| REPORT DOCUMENTATION PAGE | Form Approved OMB No. 0704-0188 |
|---|---|



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| 1. REPORT DATE *(DD-MM-YYYY)* | 2. REPORT TYPE | 3. DATES COVERED *(From - To)* |
|---|---|---|
| 18-12-2019 | Technical Report | |

**4. TITLE AND SUBTITLE**

AF CyberWorx Event:
Combat Survivor/Evader Locator Modernization

**5a. CONTRACT NUMBER**

**5b. GRANT NUMBER**

**5c. PROGRAM ELEMENT NUMBER**

**6. AUTHOR(S)**

**5d. PROJECT NUMBER**

**5e. TASK NUMBER**

**5f. WORK UNIT NUMBER**

**7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)**

AF CyberWorx
2354 Fairchild Dr, Ste 4A41
USAF Academy, CO 80840

**8. PERFORMING ORGANIZATION REPORT NUMBER**

19-003

**9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)**

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2354 Fairchild Dr, Ste 4A41
USAF Academy, CO 80840

**10. SPONSOR/MONITOR'S ACRONYM(S)**

**11. SPONSOR/MONITOR'S REPORT NUMBER(S)**

**12. DISTRIBUTION/AVAILABILITY STATEMENT**

DISTRIBUTION STATEMENT A. Approved for public release. Distribution is unlimited.

**13. SUPPLEMENTARY NOTES**

**14. ABSTRACT**

AF CyberWorx hosted 47 military and industry participants in a design sprint 16-19 July 2019 focused on how to modernize Combat Survivor/Evader Locator radio architecture and communication devices. Proposals for improvement provided highlights to make the next generation of recovery radio more usable, capable, and reliable as well as reducing the time required to locate, identify, verify, and recover isolated personnel while improving their chances of survival.

**15. SUBJECT TERMS**

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
|---|---|---|---|---|---|
| a. REPORT | b. ABSTRACT | c. THIS PAGE | | | William C. Waynick II, Col, Director |
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AIR FORCE CYBERWORX™

# AIR FORCE CYBERWORX REPORT 19-003
# Combat Survivor/Evader Locator Modernization


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**DESIGN PROJECT CONDUCTED**
**16 JUL – 19 JUL 2019 (Sprint)**

*Produced with input from numerous units including 582nd OSS, 60tn OSS, 27th SOSS, 22nd TRS, Joint Personnel Recovery Agency, 88th TES, ACC/A3, ACC/A58, AF CSEL Program Office, AFRL, United States Navy, Navy CSEL Program Office, Navy Survival Electronics ISSC Team, Navy Air Crew Systems, United States Army CSEL Program Office, 4th Combat Aviation Brigade, United States Special Operations Command, United States Marines Special Forces (MARSOC) and our valuable partners in industry.*


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**Background: The history of the Combat Survivor/Evader Locator (CSEL) radio**

The Combat Survivor/Evader Locator (CSEL) radio is a joint service program with the Air Force serving as lead agency. The CSEL radio was developed by Boeing and first delivered to the Air Force in 1998. Over the years Boeing has delivered over 54,600 CSEL radios to support the Air Force, Army, Marine Corps, and Navy. The CSEL radio was a great improvement over its predecessor because of its ability to deliver GPS-derived location information. Since the delivery of the first CSEL radio there have been a limited number of upgrades, yet the needs of the warfighter continue to grow. The current CSEL radio is largely hardware based and there are limitations in the ability to introduce new technologies and capabilities to the existing platform. Another challenge to modernization is the current requirement for the system to implement a National Security Agency (NSA) approved security architecture and design to use NSA derived keys for secure communications, which inhibits rapid uptake and test of current COTS radio systems.

