platform: VTOL 30 Quadcopter	Sensor Type: UAS Vision	Altitude: 300ft

Test Characteristics: Installed a new UAS Vision sensor

Sensor/Platform Observations: When zoomed out the image is blurry, but the bit rate is better (software). The sensor went into RTL mode, user repositioned and it went into RTL mode again. When zoomed in the users could see a black dot but that was all. The sensor went into RTL mode one last time and the users scraped the test.

Test Focus: Sensor/Platform Performance		
Date: 8/2/15		Time: 1313-?
UAS Platform: VTOL 30 Quadcopter	Sensor Type: UAS Vision	Altitude: 300ft

Sensor/Platform Observations: The IR did not work and the gimbal went into auto-pan so the UAS team stopped this test because the sensor is still not working correctly.

Test Focus: Sensor/Platform Performance		
Date: 8/2/15		Time: 1401-1414
UAS Platform: VTOL 30 Quad Copter	Sensor Type: Dragon View	Altitude: 50-300ft

300ft Observations: When zoomed out the users were able to identify that something was there but not in great detail. When zoomed in they were able to identify a head, torso, light versus dark clothing. The camera lost track. *IR: When zoomed out it is was decent and could tell it was a person. When zoomed in it was pixilated, but you could still tell it was a person with a torso.*

200ft Observations: When zoomed out the quality was similar to at 300ft. When zoomed in it was much better and the user could distinguish feet from legs. Tracking was lost again. *IR: The picture was good and when zoomed out you could distinguish people and differentiate legs from a torso. When zoomed in the quality was about the same.*

100ft Observations: When zoomed out the user could distinguish that the targets clothing was different colors. They could distinguish legs but not a head. When zoomed in the user could see that the target was holding something, give a general idea of haircut, and designs on clothing.

IR: The user was able to make out arms, legs, torso when zoomed out. When zoomed in the user could see more details including arm movements. The tracking is still an issue.

50ft Observations: When zoomed out there was a clearer image of the targets anatomy. When zoomed in the user could recognize face, see logos, and can see that the target's soda was ¼ full.

IR: Targets are easy to make out.

Test Focus: Sensor/Platform Performance and Optimization		
Date: 8/2/15		Time: 1525-1600
UAS Platform: VTOL 30 Quadcopter	Sensor Type: Canon S100	Altitude: 40 meters

Run 1 Observations: The mission was fully autonomous once the capture pattern was programmed into the GCS, including takeoff and landing. The platform and sensor functioned as expected, with 70 images captured for processing. (1525-1531)

Run 2 Observations: The UAS team slowed the VTOL 30 down from 25 mph to 12-15 mph during this mission. This mission was also fully autonomous. SMEs concluded that this speed was likely better for this type of mission, however the settings for the autonomous mission did not stick so the team landed and relaunched. (1541-1545)

Run 3 Observations: There was a problem with the system accepting the new speed. It was hypothesized that it was a software issue caused by the waypoints already being loaded and then the speed changed. (1546-1548)

Run 4 Observations: The team changed the speed and then loaded the waypoint plan to test their hypothesis and it was determined that they were correct. The mission was completed successfully. (1550-1600)



Figure 37: Talon 120 Mosaic Recovery (Left) i2-ML Integration (Center and Right)

Test Focus: Altitude Test for Scenario		
Date: 8/3/15		Time: 0835-0945
UAS Platform: Talon 120LE Fixed Wing	Sensor Type: Dragon View	Altitude: 600-2000ft

Test Characteristics: The antenna was changed to an Omni antenna.

SME Observations: The UAS team identified 800-1200ft, with an 800ft loiter altitude, as a good fit for the patrol vignette. The imagery was much improved. The Talon 120LE was identified as the best platform for the patrol vignette due to its longer flight duration time, ability to provide less noticeable situational awareness at various altitudes, identify persons in detail at 800ft, and a better tracking capability at higher altitudes.

Test Focus: Rapid Response		
Date: 8/3/15		Time: 1138-1145
UAS Platform: Talon 120LE Fixed Wing	Sensor Type: Dragon View	Altitude: NA

Test Characteristics: The setup for the raid response testing for the fixed wing included having the platform preassembled. The SMEs advised that once this system was at a location it would be immediately assembled and remain that way for the duration. However, the SMEs were not told what sensor would be mounted on the platform for each test. This test was conducted with 2 people who were required to mount the sensor, install a charged battery, setup the GCS from stowed, and successfully launch the UAS.

- 1138 = Start Time
- 1140 = GCS setup complete
- 1144 = Mission plan completed and Sensor Installed
- 1145 = Platform successfully launched

Test Focus: Rapid Response		
Date: 8/3/15		Time: 1157-1207
UAS Platform: VTOL 30 Quadcopter	Sensor Type: Dragon View	Altitude: NA

Test Characteristics: The setup for the raid response testing for the VTOL 30 included having the platform stowed. The SMEs were not told what sensor would be mounted on the platform for each test. The test were conducted with 2 people who were required to mount the sensor, install a charged battery, and successfully launch the UAS. After the first successful setup of the GCS a two minute, 1 man delay, was added to simulate the setup of the GCS.

- 1157 = Start time
- 1200 = Sensor installed
- 1201 = Platform successfully launched

Test Focus: Rapid Response		
Date: 8/3/15		Time: 1351-1357
UAS Platform: VTOL 30 Quadcopter	Sensor Type: Canon S100	Altitude: NA

Test Characteristics: The setup for the raid response testing for the VTOL 30 included having the platform stowed. The SMEs were not told what sensor would be mounted on the platform for each test. The test were conducted with 2 people who were required to mount the sensor, install a charged battery, and successfully launch the UAS. After the first successful setup of the GCS a two minute, 1 man delay, was added to simulate the setup of the GCS.

- 1351 = Start time
- 1355 = Sensor installed
- 1357 = Platform successfully launched, including 1 minute to build a flight plan for the mosaic of the patrol vignette area (it would likely take 2-3 minutes for a more detailed plan)

Test Focus: Rapid Response		
Date: 8/3/15		Time: 1409-1418
UAS Platform: Talon 120LE Fixed Wing	Sensor Type: Canon S100	Altitude: NA

Test Characteristics: The setup for the raid response testing for the fixed wing included having the platform preassembled. The SMEs advised that once this system was at a location it would be immediately assembled and remain that way for the duration. However, the SMEs were not told what sensor would be mounted on the platform for each test. The SMEs were not told what sensor would be mounted on the platform for each test. The test were conducted with 2 people who were required to mount the sensor, install a charged battery, and successfully launch the UAS. After the first successful setup of the GCS a two minute, 1 man delay, was added to simulate the setup of the GCS.

- 1409 = Start Time
- 1418 = Platform successfully launched, including time to change the GCS controls to support the fixed wing platform instead of the quadcopter.

***Raid response testing was not conducted using the i2-ML because the sensor was integrated in the field. A test of rapid response given the R&D level of the integration would not represent a real world use of the sensor.**



Figure 38: UAS Rapid Response Testing

UAS SME Survey Feedback

As part of the CV15 UAS data collection effort the UAS SMEs were asked to complete a survey to collect their feedback on the platforms and sensors used during the event. The following section provides that feedback.

Question 1: What are your overall thoughts on the Talon 120LE platform?

Respondent 1:

Despite its awkward appearance and complete lack of aerodynamic aesthetics, the Talon 120LE actually flies quite well, and seems adequately suited to the mission for which it's designed, with a few exceptions. These exceptions are:

- a. The microhard radio range is very limited. I can maybe get 1.5 miles out of it reliably. This is the biggest mission-limiting factor, but may be overcome with better antennas, an amplifier, and an antenna tracker.
- b. The servos have not been reliable thus far. I have seen two aileron servos burn out in Yuma, and have seen two elevator servos burn out here in Thailand. Fortunately all servo failures have happened on the ground.
- c. Quality Control. These airplanes need to be thoroughly tested before being shipped out of the factory. We've seen parts not work right out of the box. We've literally had to steal parts from all three airplanes in Thailand to make one airplane flyable. This seems unacceptable.
- d. Elevator servo mount has a tendency to crack right where the servo mounting screws attach. This part is critical and needs to be beefed up.
- e. The aircraft needs legitimate flight control surface hinges. Out of the box, hinges have either been overly stiff, to the point of an aileron not even being able to deflect downward (possibly the cause of servo failures), to the hinge being so loose, that it was literally delaminating and detaching from the surface it was mounted to.
- f. Control. I would like to have the option to have a Radio Controlled transmitter to have the ability to safely take manual control in the event that I need to operate from a smaller runway, or have the need to get on the ground quickly in the event of bad weather, or if I need to avoid something in flight or on the runway. Fly-by-wire mode is only adequate as long as nothing goes wrong.

Respondent 2:

- Very good, reliable platform.
- Easy to work on and assemble
- Out of the box to flight ready in less than 10 mins. (7 mins was the recorded time by Anna, I believe)

Feedback

- 2.4 GHz MicroHard Radio is not the best option being that 2.4 GHz is used by multiple over the counter systems.
- 2.4 GHz range limits ops to 1 mile out at most.
- Several servos burned out and it appears they might be too small for what they are being used.
- Multiple items (wing, horizontal, etc.) showed up damaged or warped possibly due to shipping.
- Hinge line tape not holding properly on the surface.

Recommendation

- Move away from 2.4 GHz if possible.
- Better antenna with a tracker system will help get a longer range.
- Use bigger servos on the surfaces.
- Make servos on wings interchangeable instead of having to swap the whole wing panel.
- Find a better way to cover the hinge line or better mold for the surfaces.
- Find a better, more secured way of packing components. Cardboard box is not preventing any damage being made to the components during shipping (wooden crates, pelican cases)
- Pitot/static tube needs to be mounted more securely. The way it's mounted is not appropriate as it can be pushed in very easily and damage the line inside.
- Do away from the PlayStation controller and add a real RC controller for better resolution and control in case of emergency.

Respondent 3:

Solid platform; endurance and altitude ranges exceeded expectations.

Question2: What are your overall thoughts on the VTOL 30 platform?

Respondent 1:

I've been quite impressed with the Phoenix 30. It's portable, reliable, rugged, and easy to operate. Its biggest limitation is flight time, which is the biggest limitation for nearly all multi-rotors, so no surprise there. The internals of the Phoenix are well thought out and the wiring is very neatly and cleanly routed. It does have the same microhard radio with the same limitations as mentioned above for the Talon 120LE, but overall, I'm very impressed with the Phoenix 30. Also, the quality control for this platform seems better. We haven't really had any issues, except for a magnetometer that had to be replaced.

Respondent 2:

Phoenix 30 was a good platform no issues other than the 2.4GHz issues noted on the Talon.

Respondent 3:

Versatile able to give soldiers SA with different type of camera perspectives

Question 3: What are your overall thoughts on the Dragon View sensor?

Respondent 1:

The Good:

- I really like the ability to click on an object on the screen and have the camera track it. I haven't seen this function before and it is genuinely useful.
- When zoomed out or partially zoomed in, the camera will usually reliably track a stationary target indefinitely while the air vehicle orbits around the target.
- The GUI is very user friendly.
- The EO optics are comparable to some of the more expensive turrets in the same size range.

The Bad:

- The stability of the camera still needs work. When flying in rough air and zoomed in all the way, the camera often loses track, and drifts to the point of being unusable. I believe this is a software issue and can be resolved (it is improved from earlier versions), but it's not there yet.
- Control. I would like to see the camera have its own controller, separate from the air vehicle flight controller, and I would like the controller to be able to make fine proportional inputs to the camera. If the stability and controllability issues are resolved, this camera has a lot of potential.

Respondent 2:

- Very good gimbal with good optics.
- Very easy to integrate to the platforms.

Feedback

- Controller resolution not ideal for the control of a gimbal.
- Gimbal would not stabilize and have a good, clear image.
- Hard to keep track of objects when zoomed in.
- Hard to make out objects when zoomed out.
- Point and click to track objects helps a lot with the control.
- Good IR camera.
- Overall good camera if the software/firmware issues are fixed.

Recommendation

- Find a controller with better resolution to make fine adjustments and tracking easier.
- Fix software/firmware issues that the gimbal may have with the stabilization board.

Respondent 3:

Up to 2,100 feet imagery on EO and IR. Clearly able to ID buildings, cars and targets in general. Out of all cameras, the crispest imagery on both IR and daylight side.

Question 4: What are your overall thoughts on the I2Tech sensor?

Respondent 1:

This sensor is in a class of its own. I have operated probably every sensor that I2tech currently makes, and this sensor operates with the same precision and stability that its larger versions have. It seems to be competitively priced with the other two sensors

Respondent 2:

- Very good gimbal with good optics.

Feedback

- A little harder to control on the quadcopter.
- GUI did not have a feature to record video.
- Really good IR video quality.
- Work on proper bit rate for the downlink radio that it is being used with.
- EO image could be pixelated at times, most likely because of the bitrate and radio issues we were having.
- Getting used to the controller menu was a bit complicated, being that you have to hold one button for several seconds than another to have it track, stabilize, etc.

Recommendation

- Work on stabilization with quadcopter. Quad has a lot more abrupt yaw movements than a fixed wing and it made it a little more difficult to operate the gimbal. Especially when trying to keep track.
- Create a better GUI to operate the gimbal with function to record video and maybe if possible some camera functions. (ex. Gyro stabilization, EO haze, track, etc.)
- Point and click on screen to track would be helpful.

Respondent 3:

Good control and a lot of functionality and features.

Question 5: What are your overall thoughts on the Canon S100 sensor?

Respondent 1:

The Cannon S100 is a very low cost mapping sensor. It adequately performs the mission, but I feel like it could be replaced by a much better mapping sensor for a moderate price increase.

Respondent 3:

Fantastic camera for mosaicking and mapping missions. Was able to provide a map of complete aerial coverage of operational area.

Question 6: Please provide a summary of how you think these platforms and sensors can help support various missions. Include any platform/sensor combinations that you think would be beneficial, and identify types of mission that could be supported with these technologies.

Respondent 1:

I feel like the Talon 120LE would be a nice match for the I2tech sensor. This combination would provide a low-cost and very effective picture for close air support. The Phoenix 30 cannot carry the I2tech sensor long enough to be very effective due to the additional weight of the sensor. I feel like the dragon view sensor would be best suited for the Phoenix 30 for close range support. Both the Phoenix 30 and the Talon 120LE are able to carry the mapping sensor effectively. The Talon 120LE would be the aircraft of choice to map a large area, while the Phoenix 30 would be the aircraft of choice to map a smaller area at lower altitude, therefor providing a more detailed map.

Respondent 3:

Intelligence, surveillance and reconnaissance, force protection, border security, public safety and search and rescue.

UAS Conclusion

The overall objective to demonstrate the Talon 120LE, Pheonix 30, Dragon View sensor, i2Tech Sensor, and Cannon S100 sensor for mosaicking in an expeditionary environment, within a plausible scenario, was a success. The team gained valuable exposure to the demonstration environment and as a result were able to gain insight into their technologies from a cultural, logistical, commercial, technical, interoperability, and environmental perspective. The following provides a brief description of how each of these factors related to UAS operations in CV15.

Environmental Factors: The tropical nature of Thailand provided a new environment in which to operate the TALON 120LE, VTOL 30, Dragon View, i2-Tech, and S100. The humidity, wind conditions, and precipitation were all a factor during testing and operations. The UAS team was provided an air conditioned tent for operations on the airfield, however, without these conditions the temperature would have very likely had a negative impact on the flight operations and testing.

Logistical Factors: Logistics was an important factor for successful execution of CV15. Shipment of gear is a detailed process, and the UAS team learned valuable information on how to successfully navigate that process. Due to the ever changing nature of shipping requirements into foreign countries the team's gear was delayed by one day. All gear arrived, but one TALON 120LE platform was damaged in shipping and rendered unable to fly. The team quickly learned that replacement parts were not easy to come by, and with field integration requirements to integrate two sensors that had never been integrated on the participating platforms only served to highlight the importance of considering all possible materials required to support and maintain operations before shipping gear.

Commercialization Factors: Through multiple demonstrations and discussions with Thai counterparts the UAS team was able to gain valuable feedback on how their systems might be

employed in Thailand. They were provided ideas for what sensors might meet capability gaps. These commercialization aspects of operating in Thailand, along with new knowledge on spectrum use and power options, were unforeseen benefits of the information sharing that resulted from CV15.

Cultural Factors: The UAS identified multiple cultural factors as a result of their demonstrations and testing in Thailand. The biggest of these factors was how airspace clearance and requirements are managed and enforced. On multiple occasions base personnel used the active runway during flight operations, a local RC club visited to fly their UASs, and aircraft flew over the area at low altitude. As a result, the identified differences in the airspace management process that can now be addressed during future events.

Technical Factors: Specifically designed flight tests provided the UAS SMEs with technical information on functional altitudes, sensor/platform combinations, and rapid response in a new environment. Additionally, the team learned more about the details of supporting and maintaining their systems and sensors in that environment. More information about these factors can be found in the flight test results of this report.

Interoperability Factors: The integrated vignettes provided an opportunity for demonstrating how the UASs and sensors might interoperate with other technologies in a real world environment. CV15 also provided the opportunity to learn how the U.S. systems might interoperate with host country systems given current airspace and spectrum conditions.

Overall the UAS operations during CV15 were of great benefit to the entire event, and the top notch team successfully supported all requirements with skill and speed.

ANNEX B: FUEL CELL FINAL REPORT

Introduction

The following sections provide an overview of the D350 Fuel Cell technology activities during CV15. The TEC, under the direction of the USPACOM J85, conducted a data collection and demonstration effort of D350 Fuel Cell under field experimentation conditions, and as part of the annual Crimson Viper Field Experiment (CV15) in the Kingdom of Thailand from 27 July-7 August 2015. CV15 was conducted at Fort Thanarat, Khao Noi, Prachuap Khiri Khan, Thailand.

Fuel Cell Technology Descriptions

The following section provides brief description of the participating Fuel Cell technology. Additional details can be found in the technical specification section of this report.



The **D350 Solid Oxide Fuel Cell Power Generator** system is a packable 350W Solid Oxide Fuel Cell power generator that is fueled by propane. This system is a potential replacement for remote batteries and battery chargers, especially in advanced ISR or expeditionary warfare applications. The high specific energy of propane results in a significant tactical advantage for the D350 relative to rechargeable batteries. For example, 25 pounds of carried weight will produce 2.2kWh of energy from BB-2590s (11 batteries) or 5kWh of energy from the D350 (D350 and 5, 1-pound propane tanks).

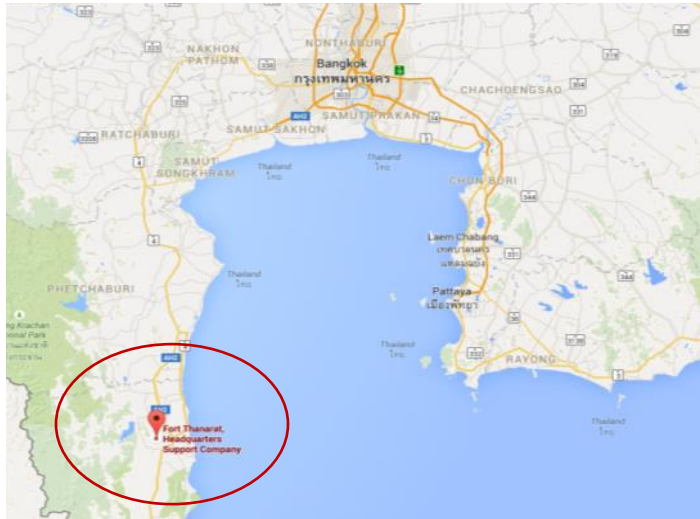
Fuel Cell Technical Specifications

The following section provides more detailed technical specification for each of the Fuel Cells technologies. The information provided includes system specifications and benefits.

Table 8: Fuel Cell Technical Specifications

Specifications	
System Mass	5.1 kg
Power Output	0-350W (400W peak)
Output Voltage	14.4-16.5 Vdc
Exhaust Temperature	50°C
Operational Altitude	up to 15,000 ft
Operational Temperatures	-20°C to 50°C
Operational Lifetime	30 Cycles/400 hours
Start Up Time	15 minutes
Fuel Consumption	65-135 g/hr, Propane
Air Consumption	2.5 CFM
Dimensions	16" L x 8" W x 6" H

Fuel Cell Operating Location



CV15 field experimentation was conducted at Fort Thanarat, Khao Noi, Prachuab Khiri Khan, Thailand.

Fort Thanarat is based on about 600,000 hectares of land near Pranburi town with the entrance on the western side of Petchakasem Road. The base is home to the Thai Infantry and Armed Forces Preparatory School. Fort Thanarat is home to around 5,000 soldiers and their families.

Figure 39: Fort Thanarat Location

Two primary areas of operations were used during CV15. The UASs, TransApps, Fuel Cell, and Biometrics all operated in the area of the JOC. The DS350 Fuel Cell static display was setup in the main static display area of the JOC from 3-7 Aug.



Figure 40: CV15 Static Display Area

Fuel Cell Demonstration Daily Evolutions

The following table is a summary of the daily schedule followed by the Fuel Cells team.

Table 9: Daily CV15 Fuel Cell Evolutions

Daily Schedule			
Date	Event	Date	Event
4 Aug	Set Up Equipment	6-7 Aug	Static display
5 Aug	Turn fuel cell on		
6 Aug	Attempt to charge Batteries		

Fuel Cell Demonstration Participants

The following table provides a summary of the participants that supported the REAL demonstration and evaluation.

Table 10: CV15 Fuel Cell Participants

Last	First	Rank	Organization	Role
	Dereck	DoD CTR	ARL	Transport and set up
Duran	Frank	DoD CTR	NAVAir	Logistics
Johns	Margie	DoD CTR	DoD Information Analysis Center Field Rep to US PACOM HQ	Data Collector and Static Display Demonstrator

Fuel Cell Demonstration Support

The 350 Solid Oxide Fuel Cell Power Generator provided a limited demonstration and static display during CV15. The system was setup in the static display area and a SME was present to answer question on the technology throughout the demonstration period. It was identified during setup week that a major component of the system was not shipped along with the unit. Due to that, and the inability to find the required component the fuel cell was not integrated into the vignettes or other technology demonstrations. However, visitor interest was very high as this technology has the potential to fill a gap for power requirements in area.



Figure 41: Fuel Cell Static Display

Although the D350 Fuel Cell only provided a static display during CV15 there was a high level of interest in the technology from our Thai counterparts. The efforts provided by the fuel cell support team in the form of troubleshooting and visitor briefs provided a valuable opportunity for learning and engagement with CV15 visitors and participants.

Fuel Cell Team Feedback and Lessons Learned

As part of CV15 daily evolutions an end of the day hotwash was held with all participating technology teams. These meeting provided team leads the opportunity to update CV15 staff on any issues they were facing, current and future operations, user and SME feedback, and lessons learned. The following section provides a summary of the daily user and SME feedback, and lessons learned collected during these meetings.

SME Feedback

- Confirm that all parts required to operate are shipped and included with the unit
- Needs an alternate way to start the units
 - Requires a specific lithium charged battery in order to charge batteries

Lessons Learned

Technology Focused

- Don't wait until execution time to start unit. Even if not using it during setup time confirm its operational early

Fuel Cell Conclusion

The claimed capabilities of this device were of much interest to the Thai Armed Forces. Technical difficulties preventing the actual use and assessment of this device were a missed opportunity. Fortunately, trusted personnel with firsthand knowledge of the unit were available and able to provide detailed information to visitors during static display events. Even with the D350 Solid Oxide Fuel Cell Power Generator only providing a static display during CV15, the CV15 team was able to gain an understanding of some of the cultural, logistical, commercial, technical, interoperability, and environmental factors that should be considered when using this system in a similar environment. The following provides a brief summary of how some of those factors related to the fuel cell technology during CV15.

