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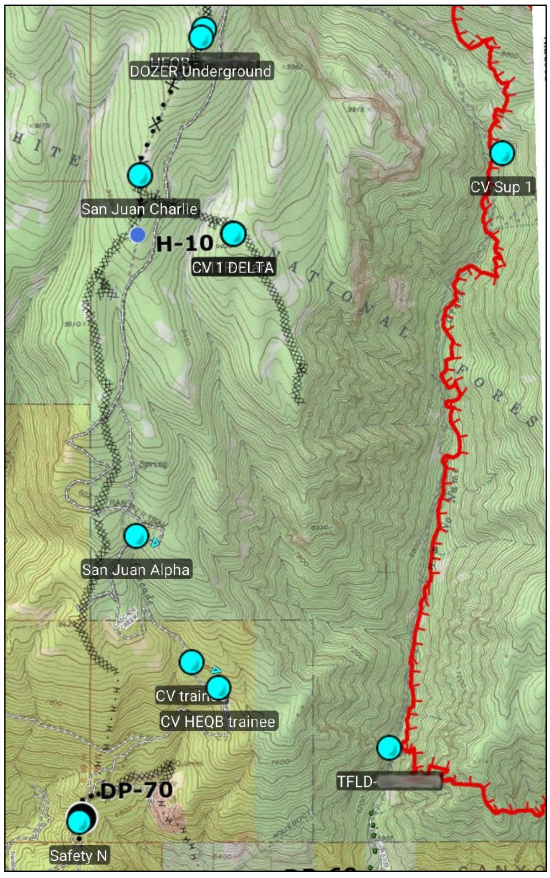

Wildland Fire Pilot Project for Development of the Team Awareness Kit & Deployment on the Grizzly Creek Fire

CoE-20-002.1

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Executive Summary

In 2019, federal legislation was enacted to develop a resource tracking capability for wildland fire. The Colorado Center of Excellence for Advanced Technology Aerial Firefighting (CoE) was awarded a pilot project under the U.S. Forest Service response to this legislation to deploy and test the Team Awareness Kit (TAK) as a resource tracker. TAK is a smartphone app that tracks the location of firefighters carrying it and creates a common operating picture, allowing users to see the locations of other firefighters as well as maps and intelligence on the fire. TAK was originally developed by the U.S. military and a demilitarized version of the app is freely available.

The CoE stood up a TAK server that ties all TAK users together and integrated this server with the Enterprise Geospatial Portal (EGP), a federally developed website containing fire maps and other intelligence. The location of wildland firefighters using TAK is displayed in the EGP in near real-time. In addition, other types of tracking data housed in the EGP, such as the current locations of wildland fire engines and other apparatus, is provided to firefighters via TAK. To test this capability on a wildland fire the CoE developed a cache of Android smartphones provisioned with the TAK app and accessories, facilitating a rapid deployment of the technology.

"The pilot project ran for 13 days and 154,304 location reports were logged by participating firefighters. On average, firefighters' positions were updated every 129 seconds."

An opportunity to pilot this capability came in August 2020 on the Grizzly Creek Fire in Western Colorado. This fire burned over 32,000 acres and threatened communities and critical infrastructure. The CoE coordinated with the fire's incident management team to deploy TAK to firefighters on the night shift, as well as on a division (a discrete geographic area) of the fire. Firefighters were provided with a smartphone using FirstNet cell service and running the TAK app. A brief training was provided on the operation of the equipment and firefighters received a pocket guide containing instructions on how to use the app.

A total of 28 phones were issued during the pilot project, with most phones representing the locations of multiple firefighters who worked together in crews. The pilot project ran for 13 days and 154,304 location reports were logged by participating firefighters. On average, firefighters' positions were updated every 129 seconds. In addition, wildland firefighters participating in the pilot project received regular updates of incident maps and information on their phones through the TAK app.

Fourteen firefighters provided survey feedback on their experience using TAK during the Grizzly Creek Fire. All stated that the pilot project was their first time using TAK and all stated that it improved their situational awareness. All participants used TAK to view the locations of others and 12 out of 14 agreed that this was TAK's most useful feature. 13 out of 14 agreed that they were able to make decisions more quickly using TAK. Some issues with maintaining the batteries of smartphones running the TAK app were noted and requests for additional features and simplification of the TAK user interface were made by survey recipients.

The CoE will present the results from this pilot project to interagency wildland fire partners and will coordinate with wildland fire and TAK stakeholders to advocate for—and facilitate further adoption of—TAK as a resource tracking and common operating picture system for wildland fire.

Background

DART

On March 12, 2019, the John D. Dingell, Jr. Conservation, Management, and Recreation Act was signed into law. Section 1114 of the Act contains requirements for the U.S. Departments of Agriculture (USDA) and Interior to modernize wildfire technology. The Act contains two tasks specific to wildland fire resource tracking: (1) implement a resource tracking/location system for wildland firefighters, and (2) conduct two pilot projects within the first 2 years evaluating the operations, management, and effectiveness of proposed systems. The Fire Management Board formally established a response team to guide the development, planning, and implementation of the pilot projects. The Dingell Act Response Team (DART) is made up of representatives from the USDA Forest Service, Department of Interior Office of Wildland Fire, Bureau of Indian Affairs, Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, National Association of State Foresters, Wildland Fire Information and Technology, and the Chief Information Officers of the Forest Service and Department of the Interior.

The Section 1114 language provides some specifications for the resource tracking system, such as that it (1) use technology such as GPS to track the location of an active resource, (2) depict the location of each fire resource on applicable maps, and (3) operate continuously when resources are assigned to a federal Type 1 wildland fire. The act language also specifies that the system not be relied on solely to ensure the safety of firefighters and that the data from the system be stored in a secure manner that protects the privacy of firefighters.