**Participants** AF CyberWorx brought together 47 military and industry partners to investigate ways in which we might modernize the Personnel Recovery architecture and communication devices for the DoD. Industry participants included: Black Horse Solutions, General Dynamics, Alion, Boeing, Raytheon, Information Management Technology LCC (IMT LLC), Treehouse Inc, and Cosmic AES. This sprint was also supported by government and military participants from a broad range of operations, program management, and technical subject matter experts (from all Service components) including: 582nd Operational Support Squadron, 60th Operational Support Squadron, 27th Special Operations Support Squadron, 22nd Training Squadron (SERE School), Joint Personnel Recovery Agency, 88th Test and Engineering Squadron, Air Combat Command Operations Directorate (ACC/A3), Air Combat Command Requirements Directorate (ACC/A589), Air Force CSEL Program Office, Air Force Research Laboratory (AFRL), United States Navy, Navy CSEL program Office, Navy Survival Electronics ISSC Team, Navy Air Crew Systems, United States Army CSEL Program Office, 4th Combat Aviation Brigade, United States Special Operations Command, United States Marines Special Forces (MARSOC)

Attendees brought a broad range of insight and experience to the sprint, informing their ability to uncover strategic solutions to a complex challenge. The AF CyberWorx approach aided the solution-oriented ideation and allowed participants to consider a variety of scenarios in order to achieve the best possible concepts and prototypes. The cognitive diversity of the group provided unique value, breaking down traditional military hierarchical barriers to allow all viewpoints to be heard and considered. Furthermore, key insights from industry partners helped shape the team's design efforts, expanding the realm of the possible beyond the DoD's current technologies.

**Design Problem**

***How might we best modernize Personnel Recovery architecture and communication devices to ensure robust connectivity between the Isolated Person, C2 nodes, and recovery mechanisms from isolation through recovery?***

The challenge of reimagining the CSEL radio and improving the personnel recovery architecture and associated communication devices was nominated by the Air Combat Command Chief Scientist (ACC/ST) as a critical need for the Air Force and DoD. While the whole of the personnel recovery architecture was too large to tackle in one design event, discussions of the personnel recovery process, support/maintenance equipment, and larger communications infrastructure were informative to the larger operational environment to ensure that the solutions to the problem met the needs of users across all of the Services components as a joint services program.

**Theme Discovery**

In preparation for facilitating the design sprint, the AF CyberWorx team conducted a discovery visit to Nellis AFB where they spent time with user/operators, maintainers, and leadership teams. The trip yielded insights into how users operate the radio and identified barriers they face. Based on pre-event research, the AF CyberWorx team divided the sprint participants into seven teams, ensuring each team had several operators, from different services where possible, as well support from technical experts (military and industry), program managers, and the maintenance community. The teams were aligned on three overarching themes: 1) experience of the isolated personnel 2) experience of system maintainers 3) perspective of rescue and rescue support forces to include the overarching command and control networks that the communications device must operate within. The teams concentrated on discovering and solving the human needs at the center of the design problem. While their visions of the solutions focused on the human needs, they did not ignore organizational viability and technical feasibility.

To identify the human needs and barriers at the center of the problem, the teams used personas and scenarios. Personas are representations of users based on shared characteristics and the task users are trying to complete. Personas are derived from interviews, observations, and other types of user research. Once personas were defined, the teams created scenarios, stories in which the crafted character walks through the current system to discover the barriers users face with personnel recovery. Importantly, the teams were able to identify barriers even in scenarios that contained no complicating factors. After identifying the barriers, the teams translated those barriers into needs. The teams then used ideation to find ways to meet these needs and overcome the barriers. The teams then categorized these opportunities based on passion, impact, ease, and innovation; and then created solutions from their best ideas.

At the end of the second day, each team presented their favorite solution to the entire group for feedback and possible improvements that the team had overlooked during ideation. With that feedback, they continued refinement work the next morning. The presentations included details about a chosen persona and the barriers identified in the current radio/system, the team's solution, and how the solution overcomes those barriers. The result was a poignant comparison between how personnel recovery looks today and how it could look if these solutions are implemented.