Logistical Factors: Logistics was an important factor for successful execution of CV15. Shipment of gear is a detailed process. Due to the ever changing nature of shipping requirements into foreign countries the gear was delayed by one day. All gear that was shipped arrived, but it was quickly determined that key parts required to operate the system were not shipped. As a result of the missing parts, and the inability to find the needed parts readily in country, the CV15 team was not able to demonstrate the fuel cell, and instead provided a static display manned with SMEs to answer questions by visitors.

Environmental Factors: Because the D350 Solid Oxide Fuel Cell Power Generator was only presented as a static display no environmental factors were identified as a result of its operation.

Interoperability Factors: Because the D350 Solid Oxide Fuel Cell Power Generator power inputs are not commonly used in Thailand, it would be difficult to find replacement power supplies. However, propane is used as a fuel source and is easily attainable in Thailand, so as long as operators planned accordingly this technology should successfully interoperate with other technologies in the field. Additionally, the small form factor is conducive to users in the area.

Technical Factors: Because the D350 Solid Oxide Fuel Cell Power Generator was only presented as a static display no technical factors were identified as a result of its operation.

Commercialization Factors: For reasons similar to those mentioned under interoperability factors, the commercialization of the D350 Solid Oxide Fuel Cell Power Generator is possible in this operating environment, if developers take into consideration the power, support, and fuel

requirements of the system. The relatively low cost, and ability to use easily attainable propane as a power source makes commercialization a distinct possibility in the area.

Cultural Factors: Even with the team not able to execute the demonstration portion of the D350 Solid Oxide Fuel Cell Power Generator execution plan, the interest from Thai counter parts was very high for this technology. Visitors quickly identified the benefits of this small form factor, relatively light, low cost system. As a result it can be construed that this technology would be quickly accepted in this AOR.

Overall the D350 Solid Oxide Fuel Cell Power Generator operations during CV15 were a wonderful example of a field experimentation team adapting to logistical and cultural factors to produce the best possible use of a technology given unforeseen restrictions. The team turned the loss of a physical demonstration into a great opportunity to focus on presentations to visitors who were very interested in the specifications and requirements of the system. SMEs made themselves available throughout the event to address these opportunities making the overall event a success.

ANNEX C: TRANSAPPS CV15 FINAL REPORT

Introduction

The following sections provide an overview of the TransApp technology activities during CV15. The TEC, under the direction of the USPACOM J85, conducted a data collection and demonstration effort of TransApp under field experimentation conditions, and as part of the C-IED scenario, during the annual Crimson Viper Field Experiment (CV15) in the Kingdom of Thailand from 27 July-7 August 2015. CV15 was conducted at Fort Thanarat, Khao Noi, Prachuap Khiri Khan, Thailand. The TransApps teams' primary operating window was from July 29-August 7. The primary operating window consisted of user training, daily demonstrations, and data collection within the identified scenario.

TransApp Technology Descriptions

The following section provides brief description of each of the participating TransApp technology. Additional details can be found in the technical specification section of this report.



The **TransApps** Ecosystem was developed as a Defense Advanced Research Projects Agency (DARPA) project focused on providing military end users with timely, relevant and accurate information. This is done via handheld devices loaded with apps, as well as C2 (command and control) software that was all built directly from military service member ideas. TransApps leverages commercially available mobile technology and provides the ability to collect, process, securely disseminate, and holistically display events, places, blue force icons, media and honesty trace data. All in near real-time, overlaid on high resolution imagery, operating on a highly-portable, mobile, lightweight and fully-integrated platform.

TransApps Application/Capability Descriptions

The following section provides a summary of the each of the applications/capabilities that were demonstrated and trained to Thai users during CV15.

Maps

Primary maps application. Shows your location and surrounding area using recent high-quality imagery. Also includes drawing and planning tools. Allows capture and review of geo-tagged media through Collect.

Route

The Plan Route tool within the Maps application allows a user to organize points on the map for navigation. Planned routes can be shared via QR code or chat (when connected to a supporting network). After route is planned, viewing plan will show user the direction of navigation towards the next point on the map.

Collect

Tool used to collect pictures, videos, audio files and notes. The data recorded in the Collect tool is geo-tagged, and directionally oriented with a magnetic bearing to inform the user or media recipient of the exact position and orientation of the photo or video.



Figure 42: Maps (Top) Route (Bottom Left) Chat (Bottom Right)

Chat

Allows users to interact with each other in an IRC style app. Text, pictures, audio, and video are all transferrable over chat. The Chat app can also transfer data from Green Notebook on the handheld device.

Spots

Spots allow users to mark points of interest. Spots can be sorted by colors and shared via QR code.

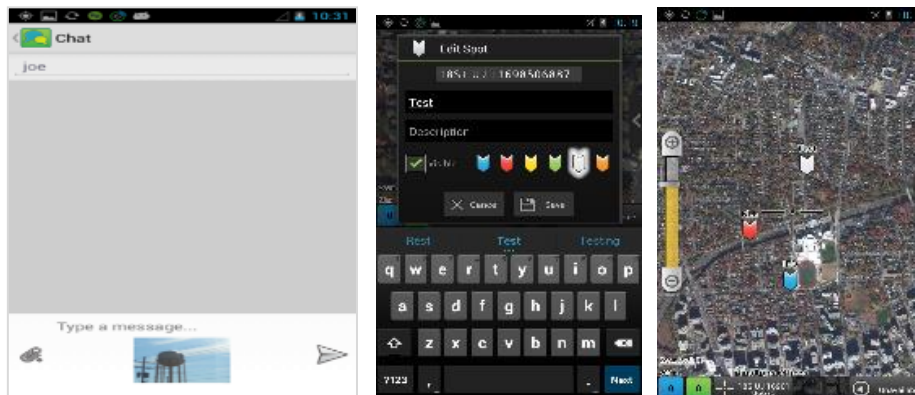
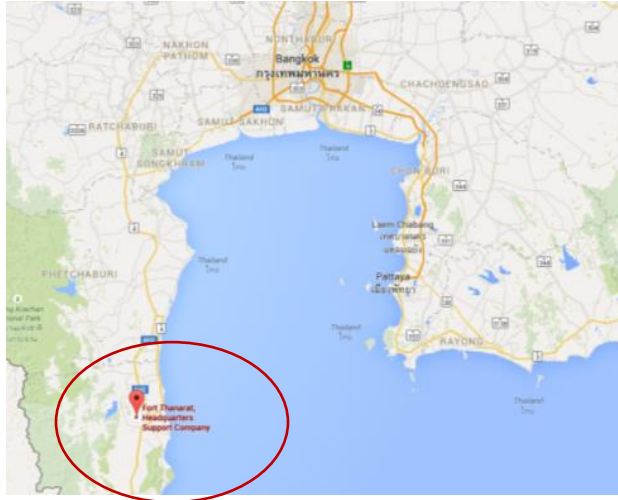


Figure 43: Chat (Left) Spots (Center and Right)

TransApps Operating Location



CV15 field experimentation was conducted at Fort Thanarat, Khao Noi, Prachuap Khiri Khan, Thailand.

Fort Thanarat is based on about 600,000 hectares of land near Prachinburi town with the entrance on the western side of Petchakasem Road. The base is home to the Thai Infantry and Armed Forces Preparatory School. Fort Thanarat is home to around 5,000 soldiers and their families.

Figure 44: Fort Thanarat Location

Two primary areas of operations were used during CV15. The UASs, TransApps, Fuel Cell, and Biometrics all operated in the area of the JOC. TransApps operated in and around the main JOC building primarily in the technology demonstration and experiment area, or the static display area. However, user training was also conducted immediately outside of the JOC depending on the traffic in the JOC area at any given time.



Figure 45: TransApps Training

TransApps Demonstration Daily Evolutions

The following table is a summary of the daily schedule and evolutions by day followed by the TransApps team.

Table 11: Daily CV15 Evolutions

Daily Schedule	
Date	Event
3 Aug	User Training with 11 Thai 1530- 1630
4 Aug	User Training with 9 Thai 0830-1030 Patrol vignette 11:00 1600

5 Aug	New user Training 0730 to 0830 5 new users 0900-1530 IED Trans App Vignettes
6 Aug	User AAR 0900 to 0930 Trans App Static Display 1330 to 1530 Equipment Pack out 1530-to 1700
7 Aug	0800-0900 CV15 AAR

TransApps Demonstration Support

The TransApps team utilized CV15 as an opportunity to test their technology and gather user feedback in a new environment. TransApps used commercial off-the-shelf (COTS) smartphones with custom multilayered security and agile development processes modified for the tactical community to host the applications for user training. The majority of the applications were translated into Thai by the TransApps support team prior to deploying to CV15. Three TransApps personnel provided eleven Thai military users with training on the TransApps mobile applications and guided them through the execution of two vignettes to provide contextual exposure to the applications within the CV15 scenario.

The systems were integrated into relevant scenarios with other participating technologies to include; 4 biometrics technologies, 3 C-IED handheld devices, the Talon 1201.E UAS with Dragon View sensor, and the Phoenix 30 quad copter with the i2Tech sensor. The TransApps and UAS teams exercised systems interoperability at CV15 by means of collecting, processing, and distributing updated map imagery of the Ft. Thanarat AO in which the training vignettes occurred. More specifically, the UAS team flew a fixed-wing UAS with a Canon S100 payload over the C-IED exercise lanes to gather new imagery, shared it with the TransApps team for mobile format processing and copying to the Thai soldiers' handhelds. Once the TransApps team received the raw imagery from the UAS team, it was less than 2 actual man hours to download the imagery, convert it, and upload it to the TransApps devices. The imagery collected by the UAS team provided TransApps and the Thais with vibrant, full-color, high resolution, 3D digital maps for the remaining CV15 execution period.



Figure 46: TransApp Users Conducting the Patrol Vignette



Figure 47: TransApp Users Conducting the IED Land Vignette

In addition to the successful integration of the mosaicked UAS imagery, the TransApps team supported the patrol and IED lane vignettes by providing communications capabilities to all aspects of the vignettes. The team used media collection capabilities to capture imagery on suspected IED emplacements, and distributed intelligence to the JOC in real-time. Once the vignettes were concluded the TransApps users completed user feedback surveys on their impressions of the applications. User feedback data, data collector and SME observations, recommendations, corrections, and conclusions will be provided in the CV15 final report.

The TransApps team and their technologies were central to the successful execution of the CV15 field experimentation event. The mobile applications capabilities provided a central technology for vignette development that allowed for the integration of multiple technologies into scenario relevant vignettes. The efforts of the team, and the attentiveness of their users, provided a collaboration and experimentation opportunity unique to the CV15 venue and valuable for continued theater engagement.

TransApps Data Collection Approach

The following information provides the data collection approach for the identified focus area for TransApps. Each SME and user involved in the TransApps data collection effort was asked to complete a demographics survey prior to data collection. Additionally, data collectors were asked to record any relevant comments made by the TransApps team concerning the utilization of and training for the applications.

The following focus area was identified for data collection during CV15:

- **User Feedback**

User Feedback

As part of the CV15 data collection effort, users were asked to provide feedback on the TransApp applications used during the event. Each of the users were asked to use all of the applications during the training and demonstration period so they are able to provide feedback on each application.

Data Collection Method: The user feedback data collection effort focused on subjective feedback from the users. Users were asked to complete surveys on the employability, usability, trainability, maintainability, and mission impact of the TransApps suite of applications. The minimum information required for the user feedback portion of the TransApps data collection effort was one user survey and one user demographics form per user.

TransApps User Demographics

The following table provides a summary of the participants that supported the TransApps demonstration and evaluation.

Table 12: TransApps User Participants

Name	Organization/Command/Unit	Specialty	Years
Ekprasit Promtun	RDC, RTF	Aero	13
Apidach Hamlakorn	RDC, RTF	Aero	30
Krit Heebjinda	RDC, RTF	Aero	8
Nuttawoot Termsap	MRDC	AF, Defence Military	3
Supatach Charkaer	MRDC	Army Defence Military	5
Surapon Onlamoon	MRDC	Army Defence Military	28
Wattichai Napang	Support Unit	Infantry, Army	3 months
Natchanon Insawan	Support Unit	Infantry, Army	3 months
Jaturon Sripasit	Support Unit	Infantry, Army	3 months
Krisana Thongsen	Support Unit	Infantry, Army	3 months
Tanavat Cantapah	Support Unit	Infantry, Army	3 months



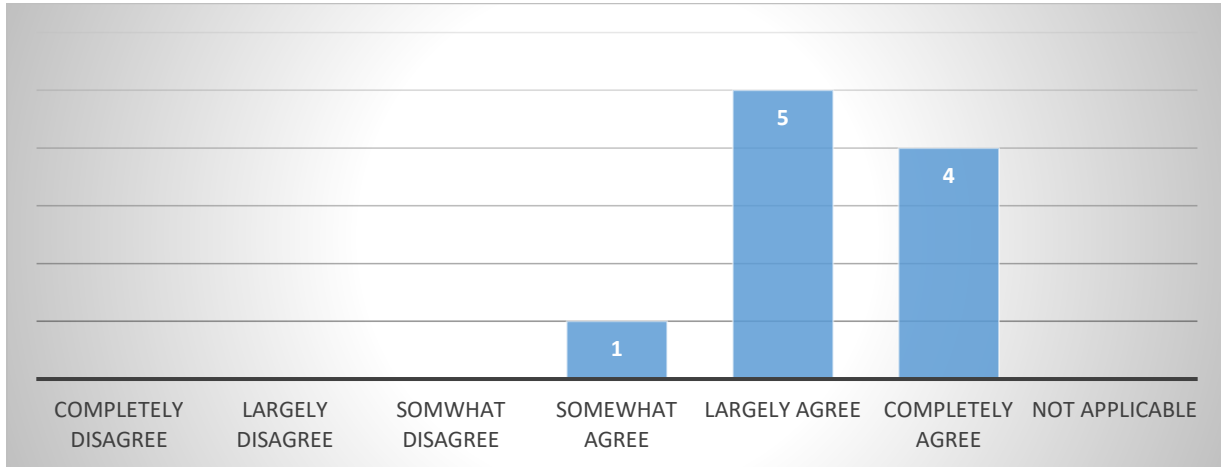
Figure 48: TransApps Team

TransApps User Survey Results

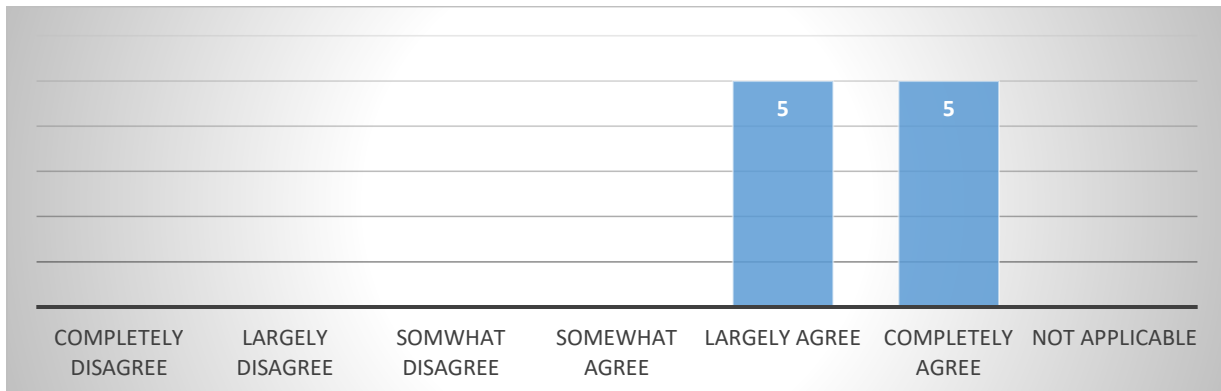
As part of the CV15 TransApps data collection effort the TransApps users were asked to complete a survey to collect their feedback on the capabilities they used during the event. The following section provides that feedback.

Section 1: Training

1. The classroom and hands-on training provided for the TransApp technology was good.



2. The training documents/presentations provided for the TransApp technology were helpful.

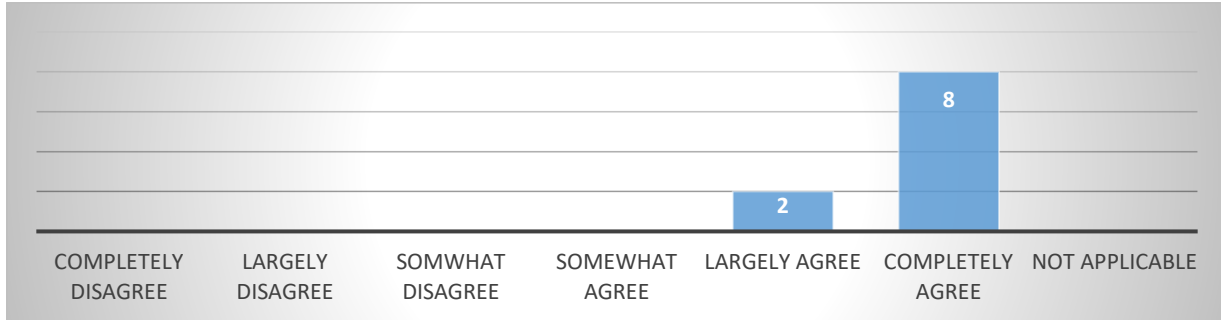


Section 2: Suitability (Usability, Reliability, Maintainability)

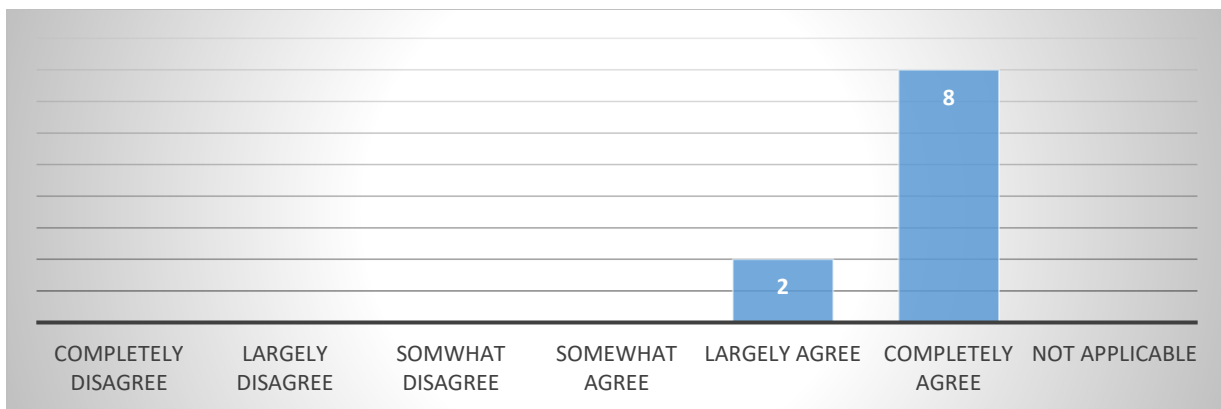
Usability: user friendliness, visual appeal

Reliability: to perform tasks without losing functionality and to provide accurate information

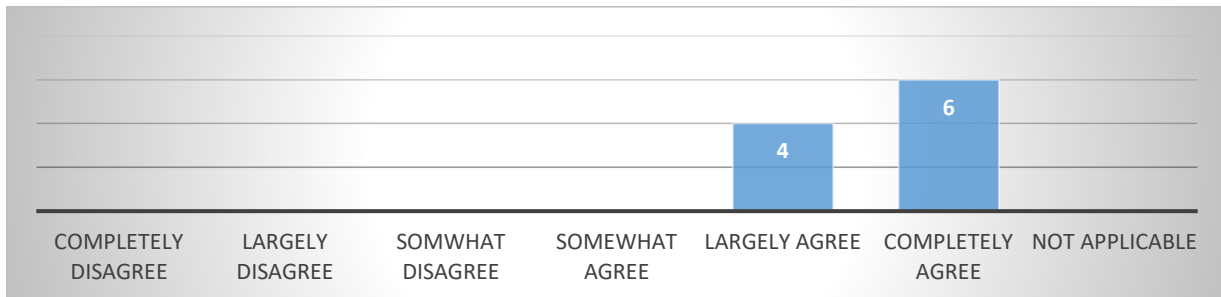
3. The visual quality of the Map application was good.



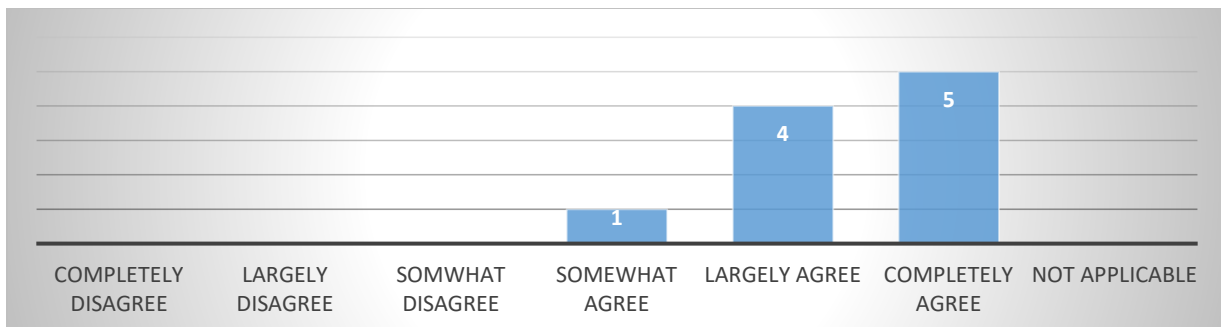
4. The visual quality of the Spot capability was good.



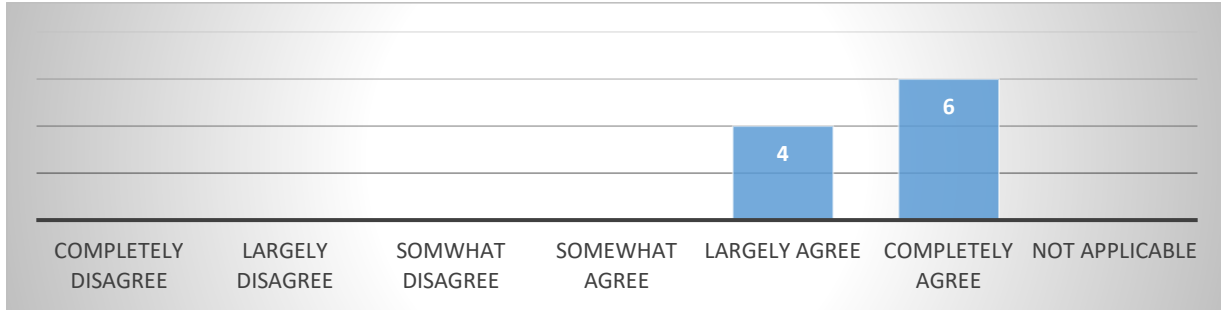
5. The visual quality of the Route capability within the Map application was good.



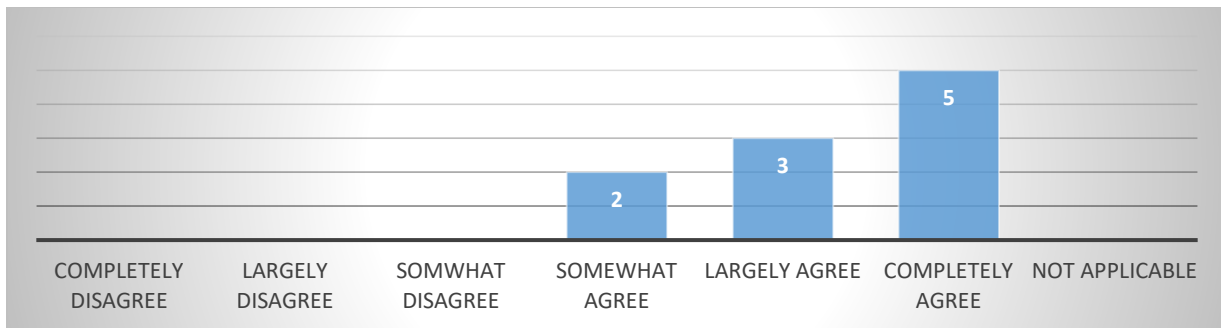
6. The quality of photos taken, sent, and received by the Chat application was good.



