Remote Design and Deployment of the Transport-Security, Tracking, and Reporting (T-STAR) System

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Abstract

Oak Ridge National Laboratory (ORNL), under the sponsorship and guidance of the US Department of Energy's National Nuclear Security Administration's Office of Radiological Security (ORS) began the development of the Transport-Security, Tracking, and Reporting (T-STAR) System in 2014. Although others have implemented security systems for detecting and tracking sensitive materials in transport, none of these systems provided asset tracking of the conveyance, detection of a breach into the cargo compartment, or the removal of cargo from the conveyance. ORS realized this left a significant vulnerability, which it sought to remedy.

T-STAR was designed to convey location and operational and security sensor status at regular intervals, which together allow near real-time assessment of the security of the shipment. Since its development and initial implementation, multiple improvements have been made, resulting in today's T-STAR Generation 3. Gen-3 improvements include improved sensors, improved battery performance, facilitation of pooled international SIM cards, and easier to use system user interface.

ORS has tested T-STAR in multiple countries and planned additional deployments in 2020. When the pandemic shut down working in person to design and install T-STAR with foreign partners, ORNL worked with partners remotely to design future implementations of the system. This paper describes the process used to successfully advance remote TSTAR design and installations.

Introduction

The Transport-Security, Tracking, and Reporting (T-STAR) system is used to provide secure transport of Category 1 and Category 2 radiological material for domestic and international shipments. T-STAR development began in 2014 under the sponsorship and guidance of ORS (NA-21). T-STAR conveys location, operational, and security sensor status at regular intervals together with immediate alerts so both can be used to assess the security of the shipment (Figure 1). Conditions monitored include equipment operation details, if it is communicating, security sensor alarms, and location of the shipment on a geographic map.

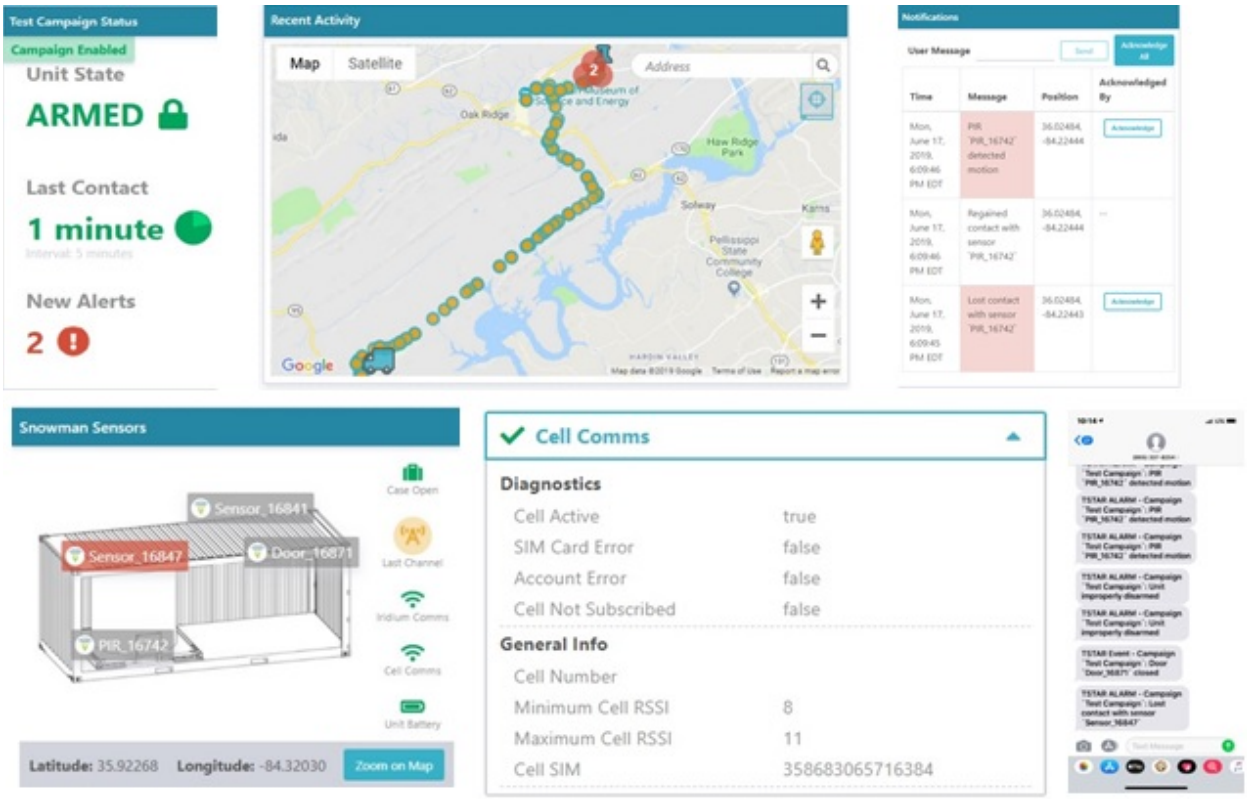

Figure 1. The T-STAR web application runs on computers and smartphones and allows assessment of the shipment's status in a single view. Through the web application, a user may opt to receive SMS messages of the system notifications.