**Personas**

The two most common personas that teams focused their solutions around were Captain Brave Brad and Airman First Class Techy Tom. Brave Brad is a 29-year-old F-15 pilot who is married and has two daughters. He carries a CSEL radio on all his missions; however, his last use of a radio was during training over a year ago. Brad typically uses or trains on a CSEL only once a year and believes that he could use the radio if he had to; but, don't ask him to teach you how to use it. Brad is a little intimidated to play with the radio before a mission for fear of accidentally setting off a distress signal. He would like a radio that is so easy to use that you don't need to worry about whether or not you know how to use it.

Techy Tom is a single, 21-year-old, Aircrew Flight Equipment technician. He is responsible for loading and maintaining CSEL radios for a flying squadron. Tom typically interacts with the CSEL radio on a weekly basis and when deployed, may be responsible for loading 30-100 radios, sometimes in short periods of time. Tom believes that the configuration software isn't difficult to use but recognizes there are a lot of steps in the configuration process, some of which seem unnecessary and increase the odds of making a mistake, which could result in the radio not functioning correctly at a critical time. In an ideal world Tom would like the loading process to be easier and quicker, not only for missions but also for the annual update of the encryption keys.

**Solutions**

The solutions conceptualized during the sprint identified and resolved current barriers to improve radio usability, radio loading and maintenance, and improve/increase operational capabilities.