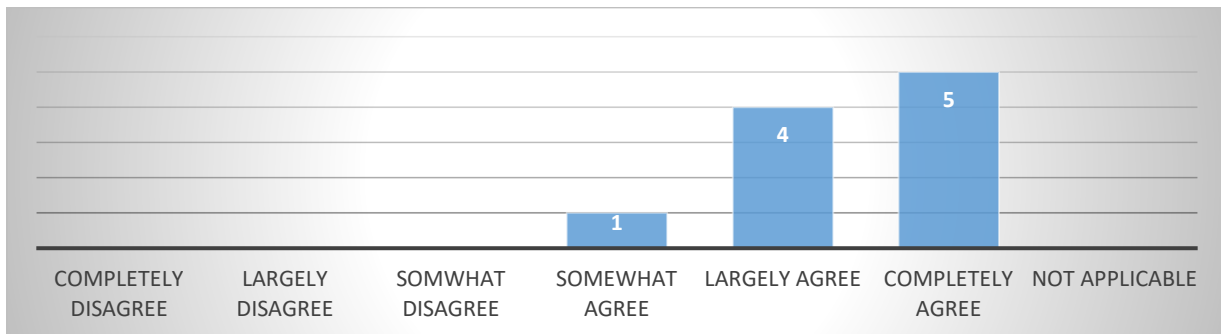
7. The quality of photos taken by the Collect application was good.



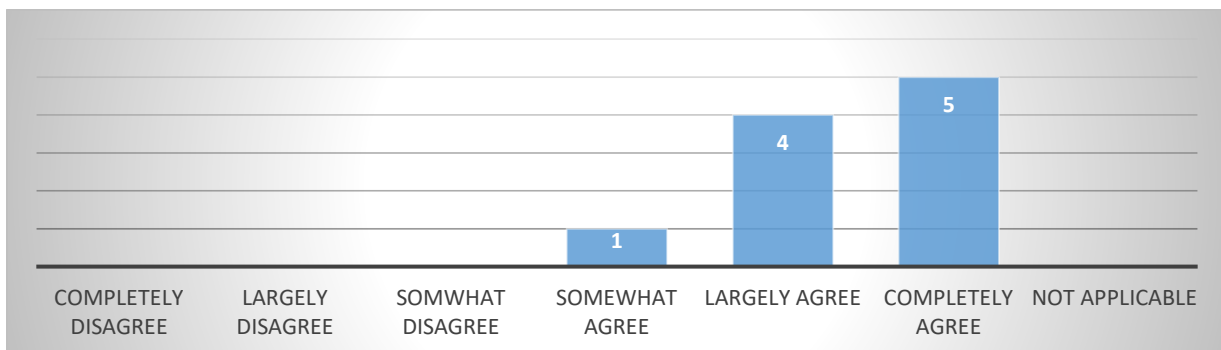
8. The quality of videos taken, sent, and received by the Chat application was good.



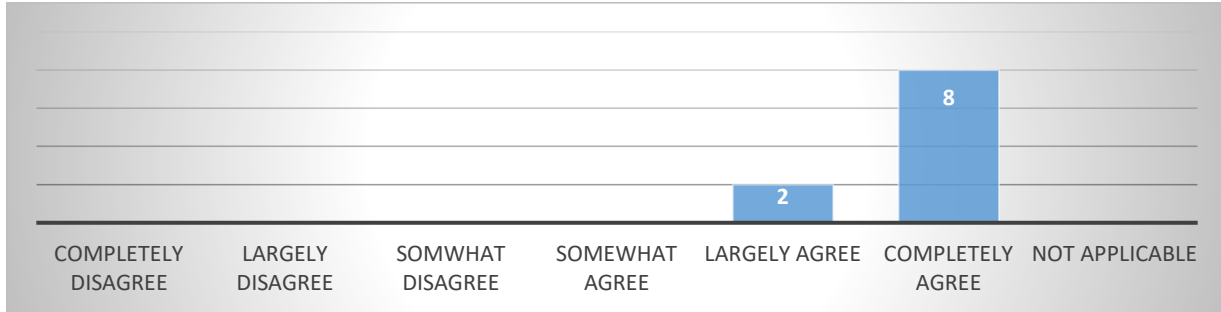
9. The quality of videos taken by the Collect application was good.



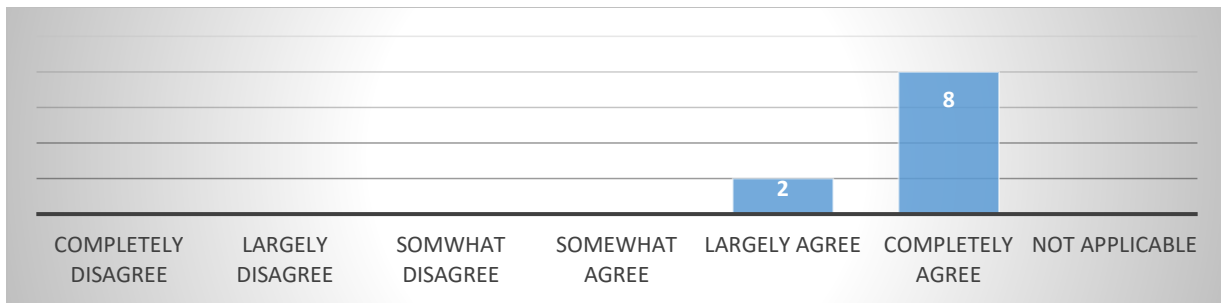
10. The quality of audio files taken by the Collect application was good.



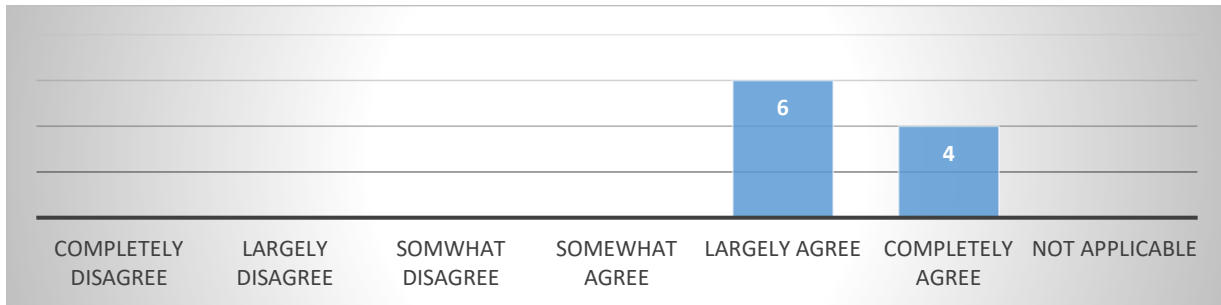
11. The overall Look and Feel of the Maps application was good.



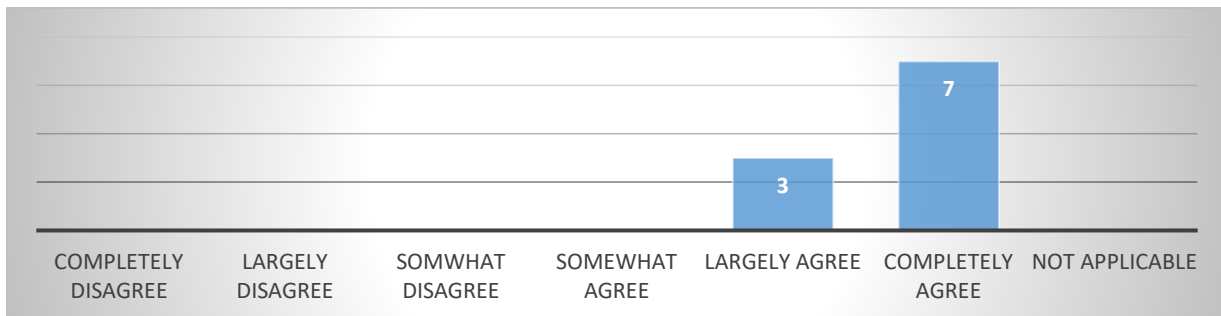
12. The overall Look and Feel of the Route planning tool of the Maps application was good.



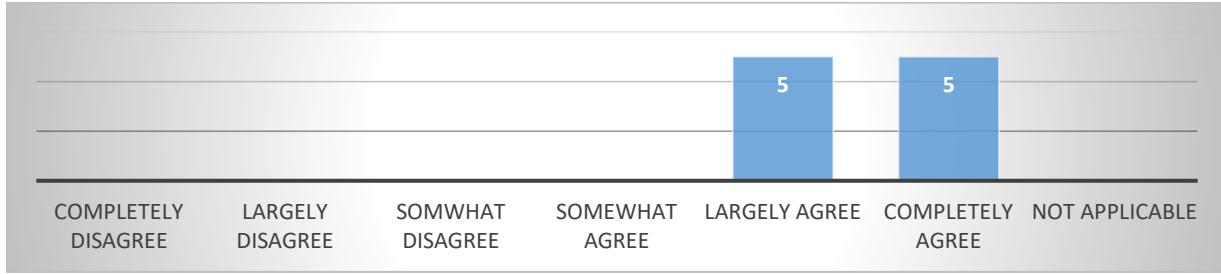
13. The overall Look and Feel of the Spots capability was good.



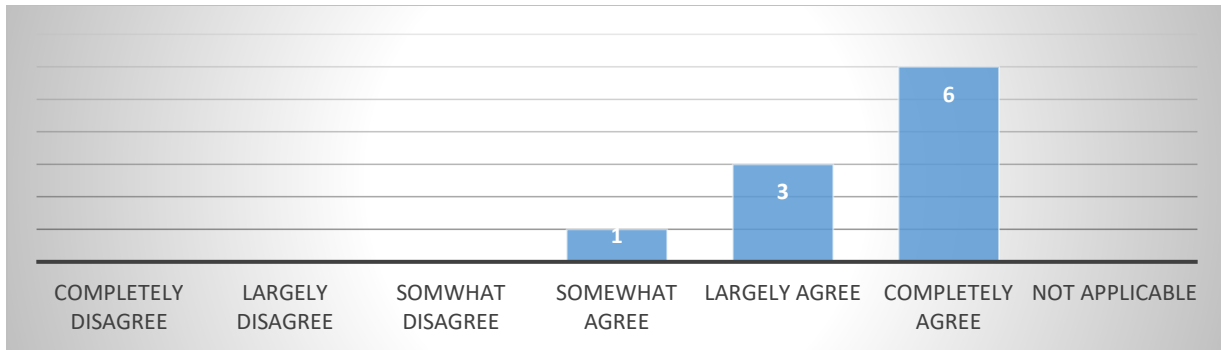
14. The overall Look and Feel of the Chat application was good.



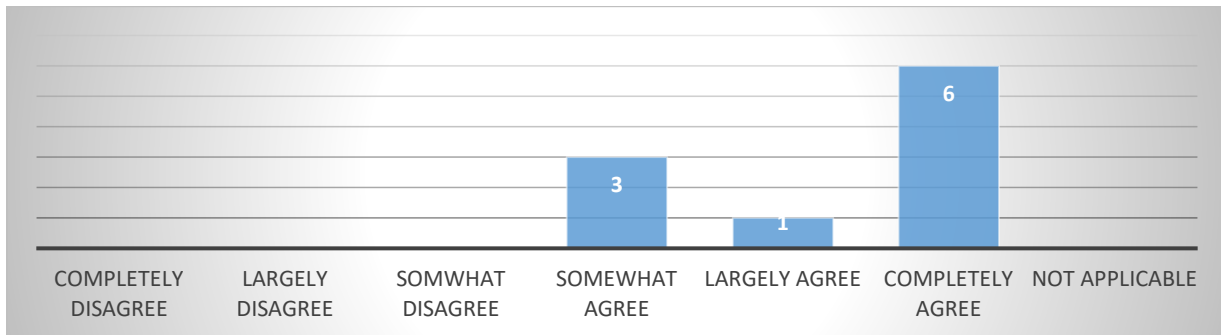
15. The overall Look and Feel of the Collect application was good.



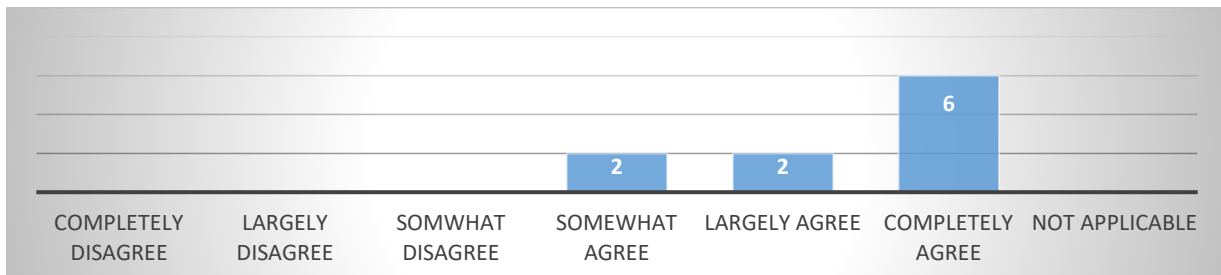
16. The time required to send and/or receive data using the Chat application was adequate.



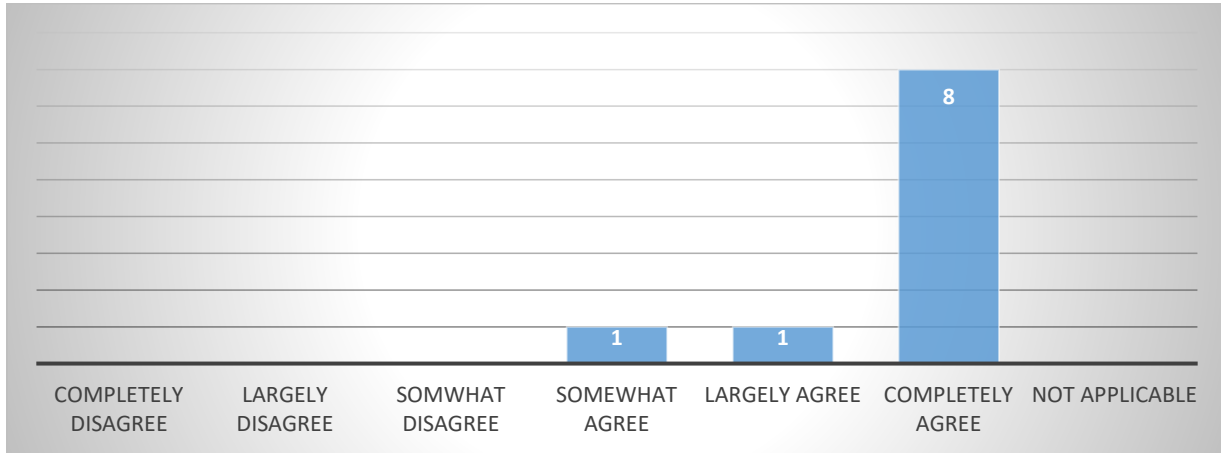
17. The time required to send and/or receive data using the Collect application was adequate.



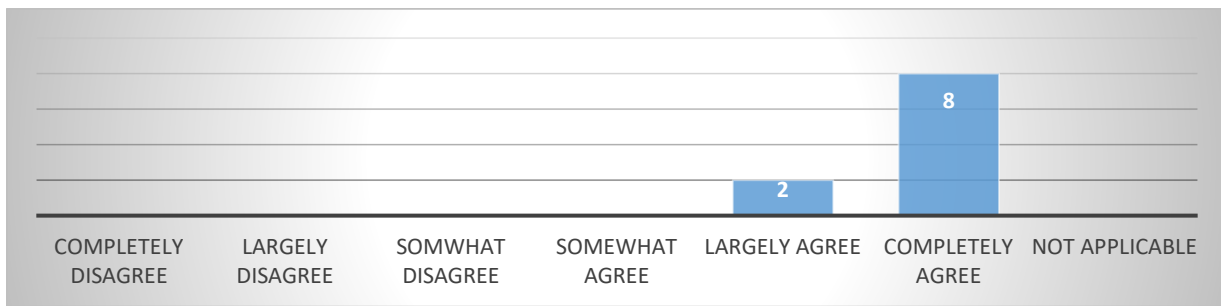
18. The time required to send and/or receive data using the Route capability of the Maps application was adequate.



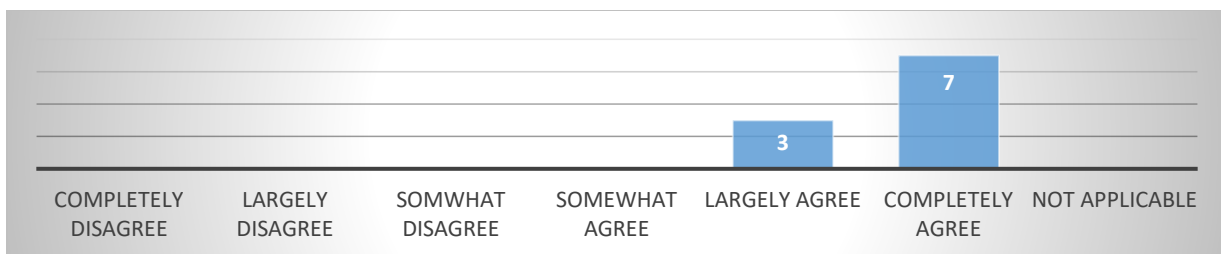
19. The time required to send and/or receive data using the Spots application was adequate.



20. The Accuracy of the data displayed in the Maps application was good.



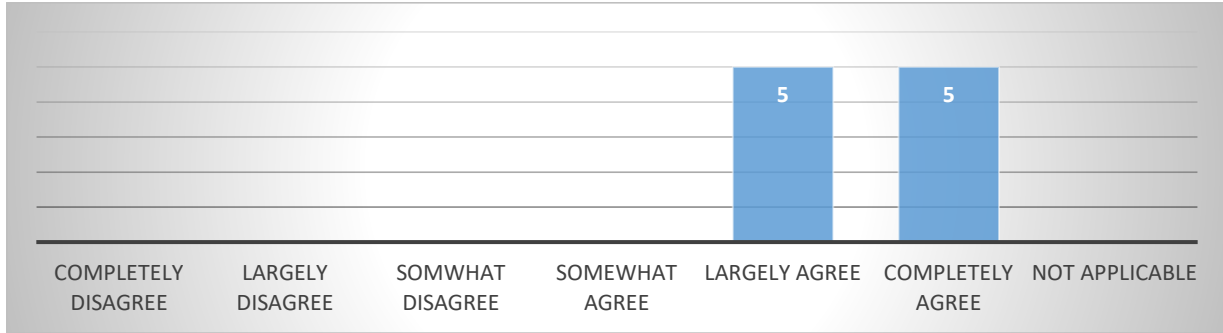
21. The overall Reliability (information displayed as expected and did not crash) of the Maps application was good.



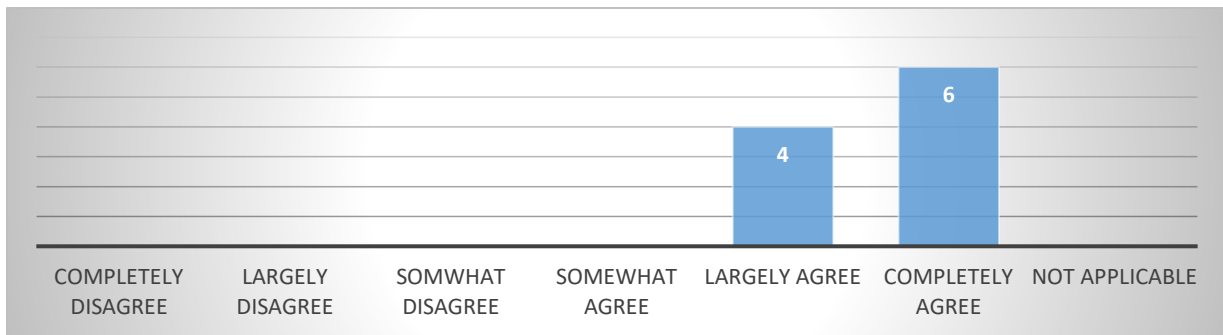
22. The overall Reliability of the Chat application was good.



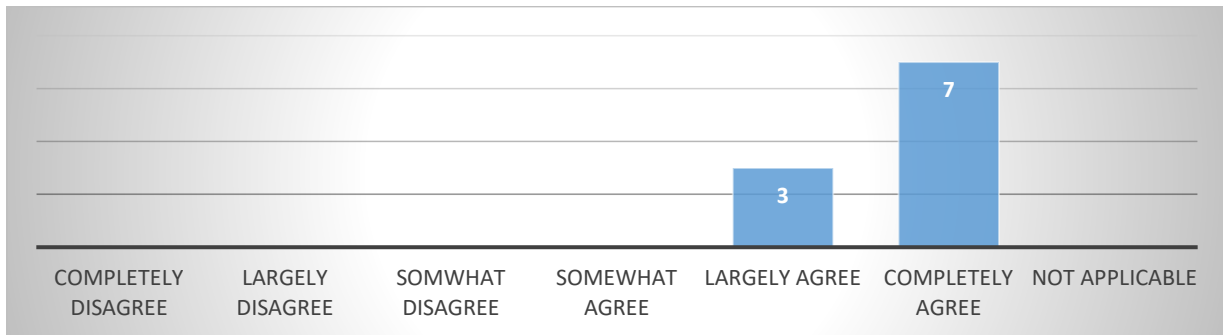
23. The overall Reliability of the Collect application was good.



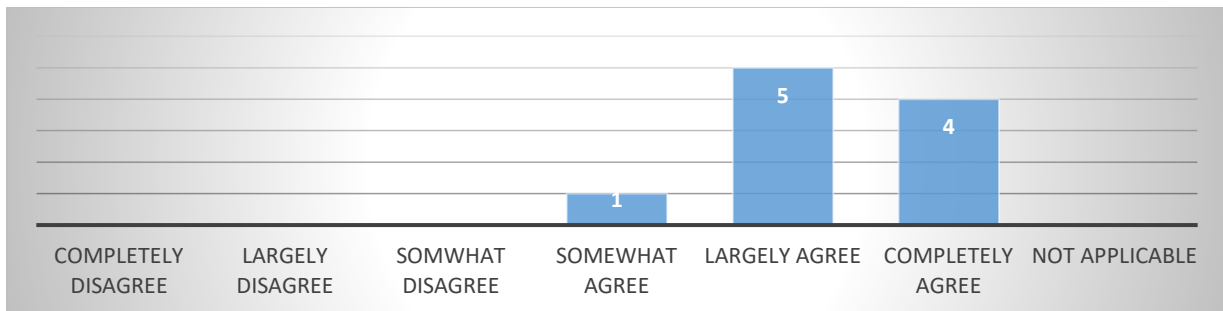
24. The overall Reliability of the Spots application was good.