In 2019, DART conducted an industry day to evaluate commercially available tracking solutions and also conducted limited pilot projects of vehicle tracking systems that had previously been deployed in the Pacific Northwest and California. In 2020, DART issued a call for pilot projects to test more comprehensive tracking solutions in the field.

TAK

The Team Awareness Kit (TAK) is a geospatial mapping engine, originally developed for the Android operating system, that facilitates situational awareness, navigation, and data sharing. TAK can function as a stand-alone situational awareness tool or can be incorporated into various tactical and commercial data networks. TAK is under continuous development by the TAK Product Center, a coalition of agencies and programs of record from the U.S. Department of Defense and other federal agencies. TAK employs a “government off-the-shelf” model, which stipulates that any new features developed for TAK be provided back to the government, thus ensuring that all government TAK users have free access to the software.

While the Android version of TAK, known as ATAK, is the most mature version of TAK, apps also exist for viewing the TAK common operating picture via Windows (WinTAK) and the web (webTAK); in addition, an iOS app (iTAK) and a virtual reality TAK workspace (VTAK) are in development as of late 2020. When operating in environments with Internet connectivity, TAK apps are connected to a TAK server, which runs on Linux and routes messages between end users of the system. When operating in environments without Internet connectivity, the TAK apps can talk directly to each other over a local

area network such as a WiFi hotspot, or can integrate with a variety of radio- and satellite-based systems to exchange information with or without a full Internet connection.
In the context of wildland fire, TAK can enable firefighters to share location information, collaboratively map an incident, and access other tools that enable them to be safe, effective, and efficient in their operations, even if traditional Internet connections are degraded or absent (as is frequently the case on wildland fires). The Android version of TAK includes a plugin architecture that allows developers to add additional features and capabilities to TAK by authoring a plugin, rather than modifying code in the base application. Several plugins are pertinent to wildland firefighters—such as plugins that integrate radio systems, allowing the app to function in areas that lack cellular service, and plugins that synchronize official geospatial data regarding the fire across all TAK phones.

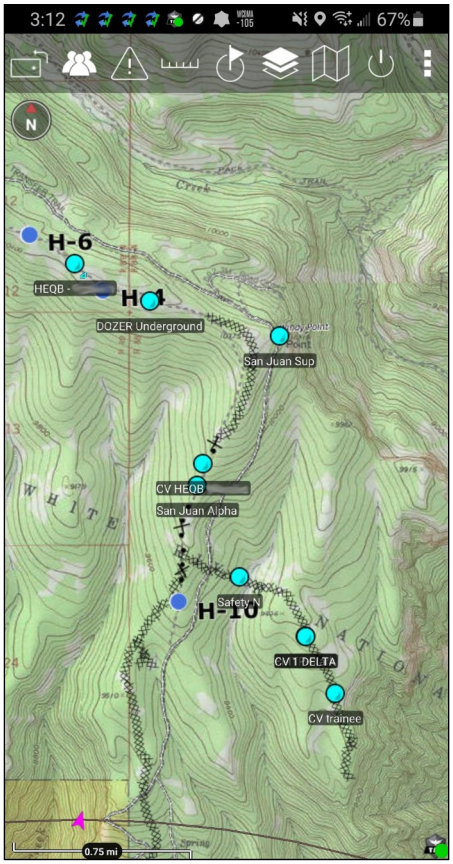


Figure 1— TAK common operating picture viewed on an Android phone

CoE Pilot Project and Goals

The Center of Excellence for Advanced Technology Aerial Firefighting (CoE) is the research and development branch of the Colorado Division of Fire Prevention and Control (DFPC), which is Colorado's State fire management agency. A key goal of the CoE is to reduce the occurrence of firefighter fatalities and injuries through enhancement of firefighters' situational awareness during emergency response. The TAK app has been under evaluation by the CoE since 2016 to improve first responder situational awareness, and was first fielded by the CoE with DFPC helitack and handcrew firefighters in 2018 as part of experimental deployments. The CoE has also supported several local fire, search and rescue, and law enforcement agencies in deploying TAK at special events and in operations.

USDA Forest Service Fire and Aviation Management funded a proposal by the CoE to develop a TAK capability for the interagency wildland fire agencies and conduct a pilot project of the TAK app as part of the USDA response to the Dingell Act. The development of TAK for wildland fire centered around creating a TAK server that is integrated with the Enterprise Geospatial Portal (EGP), a system that provides distribution, display, and analysis of geospatial information to support the wildland fire management decision-making process.

EGP TAK Server Development

EGP is a visualization and analysis tool that spatially enables existing wildland fire information and consolidates disparate geospatial data. The EGP provides a geospatial interface that allows users to access wildland fire data layers on a common web-based platform. The EGP facilitates both a continuous feed of data and the ability to combine it with other information. Users also have access to data stored in a central data repository, which allows for the exchange of information within and between land management agencies.

The information within the EGP provides first responders, wildland fire management personnel, dispatchers, and coordination centers with access to up-to-date wildland fire situational data, including fire perimeters, weather, fire detections, currently assigned resources, and the availability of other resources. The EGP and its components support the implementation of the cohesive strategy in wildland fire management by bringing data and cooperating partners together. As part of DART, a feed of vehicle tracking data from federal and state wildland fire apparatus has been developed for the EGP.