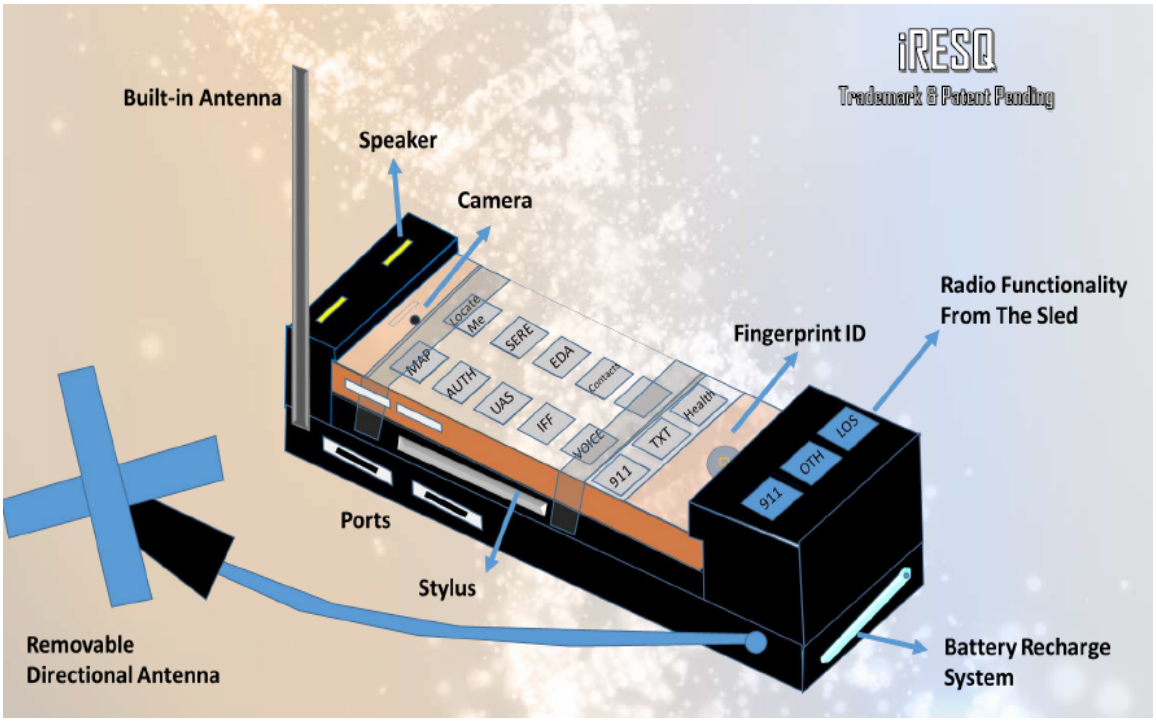
**Improving Radio Usability**

Several opportunities were identified to improve the communication device used by an isolated person. The current CSEL radio is hardware-based, bulky, has a small screen, is extremely hot when exposed to the sun for periods of time, doesn't float in water, is manually activated, and is not intuitive for users. With respect to the radio itself, the teams determined that an isolated person needs a way to:

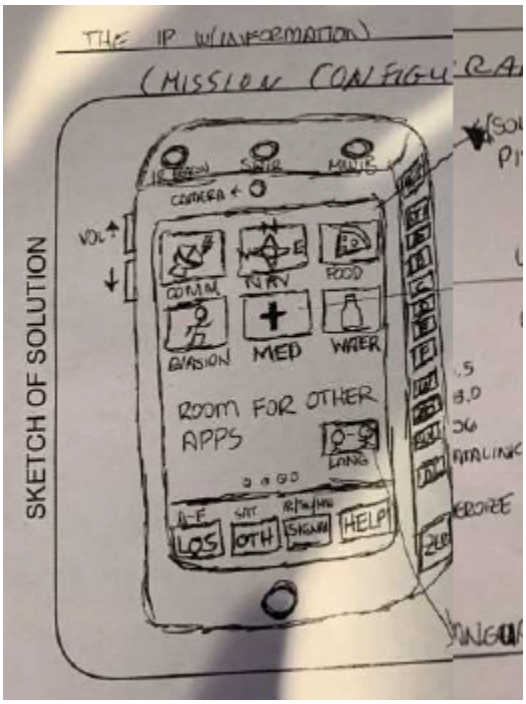
- Easily receive support and communicate with rescue forces
- Be found if they are unable to operate the device
- Keep the device running if isolated for an extended period
- Not draw undesired attention when using the device
- Adapt the radio for the mission

To meet these needs, the teams proposed communication devices with the following features:

- A modular software-based radio that will allow for greater customization to fit more warfighter needs and allow the radio to remain relevant and adaptable to future battlefield technologies.
- A modular radio that could be a smart phone-type device, which has specialized applications to support the isolated person and attaches to a rugged docking sled with external devices (multiple antennas, additional battery, and easy to use buttons).



- Be rugged, waterproof, and buoyant. The radio needs to stay with the IP when they eject or separate from an aircraft and needs to be able to durable/impact resistant to forces created during ejection and landing. The radio also needs to be rugged enough to remain unharmed if a ground troop falls on the device while evading enemy fire or other high stress combat conditions. Additionally, to meet full joint service requirements, the radio should be waterproof and be operable in marine and wet climate environments. One way to meet these needs is to leverage the capabilities in commercially available cell phone cases. These cases are already rugged and waterproof; with some modification a case could be produced that is buoyant and fits the radio.
- Be equipped with small/long lasting power sources and include a way to be recharged or sustained while isolated. The current CSEL battery is approximately 5 inches by 1.5 inches and most of the users carry spare batteries in addition to their other combat and survival kit. Based on technology advancements since the design of the original system, the size of the battery could be reduced significantly and still provide the same, or better, battery life. The radio should also be able to be recharged in the field, which could be accomplished in several ways. Some of the solutions the teams devised included embedding solar panels into the case/sled device or an external crank-operated generator that attaches to the radio.




- Currently the CSEL radio must be manually activated by the isolated person. This presents problems for IPs who are injured and might not be able to manually activate the radio. In order to address this challenge multiple teams recommended making the radio capable of being activated verbally as well as by automated G-Force and water-sensitive sensors. These technologies already exist in the commercial sector.
- Support alternate signaling methods such as having the ability to covertly signal rescue forces with Infrared (IR) strobes. If the sight line is clear this would provide a non-RF method for the IP to help rescue forces establish and home in on a better approximate location.