25. The overall Reliability of the Route Planning tool in the Maps application was good.



26. The current TransApp capability would be easy to maintain.

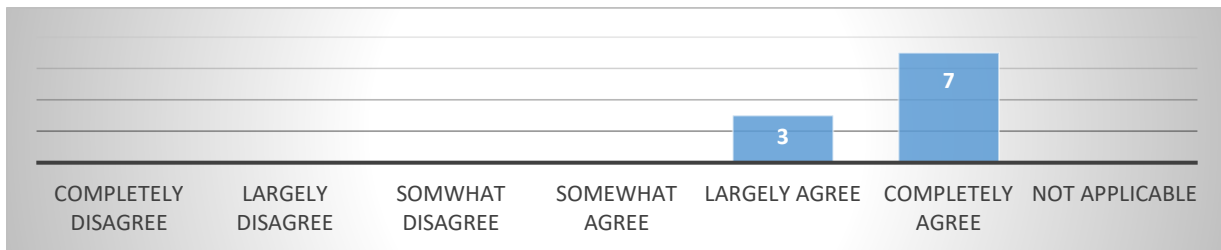


Section 4: Mission Impact

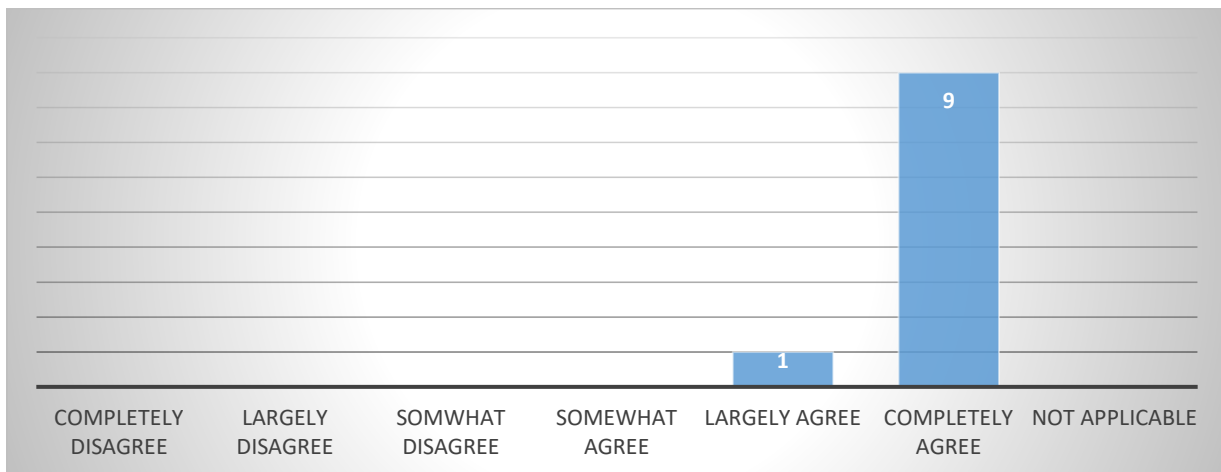
Situational Awareness: a positive impact on situational awareness is defined as providing the user valuable information that will help accomplish the mission without negatively hindering that mission.

Decision Making: In this context a positive impact on decision making is defined as providing the user valuable information that will help the user make decisions important to accomplishing the mission.

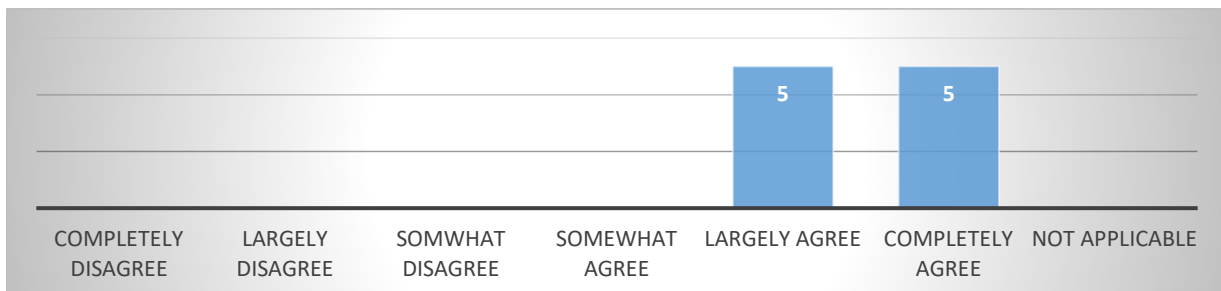
27. The TransApp capabilities would have a positive impact on situational awareness.



28. The TransApp capabilities would provide valuable information to help the user make decisions important to accomplishing missions.



29. The TransApp capabilities would be useful in environments similar to Thailand.



TransApps User After Action Feedback

After users completed training and CV15 vignettes they were asked to participate in an after action meeting to collect additional feedback. The meeting took the form of a round table discussion where each participant was asked to provide their verbal feedback to various questions. This section provides the feedback collected during the CV15 TransApps after action meeting.

Each TranApps user was asked to provide at least one thing they liked about the TransApps capabilities and at least one thing they did not like. The following bullets provide a summary of the user responses.

- Likes: The stability of the GPS
Dislikes: The apps should be real-time, like with UAS feeds. It was sometimes difficult to take pictures and chat at the same time. This technology would not work with every mission type.
- Likes: Using the Spots function to help navigate.
Dislikes: There was a problem with typing because the user was not familiar with the keyboard, first time using a smartphone.
- Likes: Everything, planning the route, spots, etc. easy to use. The user thought this capability would help with his job; knowing the area of operations, tracking team, and helps the commanders SA.
Dislikes: Not waterproof
- Likes: The ability to know their location, to observe other areas, and see a visual of the target.
Dislikes: The capabilities were only partially translated into Thai.
- Likes: Easy to use, easy for commander to inform the soldier of target and planning route.
Dislikes: None
- Likes: Fast to find the target. Good to tell the exact location on the map of targets.
Dislikes: The capabilities were only partially translated into Thai.
- Likes: Easy to understand,
- Dislikes: The training and practice time was too short.
- Likes: The app is good for supporting real world operations with the team collecting information, sending it to the commander, and the commander being able to act and send out troops based on that information.
Dislikes: The screen resolution is bad in daylight, need to find a way for better viewing. Bigger screen would be better. Only the person sending picture has an icon on their map. All users should get the choice to display the icon on their map easily on the map.

Users were also asked to provide ideas on improvements and/or additions to the TransApps capabilities. The following are the users' responses.

- Integrating a sensor on the phone that allows you to detect temperature changes, heat, vibrations, etc.
- Better camera, nightmode, extra features for good camera
- Siri type commands
- Ability to support live UAS feed

- While typing the system should try to predict word, for smart, fast typing.
- UAS control for small radius control when the usual connection is not working well
- Sensor that determines if things around you are human or animal
- Notification when a chat is coming in (make sure sound is turned on when it makes sense)
- Chat always overlaid on the map, or an easier way to use the map
- Street view on map
- Symbols to drag and drop that save time chatting, for chats you would use often, like mission complete.
- Better ID method for who is sending the Chats
- Way to automatically track bullet usage, health, etc.
- Jungle training, information on the flora and fauna, survival guide
 - Sensor, picture, that would match the plant or animal to information

TransApps Team Feedback and Lessons Learned

As part of CV15 daily evolutions an end of the day hotwash was held with all participating technology teams. These meeting provided team leads the opportunity to update CV15 staff on any issues they were facing, current and future operations, user and SME feedback, and any lessons learned. The following section provides a summary of the daily user and SME feedback, and lessons learned collected during these meetings.

SME Feedback

- Collect images do not automatically create an icon on the map for other users, only on the user who took the photos device

User Feedback

- Signal user said he could take this platform back to his job and find applications
- SME, users are picking up using the application very well

Lessons Learned

Technology Focused: Research purchasing support material, like SIMs to ensure a smooth start up. In retrospect we probably would have added at least a day for setup.

Admin/Logistics Focused: Make sure users understand their requirements as far as time and physical requirements. Overall a better control of the users would be beneficial.

TransApps Summary

The overall objective to demonstrate the TransApps capabilities with Thai operators within plausible scenarios, was a success. The team gained valuable exposure to the demonstration environment and as a result were able to gain insight into their technologies from a cultural, logistical, commercial, technical, interoperability, and environmental perspective. The following provides a brief summary of how those factors related to TransApps operations during CV15.

Logistical Factors: Logistics was an important factor for successful execution of CV15. Due to the ever changing nature of shipping requirements into foreign countries most team's gear was delayed by one day. However, because of the small form factor of the handheld devices that host

TransApps, the team was able to hand carry all of their gear into country with no issues. Once in country the team acquired SIM cards for their devices and quickly realized that the process was not as straightforward as they might have thought. As a result the team learned that planning a few extra days for sourcing in country, and locating sources for support materials in country prior to the event is key to successfully executing OCONUS.

Environmental Factors: Because the TransApps capabilities are hosted on handheld devices the environmental factors such as humidity and precipitation would likely be factors during long term operations. Additionally, the temperature would likely impact users in the field over long periods without shelter.

Interoperability Factors: Trans Apps integrated nicely with the Talon and Phoenix UASs, the biometrics, and C-IED handhelds during operational vignettes. The technology provided an excellent platform to design scenarios around and worked as expected throughout the vignettes.

Technical Factors: The TransApps team learned that their technology, and its ability to operate on multiple platforms, would work well with existing technologies in the area. As a result the capabilities could be supported and maintained without an additional logistical tail. The capability could nicely pair with other technologies to provide additional imagery and SA. With performance mostly resting on the ability of the network, it was concluded that within the testing environment the network was able to quickly transfer information assuring that information sent by users remained operationally relevant.

Commercialization Factors: Because of the platform flexibility of TransApps this technology would easily conform for local and regional use. The entirety of the capability would need to be translated into the host country language, but the intuitive nature of the applications would make them marketable in many areas.

Cultural Factors: Cultural factors that affected the TransApps demonstration included the use of non-tactical military users, users with a wide range of familiarity with handheld devices, and a language barrier in the form of some parts of the capability not being translated into Thai. Training was a key aspect of TransApps participation in CV15 and the TransApps. SMEs were efficient, patient, and extremely well versed on how to demonstrate and apply the applications to provide relevance to the user group.

The mobile capabilities provided a solid foundation for developing integrated scenarios and vignettes that allowed the UASs, biometrics, C-IED handhelds, and TransApps technologies to interoperate. The TransApps provided a great demonstration of possible on the move capabilities that can support soldier situational awareness and communications. TransApps performed very well in CV15 and would be well suited for deployment in environments similar to the CV15 location provided users are provided the proper training.

ANNEX D: C-IED HANDHELD DEVICES FINAL REPORT

Introduction

The following sections provide an overview of counter-improvised explosive device (C-IED) handheld device (HHD) technology activities during CV15. The TEC facilitated the Joint Improvised-Threat Defeat Agency (JIDA)-led data collection and USPACOM J85 technology demonstration of the Vallon VMC1, AV Minelab F3Ci, and CEIA CMD C-IED handheld devices during the annual Crimson Viper Field Experiment (CV15) in the Kingdom of Thailand from 27 July-7 August 2015. CV15 was conducted at Fort Thanarat, Khao Noi, Prachuap Khiri Khan, Thailand. The first week of operations focused on lane preparation, target placement, soil testing, and U.S.-only testing of the Vallon Minehound handheld devices. The second week consisted of user familiarization with the three devices and a scripted demonstration in a C-IED scenario with other CV15 technologies. The C-IED HHD team collected data according to JIDA test procedures including device operation and user detections and locations.

C-IED Handheld Device Technology Descriptions

The following section provides brief description of each of the participating C-IED technologies. Additional details can be found in the technical specification section of this report.



Figure 49: VMC1 (Left) F3Ci (Center) CEIA CMD (Right)

VMC1

This new design Vallon Metal Detector VMC1 is a retractable detector for demining. It is supplied with a soft carrying bag housing the complete mine detecting set. Due to its small packing size it needs extremely little space for transportation and thus facilitates operation in impassable areas. In spite of the compact design Vallon made no compromise with regards to the detection features. The VMC1 is a fully adequate Vallon Metal Detector offering highest detection sensitivity and detection stability. The modern used technology as well as simple and easy to understand operation elements ensure a high demining reliability. The metal alarms are very clear so that the operator can work without a headset and any external cables.

F3Ci is More than a mine detector. The system features variable sensitivity through the selection of seven uniquely combined audio and sensitivity configurations, two operating modes to improve target identification, a pin-pointing mode for fast and accurate location of target, preconfigured sensitivity profile to assist in the detection of non-metallic conductive targets,

fully enclosed and protected cables, audio and visual indications, a vibrating handle, an adjustable search head, is simple to operate, is waterproof, has a long lasting battery life, and is fully adjustable for operator comfort.

The **CEIA CMD** is a very high performance, high-sensitivity Compact Metal Detector designed to detect metal and minimum-metal content targets in conductive and non-conductive soils, including laterite and magnetite. The system provides effective detection of all metal and minimum-metal content targets, a balanced and lightweight design, an one piece retractable design, small packaging size, accurate pin-pointing of the target’s position indicated by acoustic modulation and maskable led display, high discrimination capability for adjacent targets, automatic compensation for mineralized and high natural metal content soil, an integrated battery charger, a long-lasting battery life, an extremely high level of electrical and mechanical reliability, operation monitored by a microcomputer controlled auto diagnostic system, completely digital electronics, with in-field program memory upgrade capability, and is easy to operate and requires minimal training time.

C-IED Technical Specifications

The following section provides more detailed technical specification for each of the C-IEDs technologies. The information provided includes system specifications and benefits.

Table 13: C-IED System Specifications

CEIA CMD	Minelab F3Ci	Vallon VMC1
<ul style="list-style-type: none"> • Lightweight and compact • Battery life 8-9hrs (2 X C Cell) • Water resistant • Effective Detection of all metal and low conductive targets • Visual and audio detection alerts • Accurate pin-pointing of the target’s position indicated by: acoustic modulation, maskable LED display • Pin-pointing mode for fast and accurate location of large targets • Automatic Compensation for mineralized and high natural metal content soil • Integrated battery charger 	<ul style="list-style-type: none"> • Lightweight and compact • Battery life 30hrs (4 X C Cell) • Water resistant • Effective Detection of all metal and low conductive targets • Visual, audio and vibration detection alerts • Seven uniquely combined audio and sensitivity configurations • Pin-pointing mode for fast and accurate location of large targets • Additional interrogation mode to improve target pinpointing • Highly effective channel selection for interoperability with other hand held detectors 	<ul style="list-style-type: none"> • Lightweight and compact • Battery life 8hrs (3 X C Cell) • Water resistant • Effective Detection of all metals, (ferrous and non-ferrous) • Visual, audio and vibration detection alerts • Highly effective automatic ground balance • Additional interrogation mode and automatic pin-point mode to improve target pinpointing • Highly effective channel selection for interoperability with other hand held detectors • Surf mode capability for salt water

C-IED Handhelds Operating Location

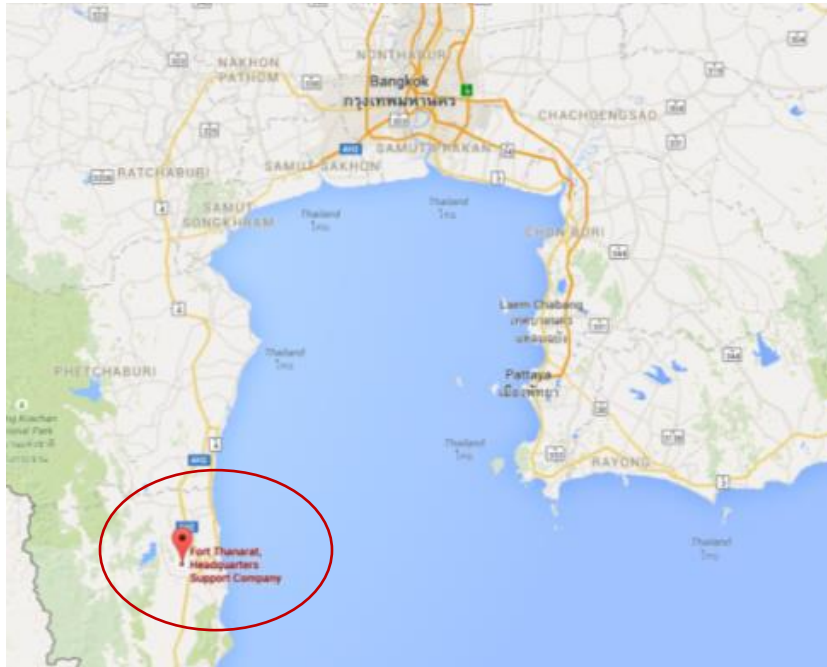


Figure 50: Fort Thanarat Location

CV15 field experimentation was conducted at Fort Thanarat, Khao Noi, Prachuab Khiri Khan, Thailand.

Fort Thanarat is based on about 600,000 hectares of land near Pranburi town with the entrance on the western side of Petchakasem Road. The base is home to the Thai Infantry and Armed Forces Preparatory School. Fort Thanarat is home to around 5,000 soldiers and their families.

Two primary areas of operations were used during CV15. The UASs, TransApps, Fuel Cell, and Biometrics all operated in the area of the JOC. The C-IED handhelds operated approximately 2 kilometers from the JOC in a designated training area suited for C-IED operations.



Figure 51: C-IED Main Area of Operations

C-IEDs Demonstration Daily Evolutions

The following table is a summary of the daily schedule followed by the C-IEDs team.

Table 14: Daily CV15 C-IED Evolutions

Daily Schedule	
Date	Event
28 July	Identified lane targets Emplaced targets on all lanes Provided C-IED handheld demonstrations to Thai users Provided sterilization team training to facilitate lane development
29 July	Created 2 new lanes for jungle testing, collected data on all targets Conducted soil testing, humidity, and temp on jungle lanes
30 July	Verified target placement on 4 original lanes Soil testing; temp, humidity, magnetic susceptibility, permittivity on 4 original lanes Emplaced targets on jungle lane 2 and conducted soil testing Initial scenario rehearsal Testing with all three handhelds on jungle lane 2
31 July	Data collection data collation and review Data collection forms modification Execution week planning
3 July	Trained Thai users on all three handheld devices User training on multiple lanes
4 July	Conducted familiarization training by Thai soldiers Jungle testing on all three lanes US led demo on scenario lane Thai practice on scenario lane using Thai TTPs
5 Aug	Thais completed teachbacks to one another Completed VIP rehearsal IED lane vignette User surveys
6 Aug	DV Day demonstrations

C-IED Demonstration Support

The C-IED team took full advantage of the CV15 experimentation venue. The team identified targets from a variety offered by their Thai counterparts, designed lanes for training and data collection, provided guidance on the emplacement of targets within the designated lanes, conducted user training and user focused data collection, conducted soil and environmental testing, and provided support to the overall execution of CV15 vignettes and DV day activities.

The C-IED team trained and demonstrated three different C-IED handheld devices to Thai users and visitors during CV15. The C-IED team developed training lanes using various terrain including; open area, light foliage, and jungle type environments. Ten Thai users were trained by the C-IED team to operate one of three of the C-IED handheld devices. After multiple days of practice and training the Thai users were able to provide teachbacks, users training one

another, so that each user would gain familiarity with all three of the technologies. During and after the training period the C-IED team conducted data collection on the ability of the users to successfully identify targets within the designated IED lanes. Prior to and in conjunction with user training the team was able to conduct environmental testing including soil testing on the area.



Figure 52: Lane Sterilization (Top Left) Soil Testing (Top Right)

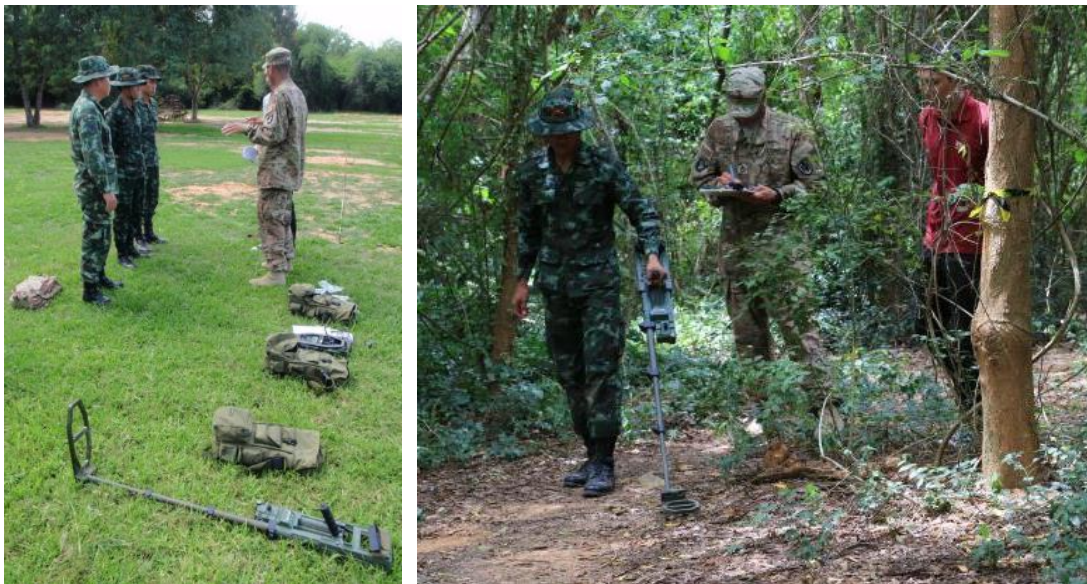


Figure 53: User Training (Bottom Left) Jungle Testing/Data Collection (Bottom Right)

As part of the IED lane vignette the C-IED users paired with TransApps users, supported by UAS imagery and the biometrics team, to execute a vignette designed to provide a demonstration of the potential interoperability of the technologies. Additionally, the C-IED team participated in the main DV day demonstration provided to visiting VIPs on the final day of CV15. After the completion of the IED lane vignettes the C-IED users completed user surveys to collect their impressions of the C-IED technologies. User feedback data, data collector and SME

observations, recommendations, corrections, and conclusions will be provided in the CV15 final report.

The C-IED team and their technologies were integral to the successful execution of the CV15 field experimentation event. The efforts of the team, and the diligence of their users, provided a collaboration and experimentation opportunity unique to the CV15 venue and valuable for continued theater engagement.

C-IED Data Collection Approach

The following information provides the data collection approach for each of the identified focus areas. To best utilize the limited training time with Thai users, each user was only trained to operate one type of system during CV15. This approach also helped to ensure more exposure time for users on their assigned system, with the focus on users being able to provide better feedback. Each SME and user involved in the C-IED data collection effort was asked to complete a demographics survey prior to data collection.

The following focus areas were identified for data collection during CV15:

- **Performance Accuracy**
- **Reliability**
- **User Feedback**

Performance Accuracy

SMEs and data collectors observed and recorded each identification attempt, the success or failure of that attempt, and false positive detections throughout CV15.

Data Collection Method: Primarily objective data will be collected on the accuracy of the C-IED handheld technologies. Data collectors recorded the number of detections each day, the number of successes and failures, false alarms, and the types of targets detected or missed. If a failure occurred SMEs were asked to provide their observations on why there was not an accurate identification.

Reliability

SMEs and data collectors recorded system failures and total system operating time throughout CV15. In this context a system failure was defined as the system not functioning as expected; e.g. loss of power, button malfunction, the impact of weather and/or the jungle environment, etc. Missed targets or false alarms were not considered reliability issues, instead they will be addressed under the accuracy portion of the data collection effort.

Data Collection Method: Primarily objective data was collected on the reliability of the C-IED handheld technologies. Data collectors recorded each time a reliability issue occurred. If a reliability issue occurred SMEs were asked to provide their observations on why the system did not function as expected. Systems were turned on during each operating period and remained on until the end of day. If batteries must be replaced the time will be noted by data collectors.

User Feedback

As part of the CV15 data collection effort, users were asked to provide feedback on the overall accuracy, reliability, and user friendliness of their assigned system. Each user was only trained on and operated one of the system types during the training and demonstration.

Data Collection Method: The user feedback portion of the C-IED handheld technologies data collection effort focused on subjective feedback from the users. Users were asked to complete surveys on the accuracy, reliability, and user friendliness of their assigned C-IED technology. Demographic information was also collected to help support the analysis of the data collection.

C-IEDs User Demographics

The following table provides a summary of the participants that supported the C-IED handhelds demonstration and evaluation.