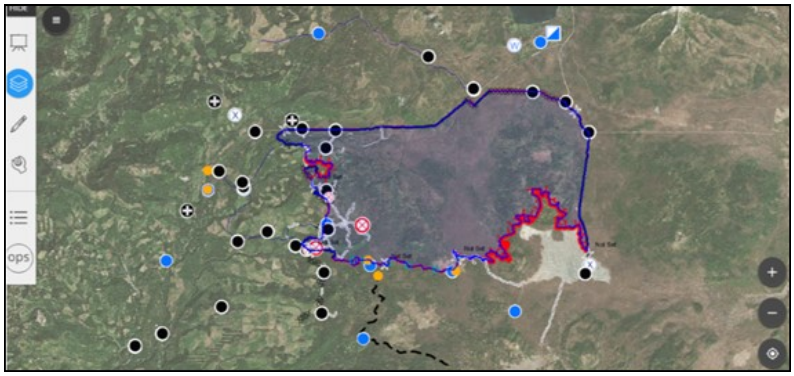


Figure 2— Fire mapping data displayed in EGP

The CoE integrated TAK into the EGP by developing a TAK server that aggregates all position reports received by the server into the vehicle tracking feed in the EGP web portal. Additionally, the vehicle tracking data within EGP is made available to TAK app users by ingesting the vehicle feed into the TAK server and rendering the data as map markers in the TAK app. Unfortunately, this integration with EGP was not live during the pilot project deployment on the Grizzly Creek Fire, but has since gone live.

The initial operating capability of the TAK server included authentication using certificate files, which are imported into the TAK app and act as a common key that many users can utilize to authenticate onto the server. The CoE will develop a username and password authentication system, which will allow future TAK app users to authenticate onto the TAK server by providing their EGP credentials to the app rather than using a certificate file. This will improve the security of the system and will make it easier for new users to join the TAK server.

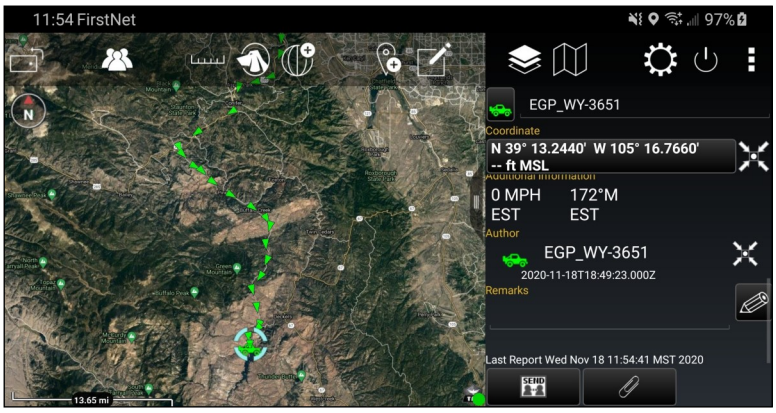


Figure 3— Vehicle tracking feed data from EGP displayed in TAK

Finally, an Extensible Messaging and Presence Protocol (XMPP) chat server is being developed for use by wildland firefighters. This chat server will utilize the same EGP credentials to authenticate users and will allow TAK app users and others to chat via XMPP. This will provide a store-and-forward capability for chat messages in the TAK app, allowing users to message others who may have intermittent connectivity, and will accommodate users outside of TAK who may need to exchange messages with app users.

CoE TAK Cache

During TAK deployments on wildland fires in 2018, the CoE utilized a cache system of Android smartphones preloaded with the TAK app, which were handed out to participating firefighters and turned in at night for recharging. While the TAK app can be installed and provisioned on any Android phone, using a cache system proved beneficial during these deployments as it quickly allowed firefighters to access the fully configured app with zero time required for installation or provisioning. As a result, the CoE chose to deploy a similar cache for the DART pilot project.

The CoE had previously created a cache of 20 Samsung® Galaxy S9 smartphones for use with TAK and the FirstNet® cellular network. FirstNet is the public safety service offered by AT&T that provides priority access to AT&T's cellular network, as well as access to a fleet of over 72 deployable cell sites for use during large-scale disasters. Each Galaxy S9 phone was housed in a Juggernaut IMPCT™ case, which provides 6.5 foot drop protection for the smartphone and can be used to mount the smartphone on chest harnesses and other mounting locations.

During the pilot project deployment on the Grizzly Creek Fire, the CoE requested 10 additional smartphones to expand the pilot project's scope. The Forest Service provided Sonim® XP8 smartphones, which run the Android operating system and incorporate a rugged design and a large battery. These phones were deployed without protective cases and also utilized FirstNet service.

FirstNet service can be procured by any public safety agency or by individual first responders. For this pilot project, the CoE worked with the Department of the Interior FirstNet pilot project to procure 20 SIM cards with FirstNet service, which were loaded into the smartphones and activated in early August 2020. The smartphones were also updated to Android 10 during this process using the built-in software update tool.

During the provisioning process, the CoE installed Hexnode mobile device management software onto each phone. The Hexnode software allows administrative policies to be applied to the smartphones in the cache. For the DART pilot project, this policy prevented the installation of apps, applied a standard wallpaper to the smartphones, and prevented users from removing the Hexnode software. Hexnode also automatically installed the TAK app, the data sync plugin, and the compass navigation plugin to all devices. Finally, the Hexnode software pushed files into predesignated locations on the pilot project smartphones. These files included a preference file that customized TAK with toolbars, coordinate systems, and other user interface tweaks for wildland fire, as well as with elevation data and certificate files to enable connectivity to the EGP TAK server.

While several steps were required to install and enable the Hexnode software, once it was installed it saved several minutes per device by automating the process of installing and configuring TAK. During the pilot project deployment, Hexnode also proved useful by enabling the location tracking of smartphones even when the TAK app was not running, which helped to track down phones for recovery during firefighter demobilization. Hexnode was also used to lock down two smartphones that were lost or removed from the incident; the lock prevented their usage and displayed a message directing users to contact the CoE at a designated phone number. This feature was successfully used by an Incident Management Team (IMT) liaison officer who was given a phone by a departing crew and contacted the CoE to return it.