T-STAR consists of the electronics that "ride" with the shipment, the cellular communications equipment that can use the available communications and network backhaul infrastructure along the route, the satellite communications used when cellular is not available, and the backend database and monitoring web application (Figures 2 and 3). These provide information for continuous security assessment. The security system employs a wireless sensor network of security sensors monitoring motion within the conveyance or conveyance door openings and closings. These sensors are battery operated, use temporary mounts within the conveyance, and communicate using a common structured communication protocol.

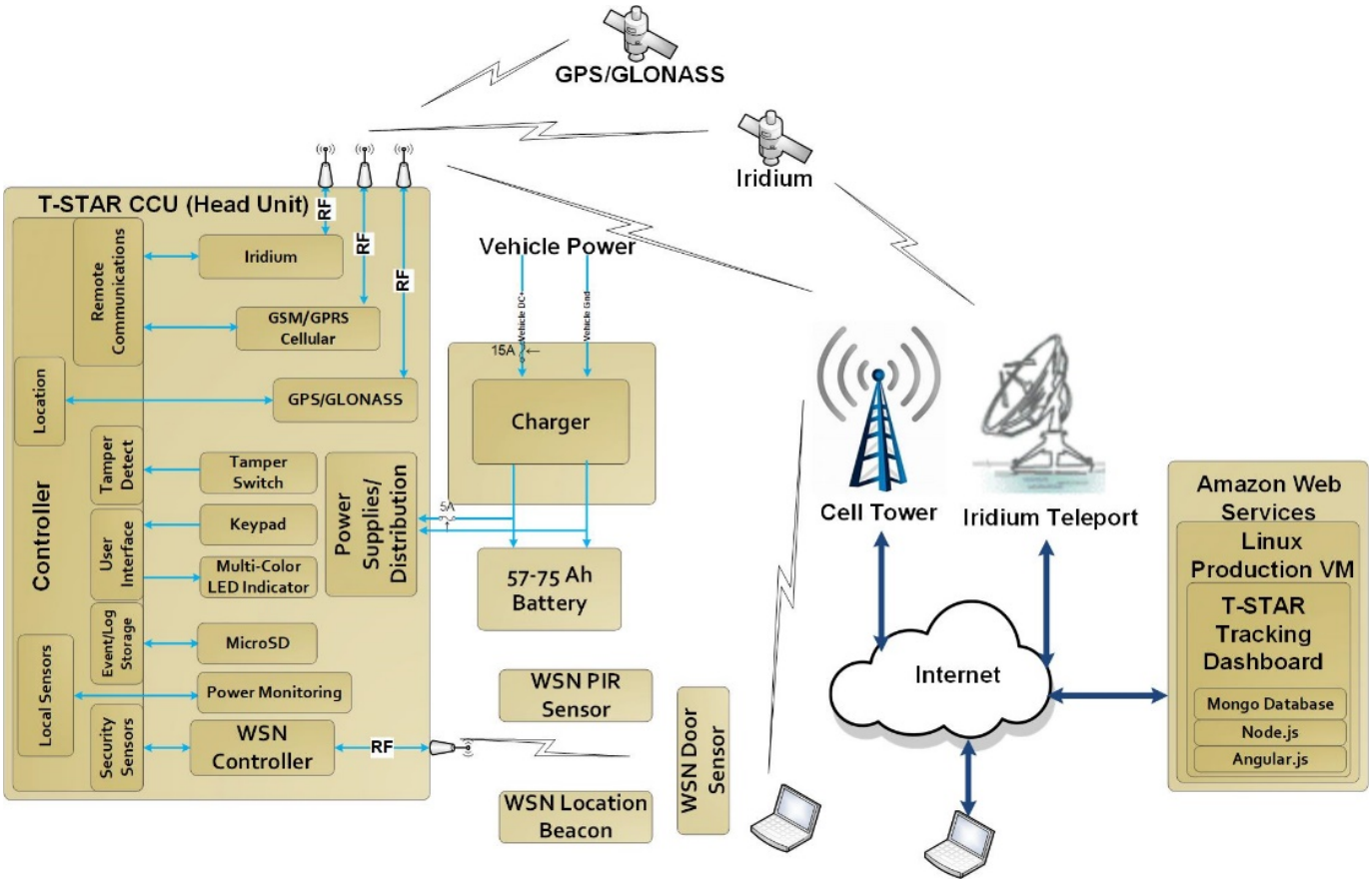

Figure 2. The T-STAR block diagram showing multiple communication modes, onboard and offboard wireless sensors, network infrastructure, and website services to monitor and assess the security of the shipment.