Table 15: CV15 C-IED User Participants

Name	Organization/Command/Unit	Specialty	Years
Pongnarin Pirawd	Weapon Division	Infantry	34
Chitchai	Weapon Division	Infantry	11
Thanormsak	Weapon Division	Infantry	11
Jantawut	Weapon Division	Infantry	10
Amorn	2 nd Infantry Battalion	Infantry	4
Woradet	2 nd Infantry Battalion	Infantry	3 months
Saphakorn	2 nd Infantry Battalion	Infantry	3 months
Adisak	1 st Infantry Battalion	Infantry	8
Jirapong	1 st Infantry Battalion	Infantry	7
Nitikorn	1 st Infantry Battalion	Infantry	6

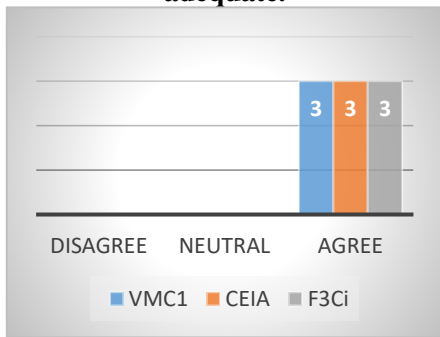


Figure 54: C-IED Team

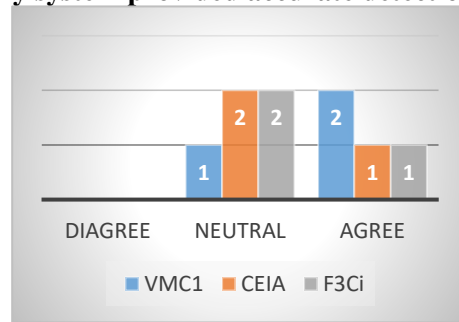
C-IED User Survey Results

As part of the CV15 C-IED handhelds data collection effort the C-IED handhelds users were asked to complete a survey to collect their feedback on the capabilities they used during the event. With a total of nine users, three users were assigned to each of the three C-IED handheld technologies. The following section provides that feedback.

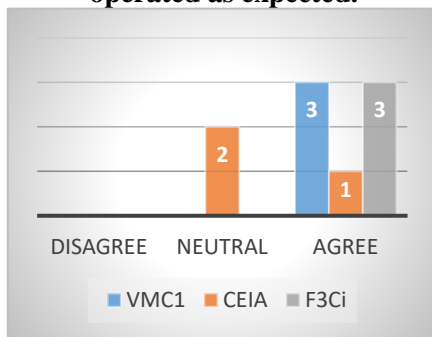
The training provided on my technology was adequate.



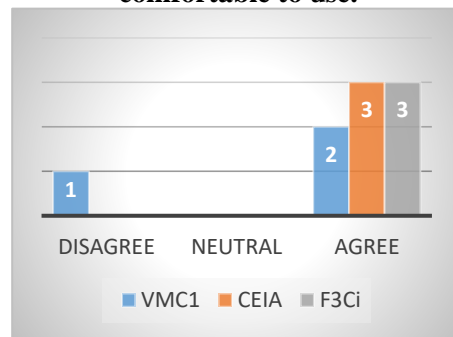
My system provided accurate detections.



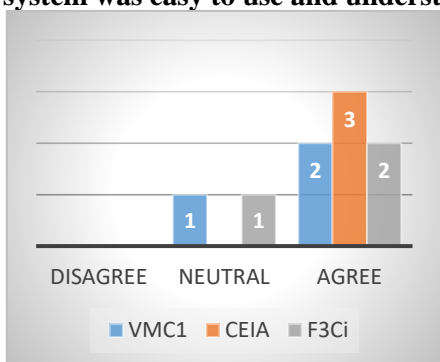
My system did not lose power and the buttons operated as expected.



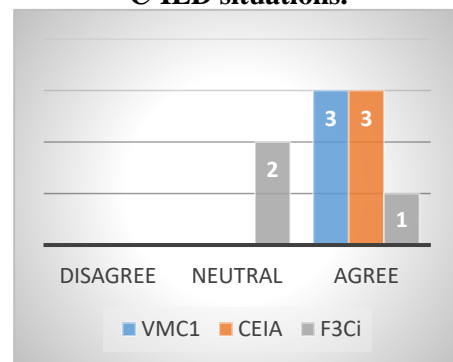
The design of my system was physically comfortable to use.



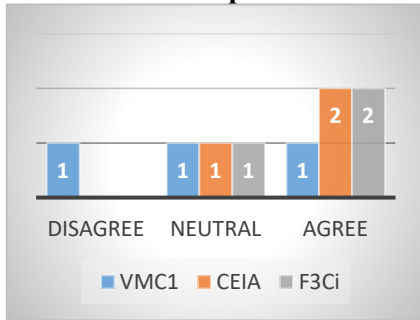
My system was easy to use and understand.



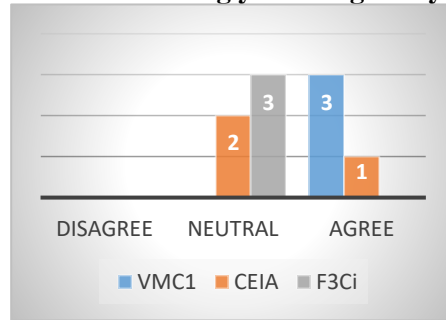
My system would be a valuable technology for C-IED situations.



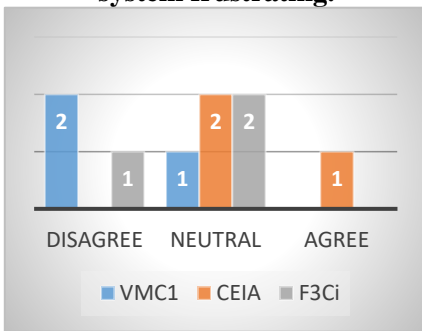
The physical activity required to use this system was acceptable.



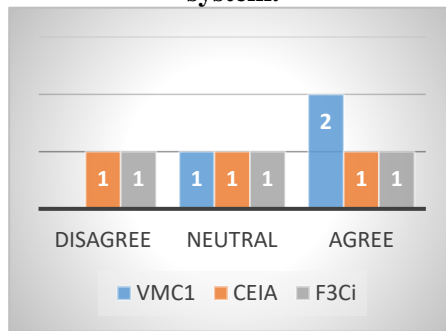
You feel that you were successful in detecting IEDs in this test using your assigned system.



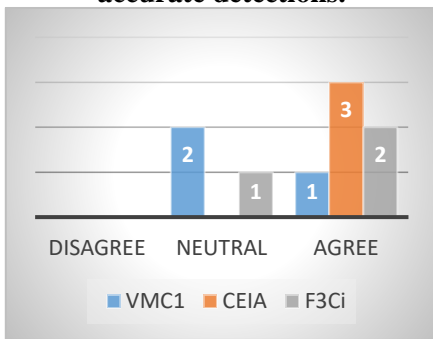
The operating environment made using the system frustrating.



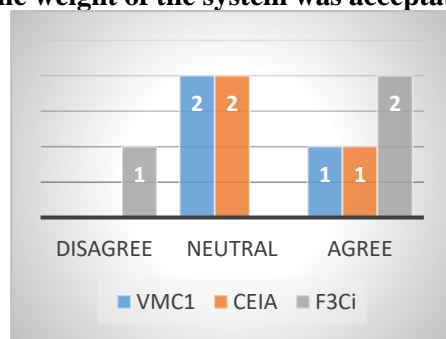
The weather did not affect the use of your system.



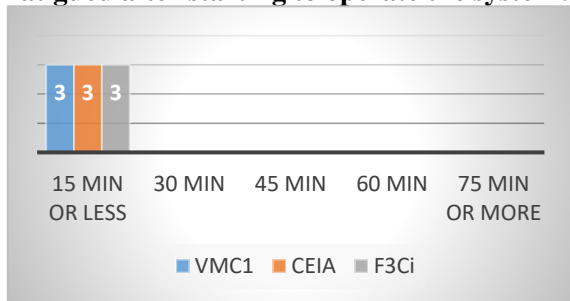
Fatigue had an impact on your ability to make accurate detections.



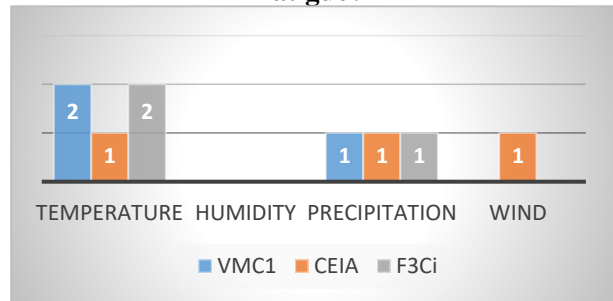
The weight of the system was acceptable.



How long did it take for you to start feeling fatigued after starting to operate the system?



What factor had the greatest influence on fatigue?



C-IED User After Action Feedback

After users completed training and CV15 vignettes they were asked to participate in an after action meeting to collect additional feedback. The meeting took the form of a round table discussion where each participant was asked to provide their verbal feedback to various questions. This section provides the feedback collected during the CV15 C-IED after action meeting.

Each user was asked to note which system they preferred and which system they liked the least. Users were also asked to provide additional features or system changes. The following are recorded user comments.

- Liked CIEA, was easy to use setup and reset, prefers the CIEA. VMC1, took too long to reset and setup
 - CIEA should have the vibrate option
- Liked VMC1, had multiple functions in one system vibrate, show light, and sound. Each function could be used in a real situation. Disliked the F3Ci, the sound continues to emit from the detector when the headphones are plugged in.
 - VMC1, anything that reduces setup time
 - VMC1 should have the ability to separate the rebar from explosive in the road
- Liked F3, easy to setup because it takes less time than the other two systems. Easy to use in the real situation. Disliked the VMC1, difficult to setup
 - F3Ci should have the button to control sound and address headphone issue
- Liked the VMC1, easy to setup and use, 3 options and can choose. Disliked the CIEA, takes too long to setup
 - Anything that reduces setup time
- F3Ci, easy to use and setup is easy. Disliked the VMC1, too slow, and setup too long
 - Function that can detect plastic and distinguish between plastic and metal
- Liked the CIEA. Disliked the VMC1.
 - Prefer the CIEA to have different sound for metal or mineral
- Liked the F3Ci. Disliked the VMC1.
 - Change volume in F3Ci
- Liked the CEIA, can detect the carbon rod. Disliked the VMC1, heavier.
 - CEIA sound for no detection and detection is too close, it was stressful
- Liked the CEIA, detect carbon rod, lighter. Disliked the VMC1.
 - Vibrate system for the CEIA
 - Ability to detect plastic
- Liked all detectors. For the functions every detector can address issues in Asia, its lighter. Problem of all detectors is batter. Takes a long time to bring the batteries to them. They should have the function to detect explosive like gunpowder and separate the sounds between rebar and metal, what is the rebar what is the metal, in urban warfare. Should have a long armrest that folds in and out for when they want to use it. Fuse all detectors into one. Lighter and smaller, that can carry by pocket.

C-IED Team Feedback and Lessons Learned

As part of CV15 daily evolutions an end of the day hotwash was held with all participating technology teams. These meeting provided team leads the opportunity to update CV15 staff on any issues they were facing, current and future operations, user and SME feedback, and any lessons learned. The following section provides a summary of the daily user and SME feedback, and lessons learned collected during these meetings.

SME Feedback

- Speed detection is totally different than US tech, how they have been taught to sweep is slow, not tactical just slow. With that rate of speed it would affect combat operations.
- The ground here is cluttered with everything from little screws, big screws, ammunitions, unidentifiable objects
- Observation: Getting a lot of high metallic false hits on all detectors
 - Not sure why the systems were detecting when hitting the high grass
- After users read handouts it was easier for them to understand
 - The users were a lot more engaged the following day as a result of reading the handouts
- Interpreters were excellent
 - Would like to have more options for information sharing. Too many questions that we can't answer do to FDO
- CIED team should have participated in at minimum the FPC and Final Site Survey

User Feedback

- During an AAR after training, users stated that the systems were very easy to learn. Setup procedures were difficult; hard to determine false hits from real hits until they were taught the proper procedures.
- Users expressed concerns about the specs of the detectors, in reference to weight and balance
- Users want to be trained on each detector, but time limitation only allow for training on one per user
- Users are concerned about the limitations in reference to the audio and the signal detection of the detectors (CEIA and VMC1), make it sound natural, device is too loud.
- The tone is unsettling to the users.
- Thai soldiers enjoyed teachbacks

Lessons Learned

Technology Focus

- Need to make sure clear guidance is given on target types to use, important to ensure target types are relevant to both parties AOR
- If we get info on the types of devices they see here there is a fabrication shop that can create exact replicas for future tests
- Having enough time on the front end of the event for the trainers to conduct their own testing provides a good opportunity for them to learn more about their equipment
- Operating in jungle environments will be challenging. There are a lot of false hits

- Additional data to capture includes moisture readings per target and target type
- Utilize Thai TTPs versus US, US team would need access to Thai TTPs before training
- Continue to build partner nation relationships through information sharing

Admin/Logistics Focus

- The Thai interpreter was a huge help
- Thai support team was critical to the successful completion of the C-IED lanes.
- Culturally taught not to ask question, users are taught to take notes during lecture, less willing to answer questions and interact in the beginning
- More time for testing with users before VIP day
- Continue to build partner nation relationships through information sharing

C-IED Conclusion

The overall objective to train Thai users on the successful operation of the C-IED handhelds, and to demonstrate the C-IED capabilities within plausible scenarios, was a success. The team gained valuable exposure to the demonstration environment and as a result were able to gain insight into their technologies and the training environment from a cultural, logistical, commercial, technical, interoperability, and environmental perspective. The following provides a brief summary of how those factors related to the C-IED operations during CV15.

Environmental Factors: The tropical nature of Thailand provided a new environment to operate the three C-IED handheld technologies. The humidity, wind conditions, and precipitation were all a factor during testing and operations. The C-IED team was provided a tent for operations in the training area, however, even with the shelter it would be likely that long term operations would be difficult for operators given temperature and humidity conditions.

Cultural Factors: The C-IED team spent the majority of their time training Thai users on the three handheld devices. The goal was to provide valuable training to the users while allowing them enough exposure to provide feedback on the systems. The trainers quickly learned that their users were not familiar an interactive training environment, where students ask questions when they have them, and trainers try to encourage students to ask questions and interact with them during training. Instead the trainers learned that their students are encouraged not to ask question or speak during training. As a result the trainers spoke with them and encouraged them to ask questions. They provided them guide materials on the systems in Thai so that their users felt more comfortable and knowledgeable about the systems. What they discovered was after the users read the guides they were much more willing to ask questions and interact. This led the very successful training sessions that ultimately allowed the Thai users to provide teachbacks, students teaching students, at the end of the event.

Logistical Factors: Logistics was an important factor for successful execution of CV15. Shipment of gear is a detailed process, and the C-IED team learned valuable information on how to successfully navigate that process. Due to the ever changing nature of shipping requirements into foreign countries the team's gear was delayed by one day. Given the design of the C-IED handhelds it would be difficult to find replacement parts in country. Therefore, future teams should take that into consideration when packing out gear for shipment.

Commercialization Factors: The C-IED team gained valuable feedback from the user surveys and round table discussion. Trainers learned that the systems are currently too heavy for local users and would hinder longer operations. They also learned that some of the sounds that tell the user if they have a detection versus no detection were actually so similar that it was stressful to the users. The C-IED handhelds are systems that would definitely fill a need in this AOR, but these factors along with others, would need to be considered were these systems to be used in Thailand.

Technical Factors: The C-IED handhelds performed well during CV15. However, the team did notice a number of false hits as a result of the soil in the area. The team learned that the soil was littered with all manner of metallic making detections tricky. Additional data on how the handhelds operated in a jungle environment was collected by the team and is still being analyzed in house to help support future development.

Interoperability Factors: The integrated vignettes provided an opportunity for demonstrating how the C-IED handhelds might be utilized in conjunction with other technologies during real world operations. CV15 also provided the opportunity to learn how their systems might work with the host country's TTP (Tactics, Techniques, and Procedures) and CONOPS (Concept of Operations).

Overall the C-IED operations during CV15 were of great benefit to the entire event, and the top notch team successfully supported all requirements with skill and speed.

ANNEX E: BIOMETRICS (RAPID RESPONSE IDENTIFICATION OPERATIONS) CV15 FINAL REPORT

Introduction

The following sections provide an overview of the biometrics technologies activities during CV15. The TEC, under the direction of the USPACOM J85, conducted a data collection and demonstration effort of the Secure Electronic Enrollment Kit (SEEK II), SEEK Avenger, Guardian Jump Kit, and the SRI International (SRI) Samsung Galaxy Pro Identification Tablet under field experimentation conditions as part of the Integrated Counter Improvised Explosive Device (C-IED) and Border Security scenarios conducted during the annual Crimson Viper Field Experiment 2015 (CV15) at the Fort Thanarat Infantry Center of the Royal Thai Army located in the Kingdom of Thailand, Prachuap Khiri Khan province, Pran Buri district, from 27 July through 7 August 2015. The first week of operations focused on equipment setup and initial data collection. The second week of operations consisted of daily demonstrations and data collection within the identified scenarios.

Biometrics Technology Descriptions

The following section provides brief description of each of the participating biometrics and biometrics support technologies. Additional details can be found in the technical specification section of this report.



Figure 55: SEEK II (Left) SEEK Avenger (Left Center) Jump Kit (Right Center) Galaxy Tablet (Right)

SEEK II (Secure Electronic Enrollment Kit) is a portable, ruggedized, handheld system manufactured by Cross Match Technologies, Inc. that combines forensic-quality fingerprint capture, rapid dual iris scan capability and facial capture technology. SEEK II is a comprehensive, multimodal identification and enrollment platform. The compact, portable system is designed for rugged field use, making it quick and easy for military, border control and U.S. government agencies to identify subjects and verify their identities in the field.

SEEK Avenger is a portable, ruggedized, handheld system manufactured by Cross Match Technologies, Inc. that combines forensic-quality fingerprint capture, rapid dual iris scan capability, facial capture technology, and multiple format credential reading technology. SEEK Avenger is a comprehensive, multimodal identification and enrollment platform. The compact,

portable system is designed for rugged field use, making it quick and easy for military, border control and U.S. government agencies to identify subjects and verify their identities in the field. **Guardian Jump Kit** is a multimodal biometric enrollment kit manufactured by Cross Match Technologies, Inc. that provides compact, highly mobile technology for capturing and transmitting forensic-quality digital fingerprints, iris images, photographs and demographic data. Guardian Jump Kit includes a mug shot camera, iris scanner, a portable handheld fingerprint scanner and global positioning system (GPS) feature that logs date, time and exact location of enrollments.

The **SRI Galaxy Pro Identification Tablet** is a low cost portable biometrics collection and identification system that provides world-class stand-alone iris identification and can serve as a remote collection device that interoperates with the ASTERIA Mobile Biometrics System for performing identifications from iris and face imagery. Utilizing SRI's Iris on the Move (IOM) technology, this device provides a multi-function Android tablet with the hardware necessary to collect Near-Infrared (NIR) iris and Visible Light (VIS) face images. Subjects can be enrolled into and matched via a local gallery or can be provided to any of the ASTERIA Biometrics Systems for enrollment and/or matching. Results from the ASTERIA Biometrics Systems can be displayed locally or on other monitoring devices, such as a Panasonic Tough Pad, providing a comprehensive enrollment and identification system for near real-time dismounted identity operations.

Biometrics Support Technologies



Figure 56: Cisco Access Points (Left) ASTERIA (Center) ASUS ROG G751 (Right)

The **Cisco Aironet 1550 Series Outdoor WiFi Access Point** provides a flexible, secure, and scalable mesh platform that is part of the Cisco Unified Wireless Network and the Cisco Service Provider Wi-Fi solution. It offers high-performance mobility across large metropolitan-sized areas. Carrier-grade design allows Wi-Fi for next-generation mobile data offloads. The Cisco Aironet 1550 Series provides high-performance device access through improved radio sensitivity and range with 802.11a/b/g/n multiple-input multiple-output (MIMO) technology, with two spatial streams. NEMA Type 4X enclosure helps ensure that the system can withstand demanding environments.

The **Aerial Surveillance Tracking Engaged from Remote Identification Assets (ASTERIA) Biometrics System** is an open architecture, scalable biometrics based system for providing

identity management. It supports a full range of capabilities including enrollment, authentication, and identification using multiple biometrics modalities. It is deployable in fixed or mobile configurations and is client server based, such as BIOWEB, using web services for remote services. It utilizes a range of standard portable devices and formats for remote entry of biometric information, including the SRI Samsung Galaxy Pro Identification tablet, SEEK II, SEEK Avenger and other devices. It also interfaces to larger scale SRI Iris on the Move (IOM) portals. Remote connection to the server is accomplished through common web Browsers. It provides a total end-to-end solution to identity management.

The **ASUS ROG G751 Series Laptop** is high-end gaming laptop that hosts the ASTERIA Mobile Biometrics System software and served a centralized server for a WiFi intranet that connected the SEEK II, SEEK Avenger, Guardian Jump Kit, and SRI Galaxy Pro Identification Table to a centralized database of biometrics records. The ASTERIA Mobile Biometrics System software can store the biometrics records of up to 10,000,000 individuals.



Figure 57: Actual gear onsite at CV15 (1) SEEK II; (2) SEEK Avenger; (3) Guardian Jump Kit laptop computer, fingerprint scanner, iris scanner, and mug shot camera; (4) SRI Galaxy Identification Pro Tablet; (5) ASUS server and Toughbook server remote screen

Biometrics Technology Specifications

The following section provides more detailed technical specification for each of the C-IEDs technologies. The information provided includes system specifications and benefits.