The CoE also integrated 14 goTenna Pro-X radios into the cache that had previously been purchased with State funds. The goTenna Pro-X is a VHF/UHF 5-watt radio that integrates with TAK via a plugin. The radio pairs to a smartphone running TAK using Bluetooth Low-Energy and can be carried in a firefighter's line gear. Using the goTenna Pro-X, a firefighter may view the location of nearby resources who are also using the TAK app and goTenna Pro-X and interact with them by sharing points, lines, polygons, or text messages. This process occurs independently of cellular service as the radios communicate in a peer-to-peer manner, and thus are of most use in areas with poor or nonexistent cell service. The goTenna Pro-X is capable of mesh networking, which allows each radio to act as a repeater and route messages across one or more hops until all nearby firefighters have received the data. The CoE planned to not deploy these radios by default, but rather to utilize them if firefighters were required to operate in an area with poor or no cell service during a pilot project deployment, at which point the radios would be deployed. During this pilot project deployment, the goTenna Pro-X radios were not deployed.

The 20 Galaxy S9 smartphones and 14 goTenna Pro-X radios were integrated into a Pelican™ 1555 case for transportation and recharging. During previous deployments of TAK on wildland fires, the CoE had recharged smartphones in trucks or at a duty station. However, as the DART pilot project was intended to track a variety of resource types from multiple agencies, CoE staff believed that relying on each resource to recharge their own device would result in failure. Instead, the CoE developed a plan to issue devices to resources and allow them to deposit their device at a central location at night for recharging support and then pick the device up the following morning. The Pelican Case included a central charging point and could be deployed outdoors as it was relatively weatherproof. The case included a 40-port USB charger (with each port capable of providing 3.5 amps), 20 USB-C cords, and 16 micro-USB cords. The box could be closed with devices inside and charged via a standard A/C outlet. The case had no onboard battery capability, but was intended to provide a single point connection to a power source for all available devices.

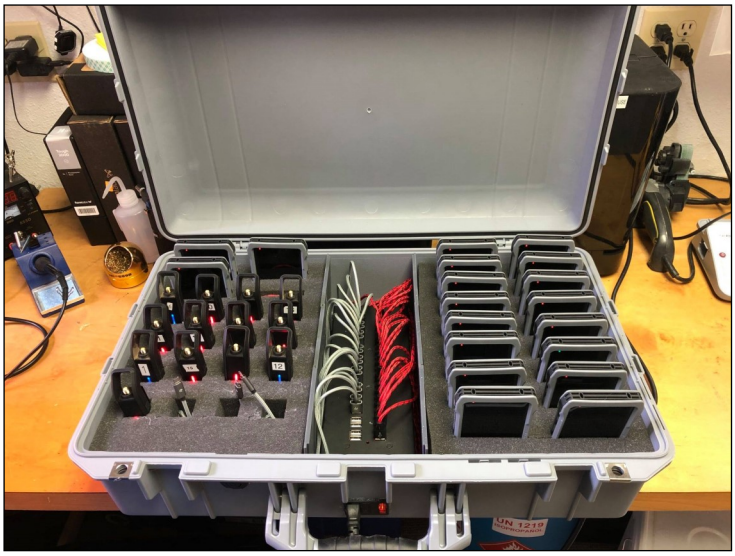


Figure 4— Pelican™ recharging case

COVID-19 Mitigations

COVID-19 presented challenges to the wildland fire service during the 2020 fire season. To deploy a technology pilot project during this difficult time, the CoE undertook special precautions to mitigate COVID-19 risk. CoE personnel were issued the National Multi-Agency Coordinating Group COVID-19 checklist, which details the personal protective equipment and self-sufficiency supplies required to operate on a wildland fire. The CoE also utilized a solution of 70% isopropyl alcohol, which was sprayed on smartphones and wiped off with a paper towel prior to issuing devices to firefighters, as well as when firefighters returned devices for rehabilitation.

Grizzly Creek Deployment Synopsis

The CoE cache of TAK smartphones was made available for incident response on August 10, 2020. A one-page flyer advertising the capability of the TAK app and equipment cache and its role in the DART project was developed and disseminated to IMTs through DART members (see Appendix 1). A handful of IMTs expressed interest in hosting a pilot project prior to August 10.

The Grizzly Creek Fire started on August 10 at 1:30 p.m. in Glenwood Canyon, approximately 27 miles east of the CoE office. The fire immediately exhibited extreme fire behavior and shut down an interstate highway, railroad line, and utility infrastructure, as well as led to evacuations in two counties. A local Type 3 team initially took command of the fire, with a regional Type 2 team assuming command the following morning (a Type 1 team was ordered at that time).

Great Basin Team 1 took the assignment as the Type 1 team and, as it happened, their Deputy Incident Commander (IC) was a member of DART and had previously expressed interest in participating in a TAK pilot project. In addition, a member of the CoE was deployed to the Grizzly Creek Fire on the Type 2 team as the Air Operations Branch Director and he coordinated with the incoming Type 1 team to help ensure that the CoE could quickly obtain agency administrator approval and begin planning the pilot project.

On August 12, CoE staff attended the in-brief meeting with Great Basin Team 1 and received verbal approval from the White River National Forest Supervisor to proceed with the pilot project. At this point, resources were still mobilizing to the fire and the incident command post was being relocated. As a result, the IMT requested that the CoE check back the following day for a specific assignment.

The following day, CoE staff met with the Deputy IC and Planning Operations Trainee to plan a deployment of TAK. Despite being previously unfamiliar with TAK, they quickly developed an understanding of the capabilities of the system and the objectives of the pilot project. Planning Operations suggested that the CoE work with Division N to plan a deployment there, due to the Division Supervisor's previous work with fireline technology and the division's location relatively close to the town of Glenwood Springs, which would help ensure the availability of cell service.

The IMT also expressed an interest in deploying TAK with the night shift on the fire, as they felt it could have the most impact to improve situational awareness during night operations. The CoE agreed with this plan and quickly made plans to deploy TAK devices that evening with night resources. The night Division Supervisor and 4 engines were issued phones at the night shift briefing and the operations map for August 13 was pushed onto the phones. Training was extremely limited by deployment requirements and active fire behavior that required engines to respond immediately to the fireline. Operations on the night shift commenced on August 13 and continued for 12 nights.