Figure 3. The T-STAR communications units, wireless sensors, antennas, and power cables to be installed and deployed remotely.

The T-STAR head unit aggregates operational information and security sensor status into messages that are transmitted via an available communications link – cellular towers, iridium satellite, or GPS/GLONASS satellite -- depending on signal coverage. Based on time and urgency, a T-STAR–message is routed using identification and configuration parameters and database tables to the T-STAR server securely via the internet. The server system parses and processes the message, tracks reporting times, translates identifiers into user-familiar names, converts location to geofence entering and exiting events, sends email and/or SMS notifications, and presents the events and information in sequence so the user can accurately assess shipment security. At the onset of COVID-19 pandemic, ORNL was preparing to begin deployments of the latest generation of T-STAR to partner countries with the goal of at least two international deployments.

Status Quo

Before COVID-19, ORNL's implementation plan involved an in person visit to the host organization for 2-4 days to determine how best to integrate T-STAR into the host organizations' concept of operations. The first day was spent discussing T-STAR with drivers, dispatchers, and others who will be responsible for the use and monitoring of the equipment. These discussions often result in feedback on how T-STAR will fit into transport operation at the organization and what configurations may work best for installation and use for specific conveyances or shipping modes. The second day would be spent with the IT administration to develop a plan for installing the monitoring system on a host server. These meetings usually include a Linux administrator and cybersecurity experts and management who will approve installation of T-STAR software on the IT infrastructure. Experience has shown it can take several months to resolve issues related to the installation of the monitoring system.

For deployment, ORNL would assemble the system components in a package suitable to the end user's requirements for shipment to the destination. ORNL would then conduct a follow up visit to ensure that all the hardware and software operates to specification and to inspect and assist in the installation, if needed. Finally, the ORNL team would conduct a 2-day training on use and maintenance of the equipment and system. From beginning to end, a successful T-STAR deployment usually takes 2–3 months.

The pre-Covid, "status quo" T-STAR deployment was fairly lengthy and required travel, the results were more assured because through multiple engagements and coordination, the subject matter experts were able to address gaps in documentation or procedures, troubleshoot any problems, and answer any questions.

With the onset of the pandemic and travel restrictions, the "status quo" was no longer an option. ORS determined that travel would be suspended for at least a year, but ORNL was still responsible for implementing the transport security and T-STAR mission as planned. This presented a challenging situation and the ORNL team was required to develop a new project implementation strategy.

Perseverance, Compassion, and Creativity

One of the greatest obstacles to successful deployment of T-STAR was not technical or hardware related, rather it was the human impacts of COVID-19. The deployment schedule would have been aggressive in a normal year, but, during the pandemic, everything seemed more difficult. Meetings took longer to organize and could be canceled on short notice because of quarantine or other work-related

restrictions while different time zones further complicated scheduling. Existing timetables and work schedules were upended because of lack of available staff and work restrictions. At ORNL, staff experienced restrictions related to the number of personnel on-site on any given day, in a given building, or a given laboratory. There were instances where staff had to spread what should have been 4 hours of mechanical engineering and electrical engineering over a work week to meet social distancing requirements. Repercussions from Covid related illnesses and deaths, uncertainty over the duration of the lockdowns, differing protocols between the international partners, spiking infection rates and surging cases all set back efforts around the world.

One of the major challenges was the uncertainty of COVID-19 and how long it would influence normal operations. In the beginning, it was thought perhaps in 6 months conditions would be back to normal. However, as time progressed, the team realized that it would not be possible to complete the T-STAR deployments without having to perform remote installations. This was a significant challenge lacking the normal data and process gathered from a team who normally went in the field, walking around trucks and talking to drivers and fleet maintenance staff, understanding how those vehicles are used day to day, and how to best install this equipment and deploy it in regular use. Obviously with travel restrictions, this was not possible, and it was necessary to be creative about the next steps to deploy T-STAR remotely. The ORNL team started developing more detailed documentation to support the remote installation and use of T-STAR, but the documentation quickly reached more than 100 pages of text and images. The documentation was detailed, but it was not going to be read by the end user and was more of an “owner’s manual” rather than an operation manual. Consequently, additional creativity would be required to be successful.