Table 16: SEEK II System Specifications

General Specifications	Features	Applications
<ul style="list-style-type: none"> • System components: Scanner unit with two-finger optical fingerprint platen, dual iris scan and facial image capture capabilities • Interfaces: 2 USB 2.0 host connections and 1 Ethernet port • Operating system: Microsoft Windows XP SP3 • Memory: 2 GB DRAM • Hard Drive: 64 GB removable solid state drive • Wireless: Supports 802.11 b/g, Bluetooth and includes embedded GPS technology • Supports 3G communications • Optional passport MRZ and smartcard readers • Dual hot-swappable batteries, 2.4 Ahr, Li Ion, with Smart Battery technology • Resistive touchscreen display (800 x 480 resolution, transmissive technology, daylight readable display) • QWERTY keyboard with tactile keys and backlighting • Touch pad cursor navigation with right and left mouse buttons • Directional noise cancelling microphone for voice sample capture • Supports on-board watchlist of up to 120,000 enrollment records plus latent records • Designed to meet RoHS, Mil-STD-810 and IP 65 standards 	<p style="text-align: center;"><u>Fingerprint Capture</u></p> <ul style="list-style-type: none"> • Large high-quality optical sensor 1.6" x 1.5" (40.6 x 38.1 mm) at 500 ppi resolution • First and only Mobile ID platform certified to Subject Acquisition Profile (SAP) 45 by the FBI. SAP 45 is for Severe Risk: Enrollment and Identification in battle field operations, verification against previously captured data • Forensic-quality rolled fingerprints adhere to the FBI Image Quality Specification (IQS) as defined in Appendix F of the EFTS • Optimized for use in bright sunlight • Available with Cross Match patented silicone membrane for exceptional image quality from difficult-to-capture (e.g. dry or worn out) fingerprints <p style="text-align: center;"><u>Iris Scan</u></p> <ul style="list-style-type: none"> • Iris matching speed in excess of 500,000 matches per second • Dual iris capture capability • 1.3 megapixel IR sensors • Fully operational in bright sunlight <p style="text-align: center;"><u>Facial Image Capture</u></p> <ul style="list-style-type: none"> • Biometric image capture with immediate feedback on image quality • 1.3 megapixel full color camera • Supports flash image capture in dark lighting conditions 	<ul style="list-style-type: none"> • SEEK II is designed for use in harsh environments where field operations require rapid, accurate biometric data capture and search against known watchlists • SEEK II is available to integrators for custom software development, including a full set of SDKs, drivers, and sample code for all peripheral functions • SEEK II is available with several software options, including MOBS enrollment application, FAST middleware, and IDTrak matching applications • SEEK II is also available with optional Latent Image capture <p style="text-align: center;"><u>SEEK II Physical Specifications</u></p> <ul style="list-style-type: none"> • Display: 4.1 inch • Unit size: 8.75" x 5.5" x 3.5" (22.2 cm x 14 cm x 8.9 cm) • Unit weight: 3.6 lbs (1.7 kg)

Table 17: SEEK Avenger System Specifications

Specifications	
Main Processor	Intel® Atom N2600 Dual Core – 1.6 GHz
Operating System	Windows® 7 Ultimate
Hard Drive	32 GB removable SATA solid state drive (64 GB optional)
Memory (optional)	2 GB DRAM (4 GB optional)
External Interfaces	2 USB 2.0, 1 ethernet, headphone and microphone jack
Cellular Data Connectivity (optional)	3G/4G (UMTS / DC HSPA+ & LTE) DC HSPA+ (850 / 1900 / 2100 MHz), LTE (700 MHz and AWS)
Other Wireless Communications	802.11 b/g/n, Bluetooth® 4.0 LE / 3.0 HS / 2.1 EDR and GPS

Ruggedized Standards	Designed to MIL-STD 810G and IP65
Display	5.0 Inch, 800 x 480 resolution resistive touchscreen
Keypad	Large backlit QWERTY keypad with optical mouse
Dimensions	9.5" x 6.2" x 1.8" (24.13 cm x 15.75 cm x 4.57 cm)
Weight	3.2 lbs (1.45 kg)
Battery	Dual hot-swappable, 2.9 Ahr, Li Ion
Battery Life	Up to 8 hours (use case dependent)
Operating Temperature	35°F to 120°F (2°C to 50°C)
Biometrics/Credential Capture	
Fingerprint Capture	500 ppi; FBI Appendix F (FAP 45)
Iris Capture	Stand-off, SAP 40 simultaneous dual eye, Autofocus range 6"-10" (15.24 cm - 25.4 cm)
Camera	5 MP autofocus, autoflash
Contact Card	ISO / IEC 7816 (CAC, PIV)
Bar Code Reading	Using Facial Camera - 1D / 2D (PDF 417, Code 39)
Applications	
Enrollment, Matching, and Transmission SDK	MOBS, IDTrak, and Transmission Manager SEEK Integrator SDK (finger, iris, face, credentials)
Additional Options	
MRZ Reader	ICAO 9303 and ISO/IEC 7501-1 (passports, visas)
RFID Reader	ISO/IEC 14443 documents (ePassports, PIV)

Table 18: Gardian Jump Kit System Specifications

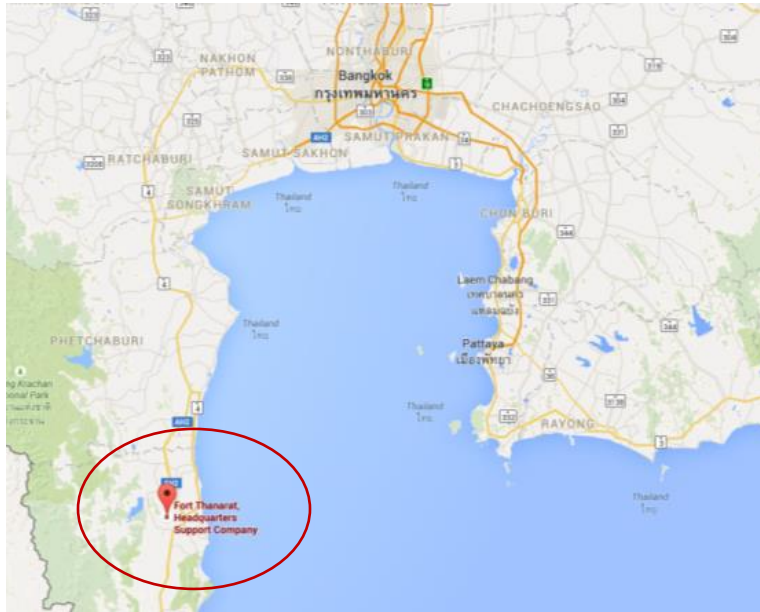
Specifications	
Main Processor	Intel Atom N2600 Dual Core – 1.6 GHz
Resolution	500 ppi
Image Quality	FBI specification EFTS Appendix F
Capture Area	3.2" x 3.0", single prism, single imager, uniform capture area
Operating Temperature	35° F to 120° F (1.6° C to 49° C)
Humidity Range	10-90% non-condensing; splash-resistant
Dimensions	6" x 6" x 5.1" (152 x 152 x 130 mm)
Weight	max. 5 lbs (2.3 kg)
Certifications	FBI-certified for both civil ID flats and full criminal ten-print rolls and flats; Ingress protection to IP66
Battery	Nickel-metal hydride battery (completely self powered)
Software	
MOBS (Mission Oriented Biometric Software) — Easy-to-use software enabling automated capture of finger, face and iris images in hostile environments where biometric processing speed is an absolute requirement for operator safety	
LSMS (Livescan Management Software) — Criminal booking software designed to quickly create EFT files for FBI background checks. Ensures forensic-quality biometric capture of fingerprint and mug shots, optimizing results of AFIS searches	
Components	
Iris Capture	Iris scanner
Camera	Durable digital camera
Fingerprint scanners	Portable handheld fingerprint scanners with tether cable

Case	Durable, water- and air-tight case containing all components
Computer	Panasonic Toughbook™ computer
Configuration	Plug-and-play capability allows Jump Kits to be configured based on users' requirements for field deployable ID management
GPS	Integration with satellite communications and other secure communications
Optional Software	
IDTrak for Rapid ID	
Quick Match	
Optional Components	
<ul style="list-style-type: none"> • Voice print recorder • MRZ Reader for collecting passport and ICAO travel document data • Mobile printer • Mobile AFIS – 65,000 ten-print records and 400 latent print databases • Dual submission and comparison against portable database on laptop or FBI's IAFIS, Department of Homeland Security's IDENT and other "watch list" databases • Document scanner for electronic import and transmission of credential documents or evidential documents found in the field 	

Table 19: SRI Galaxy Tablet System Specifications

Specifications	
Dimensions (WxHxD)	12.8mm x 21.9cm x .7 cm (5.1in x 8.6in x .3in)
Weight	331g (11.7 oz)
Battery	Li-ion 4
Drive Capacity	16 GB
System Memory (RAM)	2 GB
Connectivity	Wi-Fi, Bluetooth 4.0, IR LED (IR remote control);MHL 2.0 11-pin, HDMI
Processor Brand	Samsung
Processor Speed	2.3 GHz
Operating System	Android 4.4.2 KitKat
Display Type	Touchscreen TFT
Screen Size (diagonal)	21.4 cm (8.4 in)
Cameras	Rear-facing: 8 MP and Front-facing: 2 MP
Iris Capture Distance	16 to 30 cm (6.3 to 11.8 in)
Authentication Speed	< 1 sec
SRI Case (optional)	Enables enrollment and verification of others
Workflow Configurations	
<ul style="list-style-type: none"> • Individual: Self-enroll and verify on the tablet • Information: Add biometrics of authorized, pre-approved personnel to limit information access 	<ul style="list-style-type: none"> • Network: Remotely authenticate a user via Wi-Fi to authorize access to the tablet or specific information • Other Users: Enroll and verify other individuals with SRI case (optional) • Database: Store biometrics on board or remotely matech over wireless network

Biometrics Operating Location



CV15 field experimentation was conducted at Fort Thanarat, Khao Noi, Prachuap Khiri Khan, Thailand.

Fort Thanarat is based on about 600,000 hectares of land near Pranburi town with the entrance on the western side of Petchakasem Road. The base is home to the Thai Infantry and Armed Forces Preparatory School. Fort Thanarat is home to around 5,000 soldiers and their families.

Figure 58: Fort Thanarat Location

Two primary areas of operations were used during CV15. The UASs, TransApps, Fuel Cell, and Biometrics all predominantly operated in the area of the JOC. Because of the portable nature of some of the biometrics technologies the Thai and U.S. personnel operated the biometrics technologies in additional locations at the Fort Thanarat Infantry Center. The Guardian Jump Kit hardware was located in the Joint Operations Center (JOC) located in the building immediately east of the airstrip hangar. The server was located in the climate-controlled Unmanned Aerial (UAS) tent located next to the airstrip. The SEEK II, SEEK Avenger and SRI Samsung Galaxy Pro Identification Tablet were portable units that were in various locations within the range of the wide-area WiFi system generally defined as the runway and its immediate vicinity.



Figure 59: Primary Operating Location of Biometrics Technologies

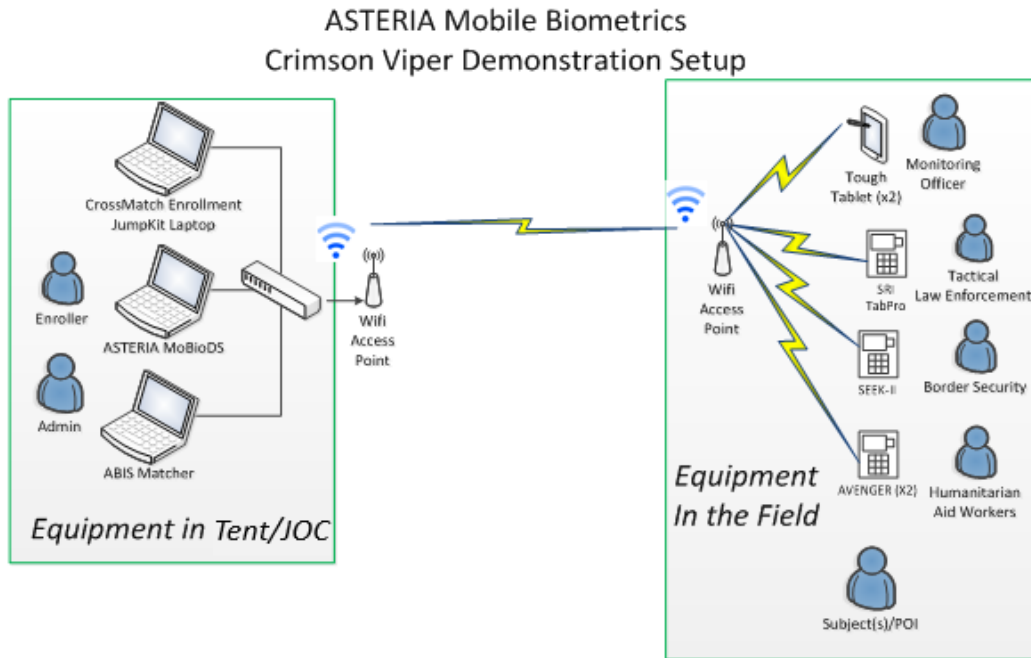
Biometrics Daily Schedule

The following table is a summary of the daily schedule and evolutions by day followed by the UASs team.

Table 20: Daily CV15 Evolutions

Evolutions by Day	
Day	
Jul 26	U.S. personnel arrived in Bangkok, Thailand.
Jul 27	U.S. personnel arrived at Fort Thanarat. Performed a site walk-through. Trained ONR-RC officer on use of biometrics equipment.
Jul 28	Initial set-up of equipment and trouble shooting. Trained three (3) DSTD officers. Performed initial data collection.
Jul 29	Set-up of equipment. Performed familiarization training by Thai and U.S. personnel.
Jul 30	Troubleshooting of equipment, set-up of WiFi equipment. Throughput testing of SEEKII.
Jul 31	Testing of WiFi ranges. De-confliction of WiFi and UAS frequencies.
Aug 1	Liberty day.
Aug 2	Performed Wi-Fi range testing. Finalized Biometrics vignettes.
Aug 3	Enrolled C-IED, Border Scenario and 10+ Thai participants into the biometrics database.
Aug 4	Completed RTAF user training. Executed biometrics portion of C-IED Patrol vignette. Executed Checkpoint vignette.
Aug 5	Executed Border Security Throughput vignette. Executed biometrics portion of C-IED vignette. Executed Checkpoint vignette. Manned static displays.
Aug 6	Manned static display for VIP day and performed live demonstrations of the technology.
Aug 7	U.S. After action meeting
Aug 8-11	U.S. After action report writing
Typical Daily Schedule	
Time	Event
0830	Arrived at Fort Thanarat
0830-1200	Operations
1200-1230	Lunch
1230-1630	Operations
1630-1700	Daily debrief
1700	Departed Fort Thanarat

Biometrics Technology Laydown



Biometrics Demonstration Support

Personnel that participated in the operations and testing of the biometrics technology throughout the entire CV15 event included one officer from Thai Defense Science and Technology Department (DSTD), one officer from the Office of Naval Research Reserve Component (ONR-RC), one U.S. government civilian, one Thai commercial contractor and one U.S. commercial contractor. Five additional RTAF officers participated with the biometrics technology on a limited basis. The U.S. Government civilian trained the ONR-RC officer and the U.S. commercial contractor on operations of the biometrics technology. The ONR-RC officer then trained six DSTD officers and one Thai commercial contractor. Additionally, approximately 33 Royal Thai Armed Forces (RTAF) personnel and approximately 25 U.S. military, U.S. government civilian and U.S. contractor personnel served as subjects as part of the C-IED and Border Security scenarios.



Figure 60: Jump Kit Enrollment (Left) and Verification (Right)

SEEK II, SEEK Avenger, Guardian Jump Kit, and the SRI Samsung Galaxy Pro Identification Tablet were intended to provide an independent, stand-alone, self-sufficient capability to use mugshot, iris and fingerprint biometric data collected in the field, to identify, and categorize persons within a field environment, using those same biometric measurements, within the CV15 C-IED and Border Security scenarios. The biometrics technology suite was operated and tested from 27 July through 7 August 2015. The first week of operations focused on equipment setup and initial data collection. The second week of operations consisted of daily demonstrations and data collection within the identified scenarios. Working hours each day were from 0800L to 1700L.

In addition to supporting the biometrics boarder security scenarios the biometrics team also supported both the patrol and IED lane vignettes. The biometrics technologies were integrated into each of the vignettes to provide a demonstration of the interoperability of each of the technologies, as well as to provide additional data collection opportunities for the biometrics testing. The biometrics team also supported the CV15 DV day by providing technology briefs and demonstrations in the static display area of the JOC.



Figure 61: Iris and Fingerprint Scan IED Vignette (Left and Center) Iris Scan Patrol Vignette (Right)

The biometrics team and their technologies were vital to the successful execution of the CV15 field experimentation event. The efforts of the team resulted in daily data collection and testing that will help to shape the future development of the biometrics technologies. Finally, the CV15 experimentation venue offered a unique collaboration and experimentation opportunity that was not only valuable for environmental and user testing within a new AOR, but for continued theater engagement with our Thai counterparts.

Biometrics Data Collection Approach

The following information provides the data collection approach for each of the identified focus areas. Each SME and user involved in the biometric data collection effort was asked to complete a demographics survey prior to data collection.

The following focus areas were identified for data collection during CV15:

- **Throughput**
- **Reachback**
- **System Accuracy**

- **User Feedback**

Throughput

Each biometric technology was looked at individually to determine the throughput level for that system within the confines of the demonstration. Additionally, once Thai users were provided training on the systems, separate throughput data was recorded.

Data Collection Method: Objective and subjective data was collected to identify the throughput rates observed during CV15. Designated data collectors observed and recorded the throughput rate during each run. SMEs and users were asked after each test run to provide their observations.

Reachback

When appropriate SMEs reached back to the regional server to access data. The current reachback time is around 3 minutes. The biometrics team looked to meet or improve upon that 3 minute reachback time.

Data Collection Method: Objective and subjective data was collected to identify the approximate reachback time for the biometric systems during CV15. SMEs were asked after each reachback test run to provide their findings.

System Accuracy

The biometrics technologies were expected to have a 99% success rate for identification. SMEs and data collectors will observe and record multiple identification attempts and the success or failures were recorded.

Data Collection Method: Primarily objective data was collected on the accuracy of the biometrics technologies. Data collectors recorded the number of attempts and the number of successes and failures. If a failure occurred SMEs were asked to provide their observations on why there was not an accurate identification.

User Feedback

As part of the CV15 data collection effort, users were asked to provide feedback on the overall user friendliness of each system. Users used any or all of the systems during the training and demonstration period so they are able to provide feedback on each system.

Data Collection Method: The user feedback portion of the biometrics technologies data collection effort focused on subjective feedback from the users. Users were asked to complete surveys on the user friendliness of each of the biometric technologies.

Biometrics User and SME Demographics

The following table provides a summary of the participants that supported the biometrics technology demonstration and evaluation.

Table 21: CV15 Primary Biometrics Participants

Last	First	Rank	Organization	Role
Carrizosa	Santiago	CDR	U.S. Navy Office of Naval Research Reserve Component	Scenario Lead
Ngamtuan	Tasapol	LTJG	RTN Military Research Development Center	Scenario Lead
Tan	Mike	Civ	Naval Air System Command SSP	Biometrics SME
Deo	Sunny	Civ	Neany Inc.	WiFi Equipment SME
Wade	David	Civ	SRI International	IT Server SME

Table 22: CV15 Secondary Biometrics Participants

Last	First	Rank	Organization	Role
Homjumpo	Sompol	Group Captain	RTAF	User
Nuyonwan	Boonchana	CDR	RTN MRDC	User
Chaichuay	Nikorn	CDR	RTN MRDC	User
Pokinwong	Prateep	Lt. Col.	Army RDO	User
Charksaen	Supatach	Lt	RTA MRDC	User



Figure 62: Biometrics Team

Biometrics Accuracy, Throughput, and Reachback Testing

The biometrics accuracy, throughput, and reachback testing was conducted throughout CV15. Testing was conducted in conjunction with troubleshooting software and hardware problems and therefore had to be restructured to adapt to the field conditions. As a result, testing was conducted when possible and not all tests were recorded as part of the data collection effort. The following section provides a summary of the data collected; organized by day, and with all user/data collector comments.

July 28, 2015			
Test Focus: Accuracy			
Technologies:	SEEKII	SEEK Avenger	Galaxy
(Attempts/Failures)	(6/0)	(6/0)	(6/0)
Feedback	None		
Test Focus: Accuracy			
Technologies:	SEEKII	SEEK Avenger	Galaxy
(Attempts/Failures)	(2/0)	(10/0)	(2/0)
Feedback	1444: Avenger to do local ID verification, fingerprint, success 1446: Avenger, Local ID, 10 sec., Used iris to ID, success confident 1445: Avenger, 3 iris, 3 finger print, 2 unknown, all OK		
Test Focus: Reachback			
Technology: Avenger	Time: 1131-1133	Success/Failure: Failure	
Feedback	Tried to ID person with the Joker playing card, no joy due to power failure. No UPS set up. Will need to setup 7kw generator		
Test Focus: Reachback			
Technology: Avenger	Time: 1059-1109	Success/Failure: Success	
Feedback	Enrolled the Joker, exported the file to the server, needed to enroll first then identify. Only showed thumb prints, not prints of 4 fingers. ABIS matching software prefers segmented fingers, not all fingers together. Software also prefers individual prints		
Test Focus: Reachback			
Technology: Galaxy	Time: 1201-1202	Success/Failure: Success	
Feedback	Reachback matching only took 5 seconds with 20k enrollments to check		

July 29, 2015			
Test Focus: Accuracy			
Technologies:	SEEKII	SEEK Avenger	Galaxy
(Attempts/Failures)		(?/many)	
Feedback	<ul style="list-style-type: none"> The Wi-Fi signal was weak in the JOC. This affects reachback so the solution was to alter the access points help improve signal Server crashed due to local time zone being used. The solution was to switch to zulu time. The software needs to be fixed to allow any time zone. Server had old profiles, sometimes multiple profiles or missing profiles for people causing the server to get confused Both Avenger units were consistently misidentifying groups (VIP, Allow, Alert). The system was just defaulting to the first category in the list which was Allow. 		

July 30, 2015			
Test Focus: Accuracy			
Technologies:	SEEKII	SEEK Avenger	Galaxy
(Attempts/Failures)	(4/0)		
Feedback	None		
Technologies:	SEEKII	SEEK Avenger	Galaxy
(Attempts/Failures)	(21/0)		(10/3)
Feedback	<ul style="list-style-type: none"> SEEK II used a local search Facial recognition issues with Galaxy likely due to inexperienced user. The conditions were also very bright, the Galaxy works better in indoor, darker conditions. 		
Test Focus: Throughput			
Technology: SEEK II	Time: 1405-1429	# Processed = 10	
Feedback	Processed finger prints (right index, left index) and iris. 9 persons were positively ID, 1 person was not in the system and was recognized as unknown. All checks were performed locally.		

Test Focus: Throughput		
Technology: SEEK II	Time: 1453-1516	# Processed = 4
Feedback	Checking throughput using reachback to server. The system correctly ID'd subjects when subjects gave false personal information. Actual reachback time was around 9-15 seconds.	