On August 14, CoE staff met with Division N to provide a briefing on the pilot project and begin distributing phones to division resources. The Division was located on the north side of Glenwood Canyon and north of the city of Glenwood Springs. The fire had become established in the No Name Creek drainage, but was stalled in the bottom of the valley. Most activity in the Division was centered on constructing an indirect fireline along the top of the ridge immediately west of No Name Creek.

Training

All firefighters who participated in the pilot project received a brief introduction to the purpose of the pilot project and an orientation to the TAK app. Firefighters were told they could use the app however much or little they wanted, but to at least keep TAK on throughout their shift. CoE staff asked firefighters if they had previous experience operating Android phones; those who did not received 3–5 minutes of training on the process of locking and unlocking the phone's screen and on navigating using the home, back, and recent apps buttons that are found at the bottom of Android screens.

All pilot project participants were given a small trifold handout detailing how to operate an Android phone and perform basic functions in TAK (see Appendix 2); users who lacked Android experience were instructed to consult the pocket guide at their leisure to learn more about the TAK app. Firefighters who had previous experience with Android received 3–5 minutes of in-person training on the operation of the TAK app. This training included how to change the basemap displayed in the app and how to recenter the map by tapping on the coordinate display bar, as well as how to drop points and share them with others.

Figure 5— CoE staff providing training on the TAK app in the field

CoE staff deployed into the field several times on Division N and with the night shift to meet with users and answer questions or trouble-shoot problems they encountered. Staff were surprised at the complexity of TAK operations users were able to discover—on one occasion, an engine was able to view a georeferenced video stream from the State of Colorado Multi-Mission Aircraft (MMA) that had been pushed to all TAK phones by the CoE. The engine crew showed this video and an updated fire perimeter to another crew that was not participating in the pilot project and the other crew reacted with disbelief that such real-time information could be available to firefighters on the fireline.

Data Dissemination

Each morning, maps for the incident were downloaded from the National Interagency Fire Center FTP site and converted from Geospatial PDF format to GeoTIFF format using QGIS software. Subsequent to this deployment, the Android version of TAK was updated to natively display Geospatial PDFs. Initially, a single ops map with coverage of the whole fire was deployed in TAK; however, the resolution of this map was found to be too low to be of use for field navigation, so later in the deployment individual division map tiles were deployed in TAK. Approximately 4 of these tile maps covered the whole incident with a small amount of overlap.

The data sync plugin for TAK was utilized during the Grizzly Creek Fire to disseminate and synchronize maps and geospatial data. Once the maps had been loaded into the TAK app of a CoE staff member's phone, they were added to a data sync mission for the Grizzly Creek Fire. All field personnel had subscribed to this mission on their TAK apps, so when the maps were added to the mission they were pushed to the phones automatically. The mission content is held in the TAK server, so even if a phone is not connected to the TAK server when the changes are made, the phone will synchronize and apply the changes when connectivity is restored. Additionally, the previous day's maps were deleted from the data sync mission each morning. This action sent a command to each firefighter's phone instructing it to delete the content.

On a handful of occasions, the MMA flew the Grizzly Creek Fire during the day and collected a new fire perimeter. Early in the deployment, these new perimeters showed substantial growth from the perimeter depicted on the incident maps. These perimeters were added to the data sync mission and pushed to firefighters' phones, providing them access to the data several hours earlier than they would otherwise receive it. On one occasion, a full-motion video clip depicting fire activity in Division N was also pushed via data sync, and at least one fire crew was able to open the clip and view it while in the field. Finally, a night shift engine made a request for mile markers to be added to the app as they needed this information to radio in reports of rockfall occurring on the interstate highway in Glenwood Canyon during the night. A KML layer of mile markers for all Colorado highways was already deployed on the TAK app of a CoE staff member, so CoE staff added this layer to the data sync mission and pushed it to all field resources within minutes of the request.