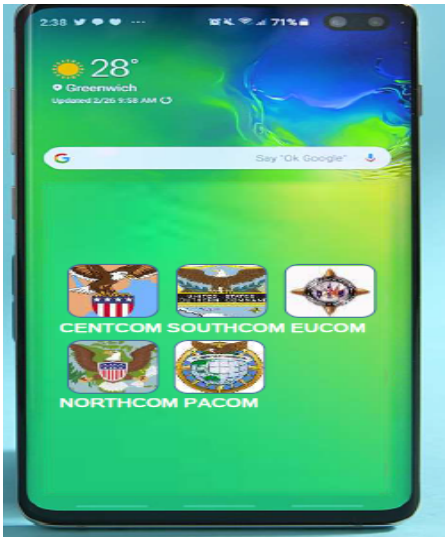
**Bottom line:** A modular, software-based radio device with high-performance batteries and alternate charging methods provides an extensible platform to support today's recovery architecture and build additional future capabilities into as they are developed. The ubiquity of smart phone-like devices presents a familiar user interface that can ease the required training for both operators and maintainers and supports expansion for more features than currently serviced. The addition of alternate activation/interaction methods and provides better support for multidomain operating environments and for better accessibility/recoverability of isolated personnel.

**Improving Radio Loading and Maintenance**

Multiple teams identified opportunities to improve speed and accuracy of radio configuration loading and maintenance. The current pre-mission process requires maintenance Airmen to transcribe their operating theater's Special Instructions (SPINS) into a configuration software computer, then load required configuration and encryption keys into the radios one-at-a-time. The teams summarized that radio maintainers need a way to:

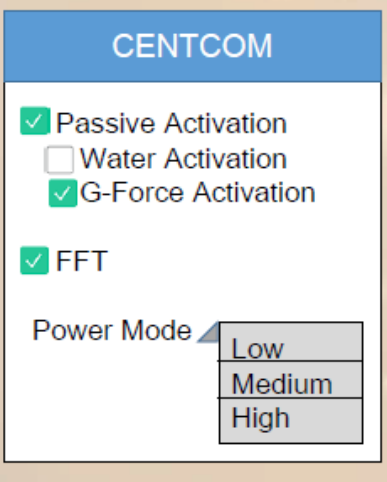
- Reduce the potential for human error
- Reduce the time required to load the radios
- Access required system information from a standardized location per Combatant Command (COCOMs);
- Easily adjust the AOR-specific data as dictated by the mission
- Access radio update information on the device

To meet the identified needs, the teams proposed the following solutions:




- Establish a position or responsible office in each Area of Operation (AOR) to create and publish the COCOM specific configuration loading file based off the current SPINS for all radio maintainers to download and use as a baseline load for the radios in their unit
- Develop the capability to allow for over-the-air configuration
- Add a feature which provides confirmation of a positive configuration load with notification provided to both the local radio maintainers and COCOM management office
- Develop a way for maintainers and operators to perform a pre-mission check to ensure everything is working and configured properly
- Develop a batch loading capability to either clone radios from a master radio or a multiple radio charging/docking device that can be used to push configurations to multiple radios in parallel

- Allow COCOMs to develop customized applications for their AOR and mission set that could be downloaded (over the air) or pre-mission
- Develop the capability for wireless charging to allow for support of a charging matt-like device that could support multiple radios and reduce the footprint of current charging stations
- Allow for customization options when configuring the radios pre-mission. For example, allowing the technician to select G-Force or water sensors for automatic activation of the radio or pre-select the default power usage mode and radio band of the radio




**Bottom Line:** In order to overcome the barriers radio maintainers currently face, the solution needs to remove as many opportunities for manual configuration errors as possible, provide positive load confirmation, provide ability to positively operations check, and reduce the amount of time spent loading configurations and cryptographic keys to radios.