August 2, 2015		
Test Focus: Throughput		
Technology: SEEK II	Time: 1305-1334	# Processed = 33
Feedback	Only used iris scan to process, conducted indoor	

August 3, 2015			
Test Focus: Accuracy			
Technologies:	SEEKII	SEEK Avenger	Galaxy
(Attempts/Failures)			(6/0)
Feedback	None		
Test Focus: Throughput			
Technology: Jump Kit	Time: 0847-0915	# Processed = 10	
Feedback	Enrollment of Thai IED soldiers, successful		
Test Focus: Throughput			
Technology: Jump Kit	Time: 1433-1450	# Processed = 7	
Feedback	LTJG of RTN first time using the jump kit		



Figure 63: Biometrics Throughput Testing 8/4/15

August 4, 2015			
Test Focus: Accuracy			
Technologies:	SEEKII	SEEK Avenger	Galaxy
(Attempts/Failures)	(16/0)	(12/3)	(15/0)
Feedback	<ul style="list-style-type: none"> Galaxy did experience Wi-Fi issues but did not impact All failures for the Avenger were due to the iris scan 		
Test Focus: Accuracy			
Technologies:	SEEKII	SEEK Avenger	Galaxy
(Attempts/Failures)		(29/2)	
Feedback	<ul style="list-style-type: none"> Both failures on the Avenger were iris 		
Test Focus: Reachback			
Technology: Galaxy	Time: 0838-1602	Success/Failure: Success	
Feedback	<ul style="list-style-type: none"> 85 successful reach backs throughout the day The Galaxy is easy to use and user friendly. It is faster than the SEEK, however it must be connected with a strong connection. The system doesn't work with a weak connection. It is lighter than SEEK, also able to get results with only one eye or just facial recognition. If you input the wrong eye when scanning you will get a failure. 		
Test Focus: Throughput			
Technology: Jump Kit	Time: 1002-1006	# Processed = 2	
Feedback	System required 8 minutes to restart after 4 restart attempts		
August 4, 2015 (Patrol Vignette)			
Test Focus: Accuracy (Run 1)			
Technologies:	SEEKII	SEEK Avenger	Galaxy
(Attempts/Failures)	(4/1)	(5/0)	(2/0)
Feedback	<ul style="list-style-type: none"> SEEK II, all iris scans, very slow at processing. Stylus is very cumbersome. Avenger, all fingerprinting, weak connection, good equipment, very heavy, cumbersome, not designed for Asians, problems with Wi-Fi. Wearing gloves would make using the device difficult. Galaxy, light, lost signal often, size is perfect, and very fast 		

Test Focus: Accuracy (Run 2)			
Technologies:	SEEKII	SEEK Avenger	Galaxy
(Attempts/Failures)	(3/0)	(3/0)	(3/0)
Feedback	<ul style="list-style-type: none"> Avenger conducted local and regional reachbacks Galaxy, issues with the Wi-Fi 		



Figure 64: Biometrics Patrol Vignette

August 5, 2015		
Test Focus: Reachback		
Technology: Avenger	Time: 1335-?	Success/Failure: Failure
Feedback	<ul style="list-style-type: none"> Intended to do a 10 minute reachback test, however, after 3 failures and 1 success the Avenger crashed 	
Test Focus: Throughput		
Technology: Jump Kit	Time: 0941-1002	# Processed = 21
Feedback	<ul style="list-style-type: none"> Enrollment of 20 Thai soldiers, jump kit was operated by Thai users Smooth evolution, however, the picture capture was not consistent. It took about three attempts to get a good picture Software was assuming two spades on a card are eyes and trying to take a picture of the card only 	
Test Focus: Throughput (Biometrics Vignette)		
Technology: Galaxy	Time: 1055-1126	# Processed = 34
Feedback	<ul style="list-style-type: none"> The data collector did not record all of the successes versus failures, but the Galaxy appeared to have a very high failure rate 	
Test Focus: Throughput (Biometrics Vignette)		
Technology: Avenger	Time: 1055-1126	# Processed = 37
Feedback	<ul style="list-style-type: none"> No failures 	
Test Focus: Throughput (Biometrics Vignette)		
Technology: SEEK II	Time: 1055-1126	# Processed = ?
Feedback	<ul style="list-style-type: none"> SEEK II not identifying subjects, crashed in middle of test 	
Test Focus: Throughput (Biometrics Vignette)		
Technology: Galaxy	Time: 1305-1334	# Processed = 31
Feedback	<ul style="list-style-type: none"> Only using iris, the data collector did not record all of the successes versus failures, but the Galaxy appeared to have a very high failure rate 	



Figure 65: Biometrics Throughput Vignettes

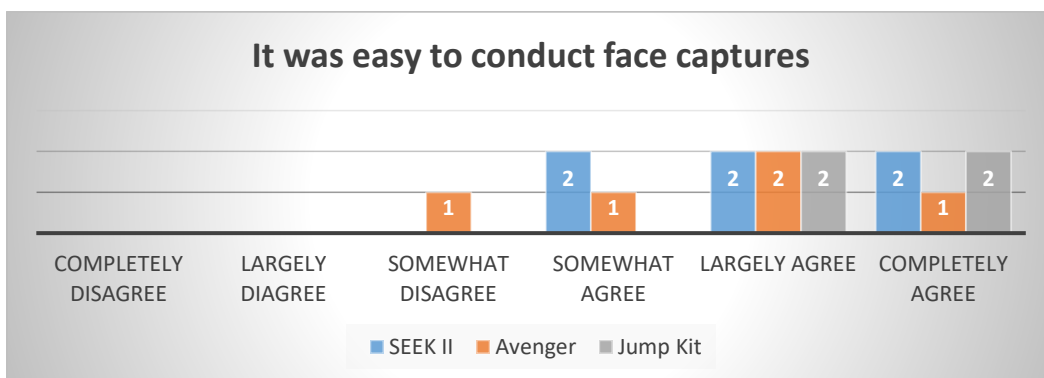
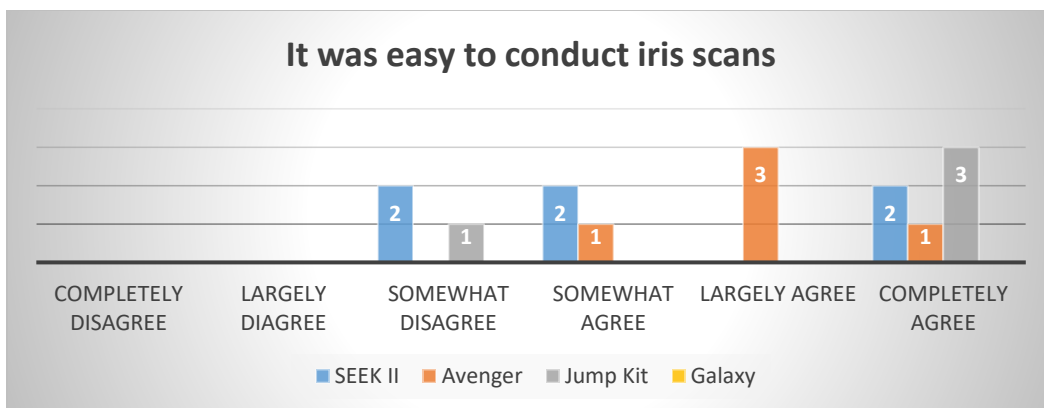
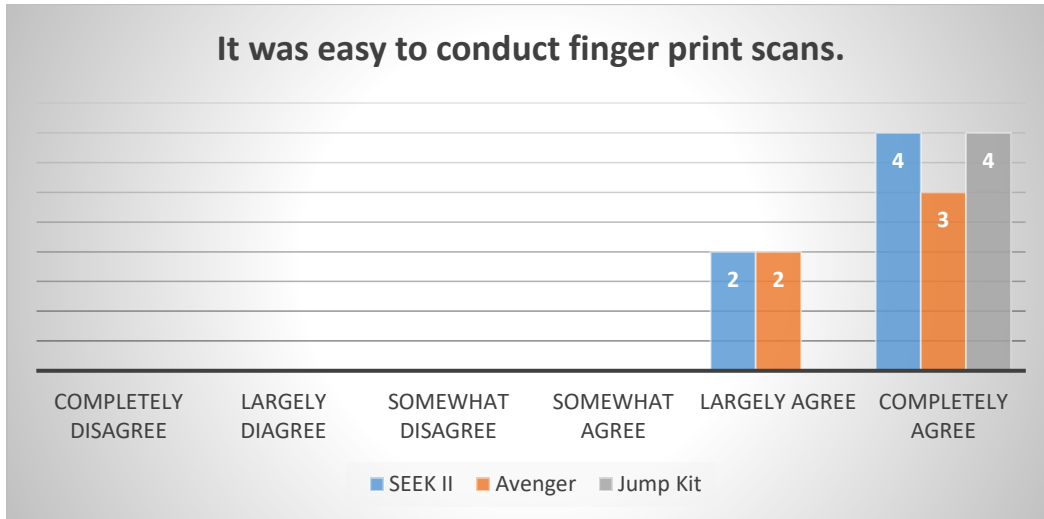
August 5, 2015 (IED Lanes Vignette)		
Test Focus: Accuracy (Run 1)		
Technologies:	SEEK II (Run 1)	SEEK II (Run 2)
(Attempts/Failures)	(4/0)	(5/0) Finger (10/10) iris
Feedback	<ul style="list-style-type: none"> All scans, iris and prints were a success in Run 1. The sun did make it difficult to see the screen and conduct iris scans All scans were successful in Run 2 	



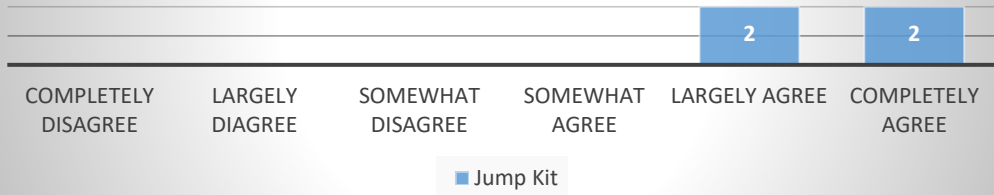
Figure 66: Biometrics IED Lanes Vignette

Biometrics User Survey Results

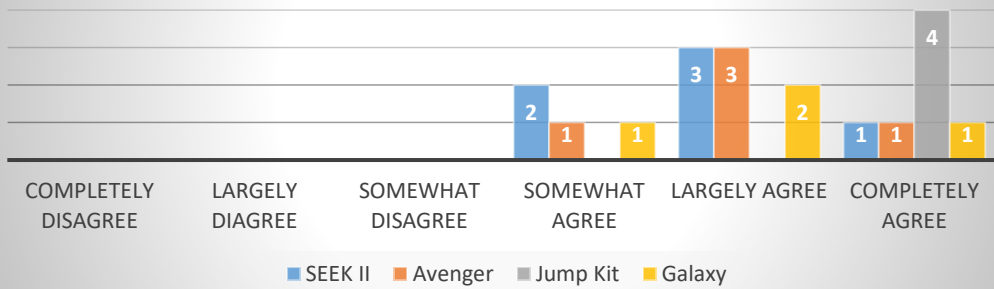
The biometrics surveys were completed by biometrics users with various levels of exposure to the technologies. Some users did not use every system and therefore only answered questioned related to the system(s) they operated.



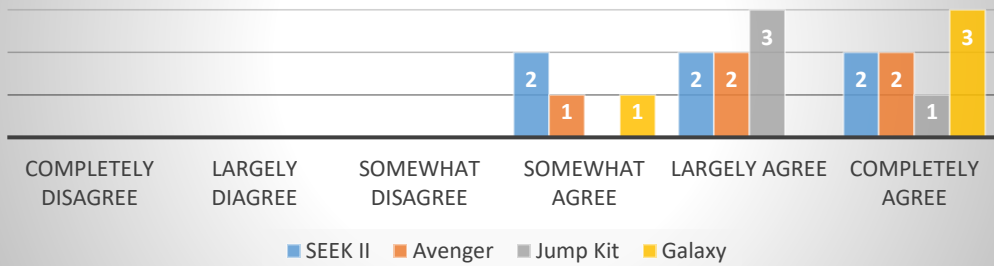
It was easy to conduct face captures with the Jump Kit.



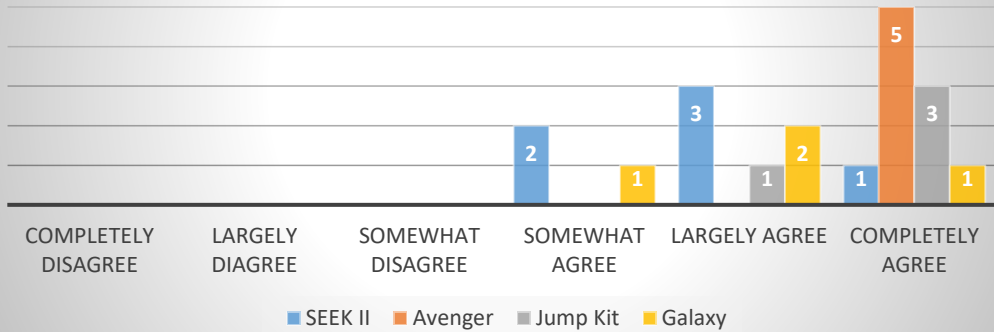
Overall the system was easy to use (user friendly).



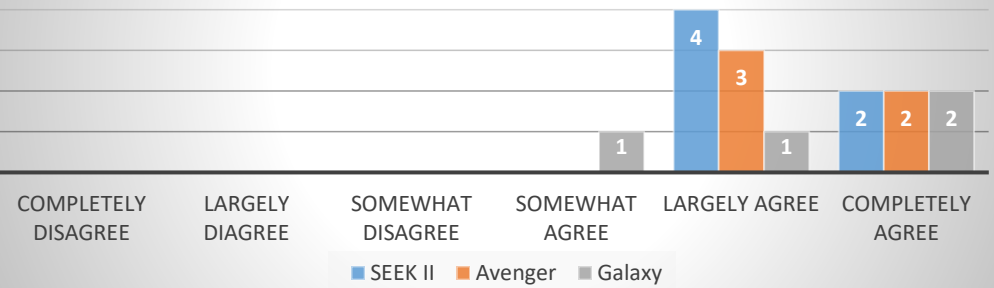
Overall the user interface of the system was visually appealing (clean, modern, organized).



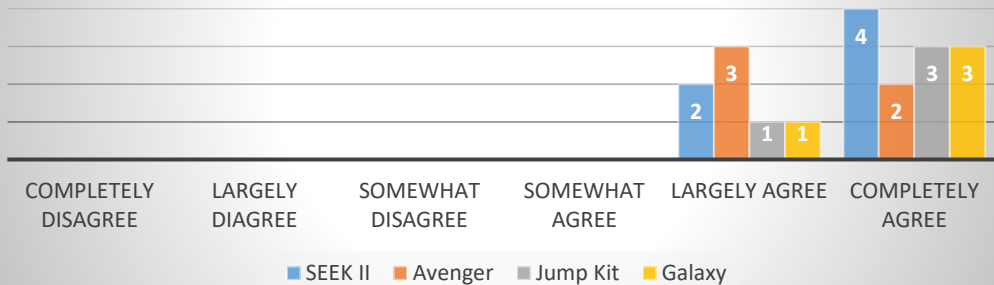
The time it took the system to collect and process information was good.

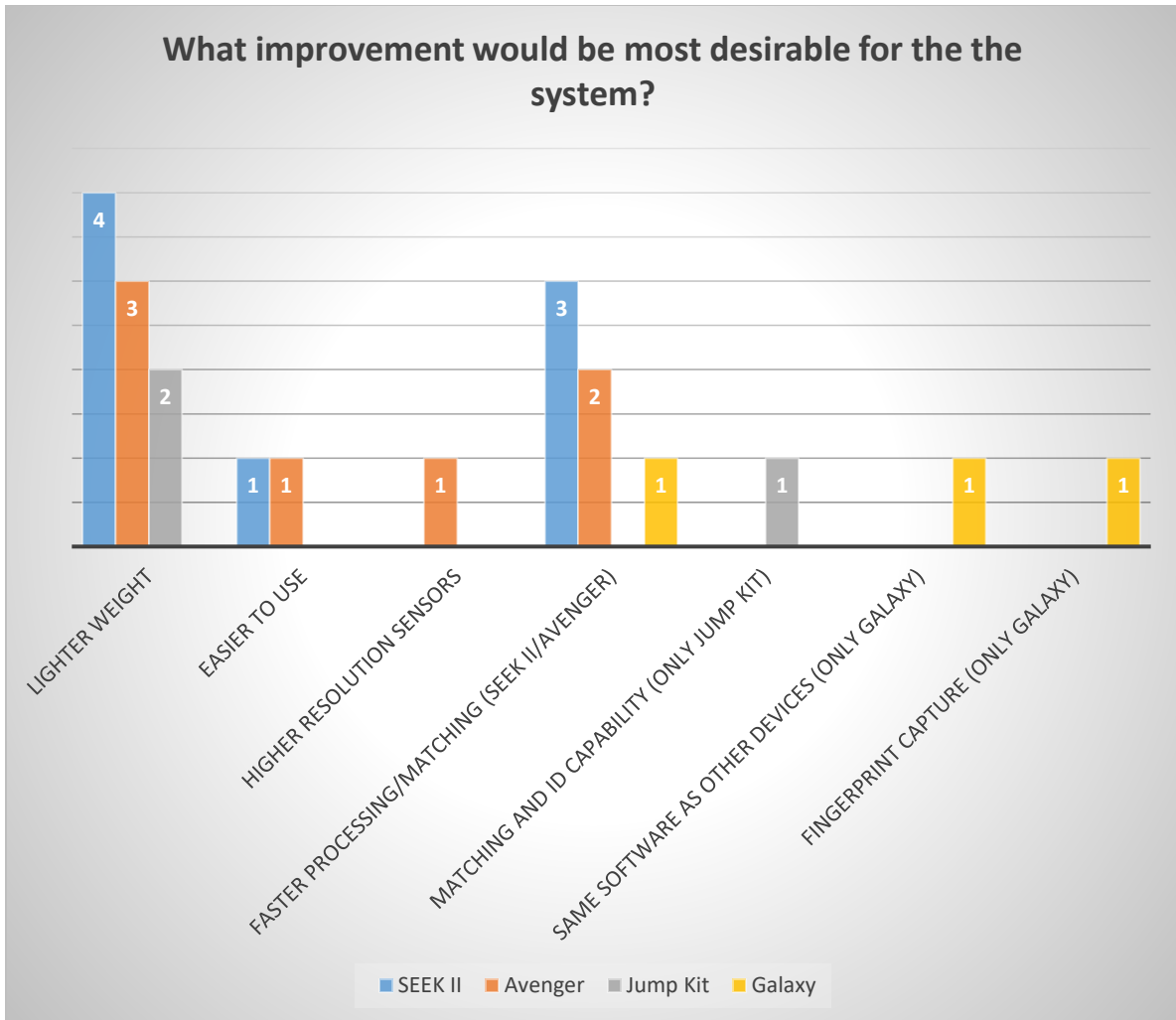


The system provided accurate information.



The system would be a valuable tool for Border Security and Checkpoint Processing.





Biometrics Team Lead Feedback

As part of the data collection effort for the biometrics technologies in CV15, the biometrics team leader, and SME, provided his observations and recommendations regarding each of the system demonstrated during CV15. This section provides his feedback in its entirety.

ASTERIA MoBioDS is an Open Architecture; Scalable Biometrics based system for providing Identity Management. ASTERIA MoBioDS supports a full range of capabilities including Enrollment, Authentication, and Identification using multiple biometric modalities. It is deployable in fixed or mobile configurations. In a client server architecture, it creates a Web services based biometrics identity services network (BIOWeb). Thin client systems then access the system through common web browsers. The CV-15 deployed the BIOWeb Server on virtual machines on laptop computers as a mobile ASTERIA configuration. The mobile ASTERIA configuration utilized a range of standard portable devices and formats for remote entry of biometric information, including the SRI Samsung Galaxy Pro Identification tablet (Iris on the Move), CrossMatch JumpKit, CrossMatch SEEK II, CrossMatch SEEK Avenger, and other devices. The mobile ASTERIA configuration also used a Panasonic ToughPad, to provide

operators a mobile monitor with access to the system to receive alerts and status. The CV-15 mobile ASTERIA configuration provided a total End-to-End solution to Identity Management.

Feedback: ASTERIA MoBioDS performed very well and was stable throughout the entire CV15 demonstration.

1. There were a few instances where the virtual machine that was running the Automated Biometric Identification System (ABIS) matcher would not start up properly due an error with the “integration service” not always starting up automatically. The temporary fix was to initiate the service manager and manually restart both the integration service and the Tomcat container service. This appears to be a temporary fix.
2. The only other issue with ABIS that we experienced during the exercise was when the system clock on the ASTERIA laptop was changed it cause ABIS to malfunction. Apparently, the ASTERIA MoBioDS system has three different time zones because it host two different virtual machines (VM), and those VMs needs to be synchronized in order for ABIS to function properly.
3. BIOWEB graphical user interface (GUI)
 - a. Overall the GUI is simple and user friendly. The matching/identification response time was fairly quick (5-10 seconds) with the database of 25K subjects. The system had a high percentage of accuracy using the handheld devices for subject reach back and identification.
 - b. System Improvements:
 - i. Increase the number of encounters from the previous 10 subjects to at least 50 in the history row above and below.
 - ii. The encounter page should not automatically clear after 24 hrs. It should stay present regardless.
 - iii. The encounter page – needs automated daily download report into a known folder for reporting and archive.
 - iv. Subject page - The category (Alert, Allow, and VIP) should be immediately next to the subject’s portrait for ease of search and categorization.
 - v. Subject page – search function only allows for one name at a time. Example, only “John” is allowed and when you type in “Doe” to narrow the search the “John” search is removed.
 - vi. Subject page - Improve filter and add more filter (middle name, DOB, etc)
 - vii. Health Tab – Additional system information like CPU, Processing, Services.
 - viii. The “log tab” is not functional and cannot export any logs?
 - ix. Upload Tab - There seem to be a redundant step in the identification and enrollment process.
 - x. Needs to be integrated with the CrossMatch devices and MOB’s software. The current reachback process has too many steps. It roughly takes 3 min/person from start to finish.

SRI Galaxy Pro Identification Tablet

The SRI Galaxy Pro Identification Tablet is a low cost portable biometrics collection and identification system that provides stand-alone iris identification and can serve as a remote collection device that interoperates with the ASTERIA MoBioDS System for performing identifications from iris and face imagery.

Feedback: The SRI Galaxy Pro Identification Tablet was much lighter in weight and slimmer form factor compared to the Crossmatch devices, and was the preferred device among the Thai users. In addition, the software GUI was much easier to use than MOBS and the response time was fairly quick when there was good Wi-Fi coverage.

1. The identification process required three easy steps and was fairly quick with only face and iris (left and right). However, the tablet lacked the capability to capture fingerprints which a major and only setback for this device.
2. The face capture feature functioned well and there were no real issues. However, the iris capture feature (both left and right) experienced a lot of issues when used outdoors and even had instances where the camera was not able to capture of iris when there was a lot of light indoors, i.e. near an open window. This resulted in a lot of iris capture failures and required the multiple attempts before the iris can be captured properly by the user.
3. There were instances when the user attempted to capture the left iris and strangely the right icon on the GUI was checked.
4. The system provides a “no match” result when the user accidentally or intentionally reverses the iris capture procedure, for example, capturing the left iris instead of the right.
5. The SRI Galaxy Pro Identification Tablet GUI was overall very simple and easy to use. The matching/identification response time was fairly quick (~15 seconds) when there was ample Wi-Fi signal strength
 - a. Improvements
 - i. The “new subject” button. The “new subject” button consists of three very small dots on the right upper hand corner home ASTERIA Demo GUI. The button is way too small for users to push and not very intuitive. There should be a large icon or + symbol on the Home GUI for new subjects and enrollments.
 - ii. Wi-Fi connectivity. The device seems to suffer from poor connectivity during the CV15 exercise, which caused the system to fail with a warning label indicating that there was an error processing your request. The users experienced this issue repeatedly. Other biometrics handhelds and mobile devices utilized during the CV15 exercise did not lose Wi-Fi connectivity within immediate vicinity of the Wi-Fi tower. It is possible that the Wi-Fi antenna on the SamSung Galaxy Tablet is weaker compared to the other biometrics devices used during the exercise or that the Wi-Fi antenna signal strength was damped by the ruggedized plastic/rubber case. The poor signal strength cause the device to be unreliable throughout the exercise.
 - iii. Matching Status – after pressing the identify button the matching status/process appears in small text on the screen and then disappears. This text should be much larger and centered in the middle of the screen and remain constant, like a progress indicator, until the match result is provided. User will often press the identify button repeatedly because they were uncertain if the transaction was sent. This result in the ABIS MoBioDS processing 5-10 extra submissions which causes the system to slow down or the tablet to crash or not provide the correct result
 - iv. Match Results – the text or more importantly the subject category should be much larger and in color similar to the BLOWEB results page. The current text is very small and “alerts” can be easily overlooked. If an alert is found the entire screen should be RED indicated that the subject should be stopped.

- v. Enrollment Summary arrow seems to only that last subject and does not provide a history of previously encountered subjects.

CrossMatch Jump Kit

The Jump Kit is a multimodal (Finger, Face, and Iris) biometric enrollment kit that provides compact, highly mobile technology for capturing and transmitting forensic-quality digital fingerprints, iris images, photographs and demographic data.

Feedback: The Jump Kit allowed for quick bulk enrollments of subjects and the overall the system performed well once the software was able to launch. Both iris and fingerprint sensors were very fast and easy to use. There were a lot of positive comments on how fast the iris capture was.

1. There were several occasions during the exercise when the MOBS software would not launch even after repeated system restarts and hard resets. The MOBS software would eventually launch after 10 minutes of inactivity. MOBS seem to have a difficult time reopening after being closed. Perhaps, the issue has something to do with Wi-Fi connectivity because MOBS opens very fast when the Wi-Fi on the computer is disabled or when the computer is not initially connected to a network.
2. The photo capture within MOBS had a difficult time capturing faces. Even though the bounding box was around the subject's face when the picture was taken, the image that would return is often the subject's shoulder or something in the background. Multiples photo attempts were taken before a suitable picture was provided.
3. Photo capture often takes a few seconds to process after the image is taken, there should a progress indicator that lets the subject or user know when the camera or subject can move.
4. The military battery was a nice feature to have during the IED exercise and prove to be valuable

CrossMatch SEEK II

SEEK II (Secure Electronic Enrollment Kit) is a portable, ruggedized, handheld system that combines fingerprint capture, dual iris scan, and facial capture technology. SEEK II is designed for rugged field use, making it quick and easy for military, border control and U.S. government agencies to identify subjects and verify their identities in the field.