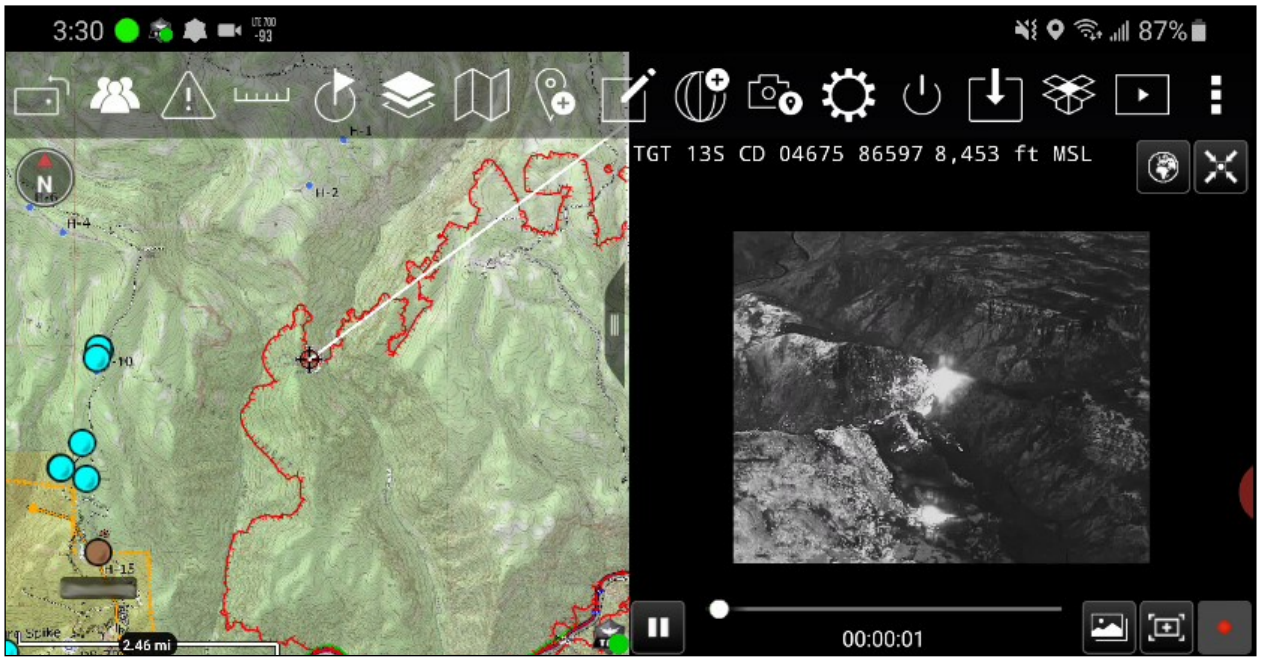


Figure 6— Infrared video of the Grizzly Creek Fire collected by Colorado MMA and displayed in TAK app (the crosshair in the center of the map corresponds with the center of the video)

During the deployment, some issues were noted with GeoTIFF maps failing to download to phones when added to the mission and failing to delete when the delete command was transmitted. The data sync plugin developer was contacted and was able to replicate the issue. This issue appears to occur when phones are disconnected from the TAK server when the mission changes occur; a patch will be applied in the next release of TAK server to mitigate this issue.

Charging Support

The TAK app requires the GPS on a smartphone to be kept on at all times and the app consistently exchanges data with the TAK server during its use. As a result, the TAK app uses a high amount of battery power from the phone and thus requires careful consideration for when and how phones will be recharged, especially during the long shifts and multi-day deployments that are common on wildland fires. During the planning phases of the TAK pilot project, the CoE envisioned centralizing the process of issuing and recharging phones running the TAK app; in other words, firefighters would visit a single location at the Incident Command Post or a spike camp to obtain a charged device in the morning, turn the device in at night, and receive a new charged phone the next morning. However, with operations taking place on the Grizzly Creek Fire during both the day and night shifts, and with staging locations for night and Division N resources 35 miles apart, this approach was quickly determined to be impractical.

Fortunately, night shift resources were all vehicle based and rested during the day in hotel rooms, both of which provided many opportunities for them to recharge devices on their own. After the first night of operations, CoE staff purchased 12-volt car chargers and issued them to all night shift resources utilizing the TAK app. No wall chargers were supplied to night shift resources, though some firefighters may have used personal chargers. During their sleep time, resources appeared to keep the phones charging in their vehicles or sleeping quarters. Several left TAK running during their off hours. While there were occasional instances of the phones of night resources dying, for the most part these firefighters were successful in keeping the TAK app operational on their phones throughout their shifts.

On Division N, the majority of resources were operating on foot during the day and were camping at night at a spike camp location with minimal electrical power available. As a result, greater charging support was needed to maintain operations with the TAK app. The CoE adapted the previous plan of providing centralized charging support to the resources on Division N. Most division resources congregated at a drop point where a maintained road ended and a jeep road began. Each morning firefighters would drive to the drop point and then be ferried to their work assignments in UTVs. The CoE placed a box trailer at this drop point as a charging hub.

The box trailer was built by the CoE with a custom solar panel, lead-acid battery, and inverter system to support unmanned aircraft system operations. The CoE used the inverter to supply power to the Pelican™ case, which was placed on a table outside the trailer. Each evening, firefighters could plug their phone into a charging port in this case, leave it overnight to charge, and pick it up the following morning. Phones were marked with their owner's name using sharpie markings on fiber tape.

The initial plan to use the built-in inverter system began to encounter problems since CoE staff found the inverter in an error mode when they visited it in the evening. Despite resetting the inverter, the problem continued to occur and prevented phones from charging at least once. After researching the issue, CoE staff determined that the inverter was likely experiencing excessive temperatures, which

was logical as the outside air temperature was reaching into the upper 90s at the drop point during afternoons.

Figure 7— Charging equipment in use on Division N

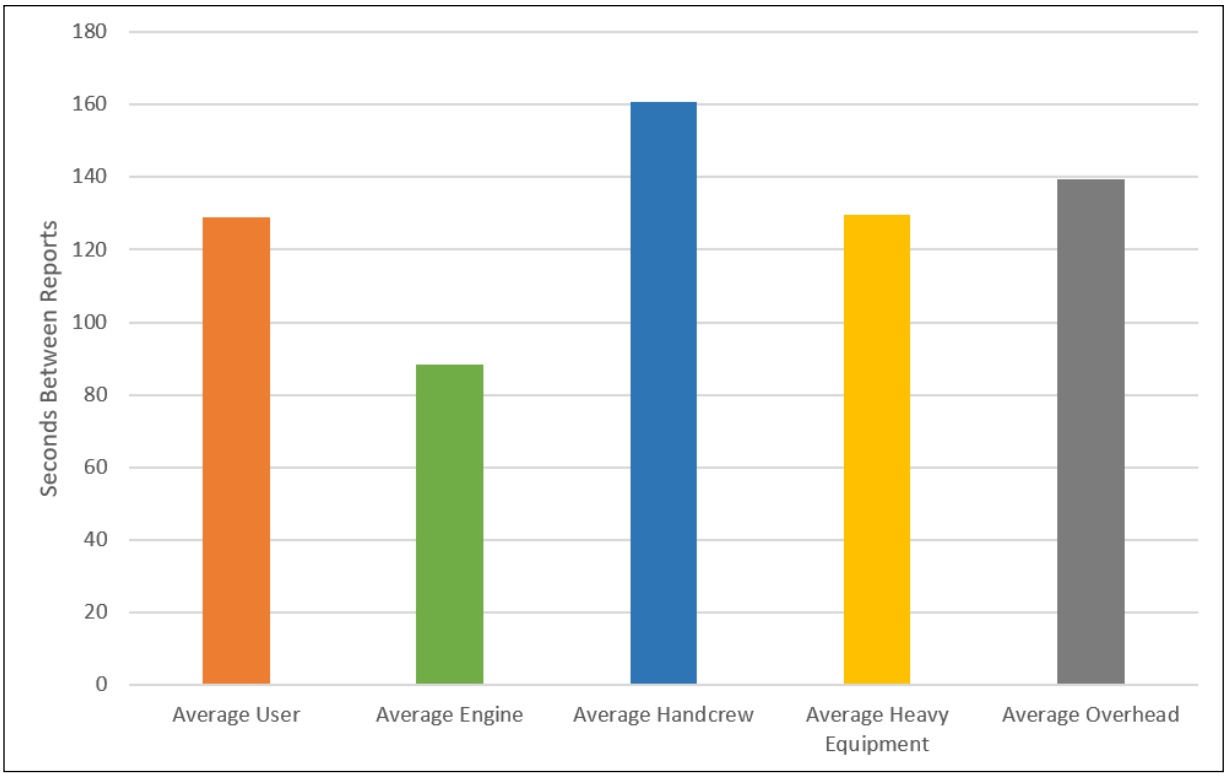
CoE staff switched from the built-in inverter to using two Goal Zero® Yeti 400 systems, each of which include a solar panel, lithium ion battery, and inverter. This system proved to be more resilient to the high temperatures at the drop point, so each Yeti 400 system was used on an alternating basis each day. While both systems were plugged into their respective solar panels every day, only one system would discharge power into the Pelican case each day. This allowed the other system to fully recharge its battery, which would be discharged the following day. Following this transition, the CoE experienced no further challenges with providing power to the phones recharging at the drop point.