**Improving the Radio Capabilities**

The current CSEL radio provides enough capability to help rescue forces locate and rescue the IP. Based on advances in technology since the original design and operator identified pain points, the redesign effort creates and opportunity to improve and expand capabilities. Sprint participants identified several unmet needs that a redesigned system could address:

- Adapt the radio for the mission (pre-mission)
- Establish precise position with or without GPS
- Communicate their location and condition seamlessly and securely to remote and local friendly (joint/coalition) forces
- Receive support while isolated

Sprint participants saw the many technological advancements made since the development of the CSEL radio as an opportunity improve and expand the radio's capabilities in redesign. Several of the suggested improvements include:

- The radio should have an alternate capability to providing position, navigation, and timing to the current Global Positioning System (GPS) which is readily available but potentially vulnerable to multiple types of disruption. This is a concern for future wars when an adversary could jam, spoof, or otherwise impact GPS performance.
- Different operators use the radio in different operational and physical environments. A modular, smartphone-like, app-based device could to be customizable to the warfighters' needs in different environments and AORs. There could be a suite of basic applications that would include an evasion aid app, a medical app, and food/water procurement app. COCOMS and special operations forces could have custom applications developed as the need arose

- Voice-to-text and free form texting capabilities would allow for better communication with rescue forces. Talk-to-text could provide injured IPs a way to communicate with rescue forces if they have limited motion. Free-form text would allow the IP to provide rescue forces with more information. (Currently the CSEL radio will ask the user a few yes or no questions and relay those answers to the rescue forces.) This technology is readily available in commercial smart devices.
- The radio should have the capability to interface with external devices such as electronic flight bags, health monitoring devices, and other mission- or operator-specific devices. Smart device technology affords multiple means to wirelessly connect devices.
- Currently, if two or more IPs from the same aircraft are separated during ejection, they have limited options for communicating with each other. The ability to communicate with other radios (of the same type), form multiple connections at one time, and form an ad-hoc network for communication could greatly improve rescue operations when there are multiple IPs who are not near each other. This solution would allow separated IPs to communicate with each other and rescue forces at the same time.
- The current CSEL architecture allows the IP to communicate over a limited number of waveforms and usually only in one method (short data burst). A radio with multiple antennas could utilize a larger number of waveforms to attempt to communicate with rescue or friendly (Joint/Coalition) forces. Along those lines, the radio could also adjust voice and data rates to achieve a better transmission of the message.
- The current CSEL radio is not compatible with some aircraft and cannot be released to coalition partners. A solution for the first part of the problem is to require the new radio to be compatible with the existing hardware in all (or the majority) of aircraft. The second part of the problem was too complex to tackle during this design effort beyond recommending the use of releasable encryption products, but could be addressed in future Air Force CyberWorx design efforts or through program engineering work.

**Summary of Benefits**

During the ideation and solution seeking processes, the sprint teams identified user pain points in the current CSEL radio (technology & design) and its interfaces into the larger personnel recovery architecture. The proposals presented in this report provide opportunity to not only make the next generation recovery radio more usable, more capable, more reliable, and ultimately reduce the time required to locate, identify, verify, and recover isolated personnel while improving their chances of survival.

**Next Steps**

The solutions presented during the sprint captured the challenges and potential solutions that the diverse teams of participants believed would be the most impactful, easy (time, cost, technology) to implement, and that they felt the most passionate about solving for the operator. As strong participants in the design sprint the program office and ACC program leads can freely draw from the captured work as they direct redesign and fielding efforts. Additionally, many of the technologies identified for as potential improvements are commercially available; AF CyberWorx or a commercial design services provider could be funded to rapidly prototype and conduct user test/design refinement for both pre-mission radio configuration and radio operational improvement

solutions, either to again inform program efforts through lessons learned and user feedback or carry those elements forward with Other Transaction Authority to expedite development.