Feedback: The SEEK II performed satisfactory and was relatively more reliable than the Avengers. The SEEK II system software and search function performed much slower than the Avenger, but it did not encounter the software (group database and ID Trak SOA) issues that crippled the Avengers during the exercise. The Thai users preferred the SEEK II's iris capture system better than the Avenger, and found that it was much easier to use on the subjects.

1. The SEEK II system performed relatively fast (15-20 seconds) local finger and iris searches.
2. Hot-swappable batteries were essential for maintaining system operations throughout the day.
3. On the last day of the exercise The SEEK II experienced the same ID Trak SOA startup error as the Avengers. Currently, the search finger and iris function on the SEEK II is not operational and needs to be reimaged to temporarily fix the ID Trak SOA startup issue. We are working with CrossMatch to remedy this issue.

4. The computer screen is not very bright for outdoor usages, especially when the user is trying to align the subject's irises.
5. This system with the current version of MOBS is not ready for deployment and does not meet NAVAIR requirements for near real-time identification. In addition, the MOBS software is not integrated with BIOWEB/ASTERIA for system reachback. The current work around solution requires too many steps.

CrossMatch Avenger

The Avenger is essentially the next generation update of the SEEK II with an updated fingerprint sensor, stand-off dual iris capture, passport reader, larger screen, and faster processor all in slimmer design.

1. The fingerprint and iris search feature was slightly faster (10-15 seconds) than SEEK II.
2. Hot-swappable batteries were essential for maintaining system operations throughout the day.
3. The overall system performance was slow and the MOBS software had issues starting up again after prolonged usages.
4. The system had numerous hardware and software issues that render it non-operational on several occasions during the exercise. The main issue appears to be with the ID Trak application. Problems with this particular service caused the following issues:
 - a. Watchlist searches with fingerprints and irises from different subjects always gave the same result. It appears that everyone who was searched locally with the Avenger, the result was always come back to what the default answer was set to (either allow or deny). This is a huge error and system problem that will cause false positive or false negatives matches.
 - b. Caused the ID Trak SOA application to crash/fail or not start up. This error causes the MOBS software to not launch when reopened or causes the MOBS software to significantly slow down during extended usage. As a result of the ID Trak SOA not being able to start, both the local fingerprint and iris search function are no longer available or non-functional in MOBS. Thus, making the Avenger non-operational for identification searches.
 - c. The system was reimaged several times in attempts to fix the ID Trak SOA issue. The initial software update did fix the watch-list default categorization issue; however, that updates seemed to broken the ID Trak SOA automatic start up function. We did discover on the last day of the exercise that when the system/device Wi-Fi connection was turned off the ID Trak SOA is able to restart and the normal functions of MOBS is temporarily restored.
 - d. The fingerprint sensor on one of the Avengers stopped working. We are still uncertain what caused this malfunction. However, we were able to fix it by swapping out the fingerprint sensor for another and restarting the fingerprint sensor drivers.
 - e. The users had a difficult time with the iris capture with the Avengers. The iris capture was difficult to keep stable and did not perform well in capturing good iris images during the initial testing with Southeast Asian. This is perhaps due to the shape of their eyes compared to Caucasians.
 - f. The stand-off iris capture feature on the Avenger did not perform well in direct sunlight as advertised in the company brochure. The users had many failed attempts before being able to capture just one iris. During these attempts, the iris capture

- function would time out and required the user to restart the MOBS software or repeat the iris image capture procedure again.
- g. The system is too bulky and heavy for extended usage.
 - h. The same recommendation is put forth to this device as the SEEK II. “This system with the current version of MOBS is currently not ready for deployment and does not meet NAVAIR requirements for near real-time identification. In addition, the MOBS software is not integrated with BIOWEB/ASTERIA for system reachback. The current work around solution requires too many steps.”

Biometrics ONR Assessor Feedback

As part of the data collection effort for the biometrics technologies in CV15, the biometrics assessment team leader, and ONR-RC representative, provided his observations from the CV15 biometrics demonstration. This section provides his feedback in its entirety.

Observation 1: The SEEK II, SEEK Avenger, and Jump Kit had significant operational problems that included the freezing of the software, slow software response times, and inability to connect to the servers.

Feedback: Nearly on an hourly basis throughout CV15 the U.S. government civilian and U.S. contractor SMEs had to perform administrator-level troubleshooting one or more of biometric systems.

Recommendation: Cross Match Technologies, Inc. should perform significant quality control of the software and its effects on the OS, the various hardware subsystems, and other applications prior to fielding these units in any forward training or operating environment.

Observation 2: There were numerous hardware issues with the SEEK II and SEEK Avenger including non-function iris and fingerprint scanners and non-functioning keyboards.

Feedback: Each of the numerous software patches implemented during CV15 had unintended consequences that would have a significant impact on either the functioning of the OS, the software applications or the hardware itself. Every time a problem was believed to be fixed, usually after an extraordinary amount of man hours expended in troubleshooting, the systems would breakdown again.

Recommendation: Significant quality control of the software and its effects on the OS, the various hardware subsystems, and other applications needs to be thoroughly vetted by Cross Match Technologies, Inc. prior to fielding these units in any forward operating environment.

Observation 3: The two-battery system for both SEEK II and SEEK Avenger proved to be very useful.

Feedback: The battery chargers were easy to use and the feature that one battery can be changed at a time while the unit keeps operating is a very useful feature and allows for much operational flexibility.

Recommendation: None.

Observation 4: The stylus attached to both the SEEK II and SEEK avenger can be used as a potential deadly weapon by any detainees or other dangerous subjects.

Feedback: None.

Recommendation: Do not use a stylus for the SEEK II or SEEK avenger. Rather, produce a unit that is more like a tablet, with a bigger screen, making the stylus not necessary.

Observation 5: Enrolling personnel is too cumbersome using SEEKII and SEEK Avenger.

Feedback: The enrollment of a person requires the user to push too many buttons, switch back and forth too many times between menus, each step requires a long wait time, etc.

Recommendation: Place a menu of the top five most common processes on the top-most menu. When a process is chosen, the sequential screens should flow sequentially much like buying an airline ticket on a civilian airline's website or a software installation wizard. Also, a voice recognition feature would help make this process be more hands free. Also, instead of the user having to wait for each step while the computer process information, the computer should be able to multitask and eliminate the waiting, and do the processing in the background.

Observation 6: Many Thai users mentioned that SEEK II and SEEK Avenger are too heavy for long-term daily use by Asians. They recommend a smaller handheld device similar to the SRI Samsung Galaxy Pro Identification Tablet be used.

Feedback: A common theme expressed by Thai RTAF personnel is that SEEK II and SEEK Avenger, as well as several other U.S. ruggedized portable equipment, are too heavy to be used by Asians. Yes, they can use the equipment for short periods of say 2-3 hours without a problem. However, extended, daily use would induce fatigue.

Recommendation: Make the necessary effort to try to reduce SEEK to the size and weight of a medium or large, ruggedized tablet computer.

Observation 7: The software in all of the equipment was only in English.

Feedback: In CV15, as in previous CV events, U.S. personnel normally interface with S&T officers who have at least some proficiency in English. However, ideally, U.S. personnel would have interfaced with both a mixture of Thai S&T officers, and RTAF personnel, ideally enlisted personnel, who perform military policing duties or other related functions. These security personnel may not be as proficient in English as the S&T officers and hence would likely find the software and menus difficult to use.

Recommendation: Have a database of all of the terms in all the menus in some 10-20 languages and have the languages be easily chosen by the user. Also, there should be the option to input one or more menus in any other language. The software should be able to handle scripts other than the Latin alphabet such as Thai, Korean, Arabic, etc.

Observation 8: SEEKII, SEEK Avenger, SRI Samsung Galaxy Pro Identification Tablet, and Guardian Jump Kit had great difficulty in scanning the irises of East Asians and Southeast Asians.

Feedback: Repeated, throughout CV15, all of the equipment consistently had more trouble obtaining the iris scans of East Asians and Southeast Asians compared to that personnel with more rounded eyes. The cause could be that eyelids, and in some cases, the eyelashes, cover more of the iris in East Asians and Southeast Asians than other personnel.

Recommendation: Test and understand this difficulty, then adjust the technology to compensate for this performance issue with the technologies.

Observation 9: SEEKII and the Jump Kit requires the user to place one hand behind the head of a subject while pressing the eyes against the iris scanner visor.

Feedback: Touching the head of a Thai is culturally unacceptable and has the potential to cause cultural misunderstandings.

Recommendation: The technology used in SEEK Avenger and SRI Samsung Galaxy Pro Identification Tablet should be developed further to make iris scans as easy to obtain as with SEEK II and Guardian Jump Kit so that touching the head of a subject is not necessary.

Observation 10: Obtaining an iris scan for both the SEEKII and the Jump Kits is much easier than using the SEEK Avenger or the SRI Samsung Galaxy Pro Identification Tablet.

Feedback: Throughout, CV15 SEEK II and Guardian Jump Kit could more easily obtain iris scans than could the SEEK Avenger or the SRI Samsung Galaxy Pro Identification Tablet most likely due to the fact that SEEK II and Guardian Jump Kit requires subjects to press their heads up to a visor on which the iris scanners were mounted, thus ensuring optimum scanner distance from the eyes, producing better iris scanning lighting conditions, and greatly reducing the relative movement between the subject's irises and the iris scanner. For users using SEEK II and Guardian Jump Kit must develop proper iris scanning techniques over a period of time, likely on the order of 2-3 weeks.

Recommendation: Develop ways that can better compensate for distance and shakiness by the user.

Observation 11: The use of an intelligent, motivated, friendly interpreter greatly helped the Thai-U.S. interactions.

Feedback: While all of the Thai officers had some knowledge of English, the overall proficiency level was not enough to be able to convey a large amount of technical information in a short amount of time regarding instruction and training of the biometrics equipment. The translator employed to assist interactions with Thai officers during the orientation, training, and scenario execution phases of CV15.

Recommendation: Continue to employ translators with the quality, training and disposition of those provided by NSM.

Observation 12: The CISCO wide-area Wi-Fi had significant issues regarding frequency interference with the UAS and it interfered with biometrics operations.

Feedback: The CISCO wide-area Wi-Fi operated on channels a set number of channels. . The UAS operated on all of the same channels with one additional channel. This left the only one channel as a useful frequency.

Recommendation: Match Cross Technologies should determine the least obtrusive Wi-Fi frequency relative to all of the frequencies commonly encountered in forward operating areas and produce a system that is compatible for combine environments.

Observation 13: The CISCO Access Points worked well outdoors and in rainy conditions.

Feedback: The CISCO Access points had no issues with precipitation or other environmental moisture.

Recommendation: None.

Observation 14: Battery chargers worked well with the local electricity supply of 240VAC, 50 Hz, U.S.-style wall outlets.

Feedback: CV15 participants had no trouble with charging and keeping charged all of the portable biometrics equipment.

Recommendation: None.

Observation 15: Comprehensive administrator-level training would be required for any unit to be able to independently operate this technology in order to troubleshoot types of equipment failures that often arose during CV15.

Feedback: Several software issues occurred every day and seemed to occur during every formal testing event. Often the users would have to hand one of the units to the SMEs to try to get the unit working again. This severely hampered almost every CV15 undertaken. Had the SME not been available, the equipment would have been largely useless. Administrator-level training is needed to be able to keep the units working.

Recommendation: When providing these biometrics systems such as the one used in CV15, comprehensive administrator-level training must be provided to have at least one SME that can troubleshoot and repair the hardware and software at are so prevalent with these particular systems.

Observation 16: Real-world use of this data would need a tie-in to actual biometrics data bases or an extensive enrollment effort with a proportional number of biometric enrollment units.

Feedback: The overall biometrics systems as evaluated in CV15 provided only four points for enrolling detainees and all would have to work with 1-2 km at most of each other due to the WiFi ranges of the CISCO Access Points. At present, it is not known by the CV15 participants what is the actual concept of operations (CONOPS) of the biometrics technology is so that the CONOPS can be tested in a more realistic field trial with realistic data bases and realistic enrollment and identity verification scenarios.

Recommendation: Make the CONOPS or intended CONOPS known to any exercise participants so that the systems can be tested against actual CONOPS can be tested against established standards or expectations.

Observation 17: SEEK II, SEEK Avenger, SRI Samsung Galaxy Pro Identification Tablet, Guardian Jump Kit, and the ASUS can all be readily shipped in ruggedized carrying cases.

Feedback: All of the equipment was able to easily packed, transported and unpacked on a daily basis. The carrying cases worked well. This was critical as the equipment contained the biometrics of the CV15 participants and had to be packed up at the end of each day and taken back to the hotel room of the CV15 participants. The cases protected the equipment well.

Recommendation: Continue to refine the carrying case system so that the total weight of the box and the equipment is about 40 lbs [18 kg], thus providing an extra 10 lbs [4.5 kg] of additional gear (books, notes, papers, etc.) to be included in the cases as may be required.

Observation 18: The CISCO Access points were shipped without tripods, requiring having to improvise the mounting of the units onto locally purchased A-frame ladders.

Feedback: CV15 personnel had to obtain locally sources aluminum A-frame ladders which took time and resources. The CV15 team then had to modify to top of the ladders so that portions of the CISCO Access Point mounting hardware could interface with the ladder. The CV15 team then had to improvise methods of attaching the CISCO Access Point to the ladders using zip ties. Finally, sands two sand bags per ladder had to be obtained so that the weight of the sandbags would keep the ladder from tipping over.

Recommendation: Ship all of the correct hardware to an event like CV15 and perform proper quality control on all associated logistics processes.

Observation 19: Software fixes required software downloads of up to 9 GB.

Feedback: In locations with even moderate internet speeds downloads of 9 GB can take many hours to complete. In CV15, two downloads of 9 GB were performed each in excel of 24 hours. If the downloads not been successful, the CV15 team already had made secondary arrangements to send the software via overnight courier to U.S. personnel who were about to travel to CV15.

Recommendation: Provide full back-up software to system administrators on USB drives or SD cards. Incorporate a compartment to house such USB drives or SD cards within the units themselves.

Observation 20: The Thai users of the technology were mostly senior officers from science and technology organizations. No enlisted personnel proficient in security matters were assigned to participate as users with the biometrics technology.

Feedback: None.

Recommendation: The types of military personnel that will evaluate a particular technology should be carefully chosen to evaluate a particular technology based on their vocational field, experience, likely type of ultimate user, etc. so as to ensure a more thorough, more professional evaluation of a given technology.

Biometrics User After Action Feedback

After users completed training and CV15 vignettes they were asked to participate in an after action meeting to collect additional feedback. The meeting took the form of a round table discussion where each participant was asked to provide their verbal feedback about the various systems. This section provides the feedback collected during the CV15 biometrics after action meeting.

Jump Kit

- Is fast, and all inclusive, easy to use
- Camera needs a tripod
- Easier to use if the software was in Thai, bilingual
- As low as privates could use this equipment
- The training provided was sufficient to do the basics
- Jump kit user interface is similar to a computer easy to use, SEEKs is too small
- Didn't like the camera, need to have a tripod, the delay on the camera response for the picture is not good and it surprises the subject and the user, the camera is controlled by the software instead of the operator for timing to take the picture
- Should be able to handle any environment, white background or any background
- Iris and finger prints worked very well
- Training, was good for operating, but I would want more so I could fix basic problems
- Of all of the devices the jump kit was easiest to use

Galaxy

- Its light and easy to use
- Limited functions, fingerprints should be included, and wifi connect always a problem
- Prefers the tablet if it had all of the features the other systems had
- Better if it had fingerprint feature and could connect with other devices
- Privates can use all of the systems
- Training, received enough to operate, but not troubleshoot (apply to all technologies)
- Light, easy to use, but the iris is hard and takes forever and hand many problems, and wifi was a problem
- SME: I wish it did local searches, its tied to the wifi
- Slower than SEEK when processing
- Not easy to capture images if you are shaking
- The Galaxy might be effected by the database size and the case

SEEK

- Easy to carry around, but is a little heavy, but the shape is OK
- Hard time scanning when someone is taller than you, can have glare on the screen
- Easy to use
- Magnetic one doesn't have smudging
- Bulky but it was reliable, had all of the functions, iris was easy, too heavy to carry around all day, but a shoulder strap would help with that
- Galaxy is sexier, but the SEEK is older and wiser

- Keyboard and screen were too small
- Big buttons on the screen help, but little buttons are too small, system was more accurate

Avenger

- Smaller than SEEK II, so easier to carry around, but the iris is harder than SEEK II
- Screen could be bigger and a touch screen, and a touchscreen keyboard
- Touch screen had a delay
- Full keyboard, Bigger screen, better processor

Biometrics Team Feedback and Lessons Learned

As part of CV15 daily evolutions an end of the day hotwash was held with all participating technology teams. These meeting provided team leads the opportunity to update CV15 staff on any issues they were facing, current and future operations, user and SME feedback, and any lessons learned. The following section provides a summary of the daily user and SME feedback, and lessons learned collected during these meetings.

SME Feedback

- Buttons a bit too small on the galaxy
- Galaxy results are too small
- Worked really fast, one issue with one guys pupils being so small that his info was rejected repeatedly
- Asian eyes are harder to catch (all devices)
- Reach back capability was very fast on the server, event with small wifi server, with 50,000 records
- Some buttons on the SEEK and Avengers are not intuitive
- Process is long for enrollment, export, import, and upload to the server. Should be one button to handle all
- One failure occurred when the power shutdown to the wifi access point, it returned a no match even though info was in the server (false reject)
- ABIS matching prefers individual prints instead of 4 fingers closed together.
- 3 failures occurred on the galaxy out of 10 on Sunny for facial recognition, do to Sunny's shakiness and inexperience, additional user training should help correct the issue
- Galaxy works better indoors
- The software glitch on the Avenger that gives the default result is a known issue by the developer and they are currently working on a patch.
 - Interim solution is to have one handheld only host allows and one only host denys. Subjects will be tested in allow first if they are not found in the database they will be checked in deny. If in neither they will go to triage for enrollment. Everyone from both categories will be on loaded onto the SEEK II.
 - Likely use SEEK II for the CIED vignette
- SEEK Avenger is highly temperamental
- Jump kit worked very well
- Having the interpreter is very useful
- Galaxy does not provide the correct result if the user scans the left eye when they should scan the right and vice versa
- SME: Does not meet user requirements; speed, would not deploy any of the systems

- Additional feedback recorded on data collection logs
- Generally good feedback, however,
 - SEEK and Avengers are slow and heavy, too heavy for Asians and wifi issues
- All units are highly unreliable
- Software patches seem to fix the issues and then create new issues
- The interpreter worked incredibly well
- NAVAIR and Neany rep was an awesome performer, very hard worker

User Feedback

- Users were happy with the technologies
- MG Sirisak was impressed with the matching response time

Lessons Learned

Technology Focus

- Don't change the time on the server
- Include drivers and/or recovery CDs with the systems in case there is a need for a reinstall
- Wifi is transmitting on 2.4. It appears the UASs and the WiFi are interfering with one another, possibly also impacting the biometrics
- Commercial Wi-Fi interferes with other types of Wi-Fi; in the field whatever has the highest priority will get it. So there may be sacrifices. Need to deconflict early
- Ensure software is updated and patched before shipping
- Bring installation CDs for all technologies
- This technology needs to be tested more before deploying to events like this

Admin/Logistics Focus

- Cultural Observation, don't touch head
- Have an ups or generator for power failure
- More time for pack-out prior to shipping
- Commercial Wi-Fi interferes with other types of Wi-Fi; in the field whatever has the highest priority will get it. So there may be sacrifices. Need to deconflict early
- Continue having interpreters

Biometrics Summary

The overall objective to test the biometrics technology suite consisting of SEEK II, SEEK Avenger, Guardian Jump Kit, SRI Samsung Galaxy Pro Identification Tablet, CISCO Access Points, and ASTERIA software, in an expeditionary environment, within plausible scenarios, while demonstrating interoperability with RTAF, was only partially successful due to repeated software and hardware malfunctions of the equipment. However, the team gained valuable exposure to the demonstration environment and as a result were able to gain insight into their technologies and the training environment from a cultural, logistical, commercial, technical, interoperability, and environmental perspective.

Environmental Factors: The tropical nature of Thailand provided a new environment to operate the four biometrics technologies. The biometrics team mostly operated out of the JOC area, however, even with the shelter it is likely that long term field operations would be difficult for operators given temperature and humidity conditions in this AOR.

Cultural Factors: RTAF users not familiar with the biometrics technology suite were able to be trained and subsequently became proficient at operating the various systems. RTAF users were able to operate the equipment each day over several days. The training provided to RTAF personnel was limited to the use and operation of the biometrics technology suite and did not include technically oriented administrator-level, maintenance or troubleshooting training. A barrier to training and operation of the biometrics technologies in CV15 was the software and keypads not supporting Thai. Luckily the team's assigned translator was able to assist with training to overcome this issue. The team also learned that some of the systems had more issues correctly identifying Asian users, or getting good iris scans.

Logistical Factors: Logistics in CV15 was an important factor to ensure successful execution of the event. SEEK II, SEEK Avenger, Guardian Jump Kit, CISCO Access Points, SRI Samsung Galaxy Pro Identification Tablet, and ASTERIA software proved that the entire system was transportable and rugged. As a result the biometrics team was able to hand carry all gear, except supporting access points, into country with no issues. During the event the team was faced with a number of software and hardware issues. Unfortunately, the software issues required a complete reinstall of onto a system. The team quickly learned that not having the correct support materials in country would have a big impact on their operations. The team was forced to download replacement software using internet speeds much slower than what they were used to in the U.S. this process resulted in two days of lost operations and demonstrated to the team the importance of ensuring a thorough pack out, including backup software, is key to field experimentation OCONUS.

Commercialization Factors: The overall size and form of the biometrics devices seemed to be acceptable for Thai users. However, some did mention that larger keyboards, or lighter weight would make adoption of the technology more likely. A key factor for the commercialization of the biometrics technologies would be cost and maintainability. If these technologies could be adapted to an acceptable price on a platform that is easy to maintain and support with the given conditions and standards within the country.

Technical Factors: The biometrics team learned a variety of technical details about their systems while participating in CV15. Issues with software, iris scanning, network, lighting, and processing were just some of the problems encountered by the team. The biometrics team lead, based on CV15 events, concluded that these technologies need more development before continued field experimentation. Additional details on technical factors can be found in the biometrics SME feedback section of this report.

Interoperability Factors: Numerous software and hardware problems repeatedly affected all training and scenario evolutions conducted during CV15. Of the five individual pieces of hardware available to be used, on average, only 1-3 were functioning at the time of each of the scenario vignettes namely the Patrol vignette and the C-IED vignette of the C-IED scenario, and

the Throughput vignette and Checkpoint vignette of the Border Security scenario. The problems consisted of numerous software and hardware problems that required system administrator interventions several times each day and often in consultation with the manufacturer. Also, the Wi-Fi system used to connect the various components of the biometrics technology suite initially interfered with the UAS Wi-Fi signal until Wi-Fi SME intervention was able to resolve the signal interference. The integrated vignettes provided an opportunity for demonstrating how the biometrics technologies might be utilized in conjunction with other technologies during real world operations. The biometric devices were very successful in supporting the vignettes even with the technical difficulties they experienced.

Even with the technical difficulties experienced by the biometrics team, the new information learned about the technologies by the SMEs, and the feedback provided by the users resulted in a valuable field experiment that will help support the continued development of the biometrics technologies.