Grizzly Creek Results and Feedback

A total of 28 resources utilized the TAK app during the Grizzly Creek Fire Pilot Project, with overhead personnel being the most common type of user, followed by engine, handcrew, and heavy equipment. It should be noted that while some resources represented a single person, others—such as engines and handcrews—were issued one phone for multiple firefighters. On average, the length of time firefighters participated in the pilot project was 7.57 days, with the longest deployment lasting for 12 days and the shortest for 1 day.

A total of 154,304 location reports were received by the TAK server from firefighters participating in the pilot project. On average, users' locations were transmitted every 129 seconds. For individual users, the longest average length between location reports was 328 seconds and the shortest was 45 seconds. The TAK app uses a dynamic location reporting methodology, which sends out location updates more frequently when the phone is moving quickly, and less frequently when the phone is moving slowly or is stationary. As a result, the handcrew resources, which operated on foot for most of their deployment, had the most time between location reports with an average of 161 seconds, while engines, which were often on continuous patrol during night shift, had the shortest average time of 88 seconds. Cellular connectivity also impacted the number of position reports received, since when users lost cell service and their connection to the TAK server, the position reports from their time out of service were not logged to the server.

Chart 1— Average number of seconds between location reports by resource type



Division N Operations

CoE staff commenced operations on Division N on August 15 and continued the TAK deployment there for 9 days. Resources using the TAK app included the division supervisor and trainee, taskforce leaders, engines, two hotshot handcrews, heavy equipment bosses and operators, a line paramedic, and a line safety officer (for a total of 15 phones).

On Division N, FirstNet cellular service was fairly reliable. The lower areas of the division were 2–4 miles away from a FirstNet macrocell site on Lookout Mountain, which was at an elevation of 8,000 feet; this site provided excellent coverage in areas with line-of-sight to the tower, and continued to provide coverage even in areas where line-of-sight was obstructed by terrain. At a spike camp partially up the ridge at 7,000 feet with line-of-sight to the tower, FirstNet speeds were tested and found to be 200 Mbps download and 37 Mbps upload. However, line-of-sight became a more significant factor at higher elevation areas on the division, which were 5–6 miles away from the tower and 9,400 feet–10,400 feet in elevation. At higher elevations, minor disruptions of the line-of-sight to the Lookout Mountain tower caused TAK to lose connection to the TAK server and users in these areas stopped sharing their locations with others. This was likely due to a combination of increased distance from the cell tower and the increase in height relative to the cell tower. The panel antennas on cell towers are often tilted slightly down to improve signal strength in nearby areas and, while the CoE was not able to confirm if this was the case on the specific tower providing service to this area, a downward tilt may have decreased the signal strength available to firefighters who were well above the tower. A second cell site in South Canyon also provided some coverage to Division N and worked best on west-facing aspects, while the Lookout Mountain site provided best coverage to south-facing aspects. The CoE has