At the outset, the ORNL team determined that it would be persistent and understanding of the situation. After all, everyone was adapting to a new way of working virtually and dealing with the pandemic.

Compassion and technical activities are not often associated with one another, but during the pandemic compassion was as important as the engineering behind the hardware. Many existing timetables or work schedules were upended because of lack of available staff and work restrictions. Working on-site to accomplish IT related tasks was difficult for foreign partners. Even at ORNL, staff experienced many restrictions related to the number of personnel on-site on any given day, a given building, or a given laboratory. There were instances where staff had to span what should have been 4 hours of mechanical engineering and electrical engineering over a work week to meet social distancing requirements during hardware assembly. The ORNL team certainly understood what foreign counterparts must also be going through in even more restrictive and uncertain environments, so compassion came easily. Further, it is not possible to know for certain what a counterpart is dealing with related to COVID-19. It could be that they have become ill themselves or are caring for a family member with COVID-19 or suffering the loss of someone dear to them. In fact, it is difficult to know those things with which your now virtual officemate down the hall is dealing—let alone a continent away.

All these things lead to being creative and taking ideas that always seemed to be good ideas but were not easily implemented during normal times due to schedule tempo, or just were outside the status quo. During the onset of the pandemic, the technical team was able to pause and evaluate how best to deploy T-STAR units remotely in case the team was unable to travel or assist directly. To begin with the technical team worked with ORNL’s Learning Sciences group and adopted Zoom and Microsoft Teams to

conduct virtual coordination meetings, which worked well to identify many of the hurdles that would normally be discovered during in-person meetings.

As ORNL's Learning Sciences began to transition to a virtual learning environment, the technical team engaged with the media production crew, which was bolstered as ORNL began to conduct more online training. This meant that video production resources not usually available during normal operations became available. The team was fortunate to have an Emmy award–winning producer to support these efforts, making the task of developing videos for both the hardware and software a much easier process. Because of COVID-19 access restrictions, the subject matter experts became the actors in the videos and developed the scripts and voice overs, with assistance from the producer (Figure 4). Requiring many retakes of instructional voice overs led to improvements in the final documentation. We were able to develop two short videos for operations and monitoring, as well as 11 short videos for the monitoring software using Open Broadcast Studio, which could be captioned in additional languages as needed (Figure 5). These videos would not only support the future remote installations, but they also became a component of internal training materials.

Figure 4. ORNL staff shooting video about the installation of T-STAR.

Figure 5. Example of video production for installation of T-STAR in a conveyance.

The ORNL team had used videos in its existing training and had always considered creating additional videos for refresher training and as supplemental material for the training curriculum. Time and

schedule were issues before the pandemic, but during the pandemic, videos became a major pathway to success.

Working with other people and expanding horizons was a necessary step in preparing for remote installations. The equipment and "owner's manual" were provided to an ORNL staff member with no T-STAR experience to ensure that the instructions were clear and produced desired results. This strategy worked well, and great feedback helped improve the training material and equipment documentation. The end product was a series of one-page "quick start" guides that could be used by a driver or operator to get started or as a quick refresher.

The other major component of T-STAR is the monitoring system user interface. Previously the system installation would be accomplished by meeting with an IT administrator in the partner country and walking through the steps of the installation, installing each component one at a time. However, in lieu of travel, the software developers created an installation package using Docker that could be easily run from the command line of a server. In two to three commands, the entire website and monitoring system could be fully installed. This streamlined the future installation in both time and complexity and took a process that previously took an entire day and shortened it to a few command lines that were executed in a matter of minutes. ORNL also found that updates and software upgrades are more easily implemented.

Conclusion

COVID-19 was a tremendous disruption, but that disruption also led to some creativity and improved methods of working towards implementing and accomplishing goals that were always considered but hadn't surfaced as a priority. It led to a period of innovation on how to overcome the challenge of restricted travel, restricted personnel, and challenging the status quo. Even now as variants of COVID-19 circulate through the global community, ORNL is positioned to be able to accomplish its mission by remotely installing and deploying T-STAR when conditions improve. Even though ORNL was not able to ship T-STAR during the pandemic as planned, the end result was more complete documentation, easier to use quick start guides and informational videos, and faster deployment and preparation for future deployments—remote or otherwise. The key to ongoing success will be to continue to be creative when the pace of "business as usual" eventually returns.