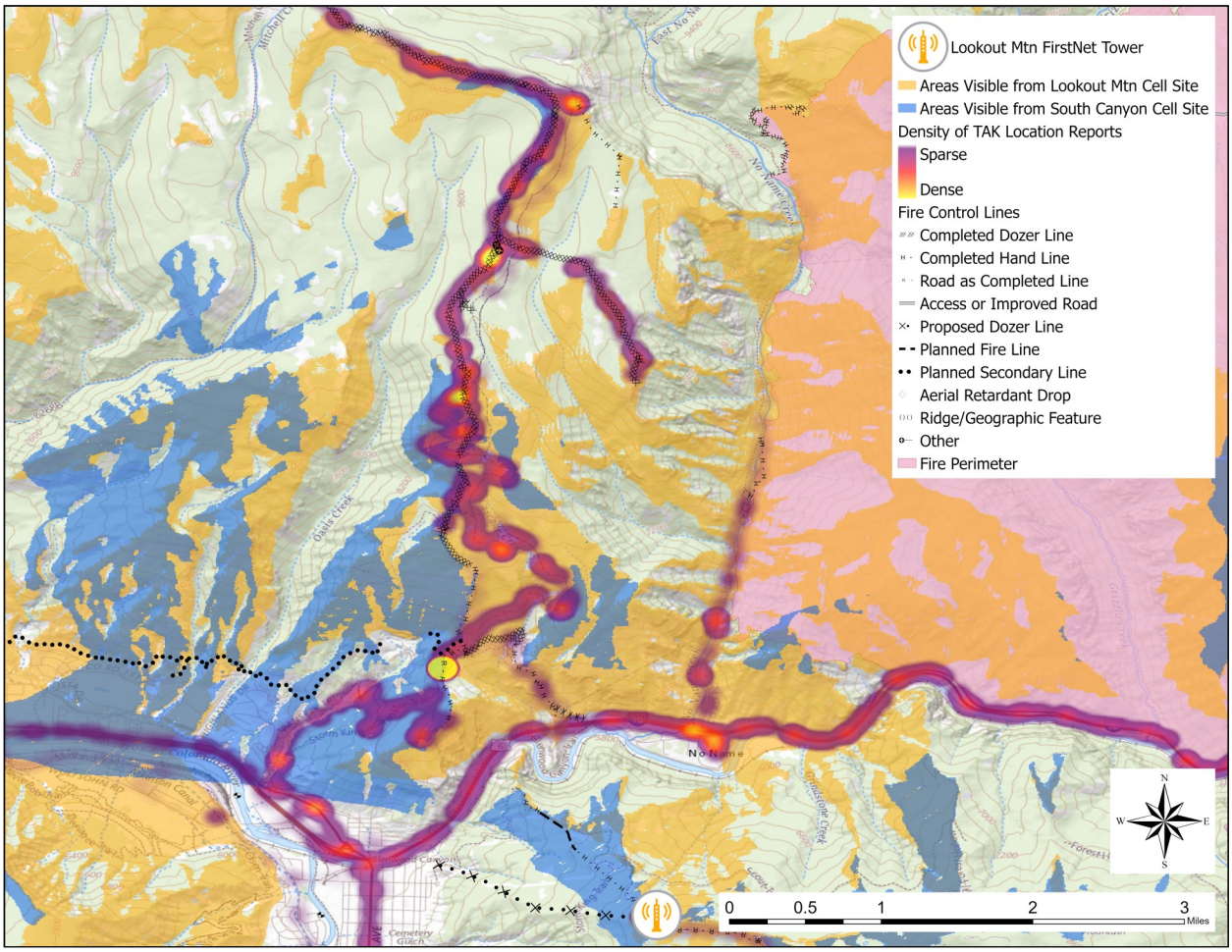


Figure 8— Map of density of TAK location reports and line-of-sight to cellular towers on Division N

recently received a donation of an advanced radio frequency testing and detection system that will allow for additional quantification of cellular coverage on future deployments.

An example of the importance of line-of-sight to cellular connectivity and the performance of the TAK app was found on a spur dozer line that progressed eastward from the division safety zone 4.4 miles away from the Lookout Mountain tower at 9,600 feet elevation. This dozer line crossed a gully, at which point line-of-sight to the tower on Lookout Mountain was significantly disrupted (see Figure 9). In this gully, almost no TAK location reports were successfully transmitted (the few reports in this area were from overhead personnel who were in helicopters scouting the area, and thus were well above the ground). Once the dozer line progressed east out of the gully and turned south, line-of-sight to the tower was restored and the number of TAK location reports immediately increased.

Night Shift Operations

A total of 13 phones were issued to night shift resources, which included engines, the division supervisor, task force leaders, a line paramedic, and a line safety officer. The fire itself was roughly 15 miles long and night shift resources were providing structure protection on private property all around

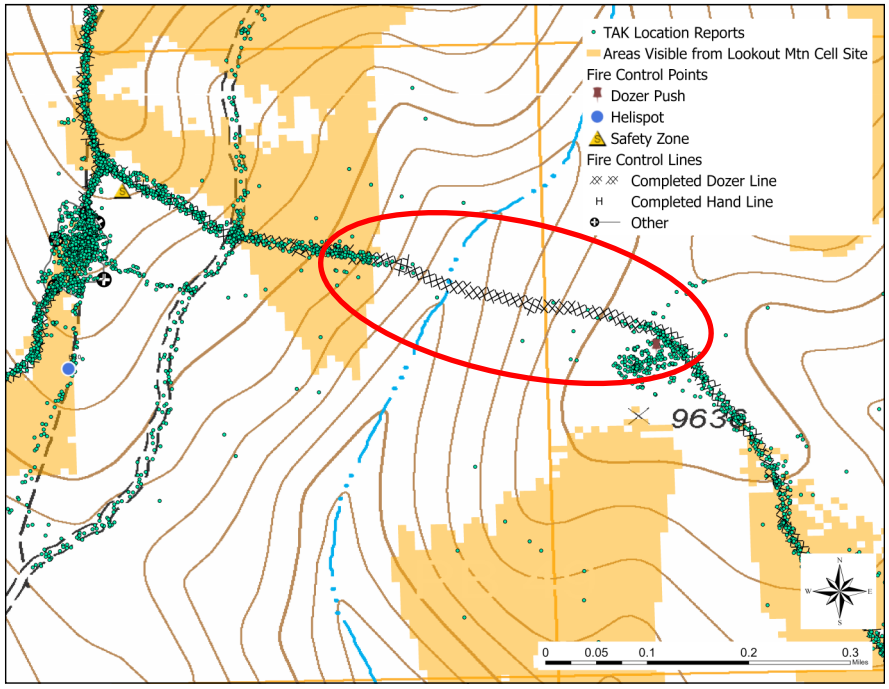


Figure 9— Map of TAK reports on Division N spur dozer line, with a circled area of sparse location reports at the gully in the center of the map

the fire perimeter, often requiring lengthy mobilization times to reach subdivisions located up winding mountain roads.

Night shift resources typically had FirstNet coverage in the subdivisions where they were providing structure protection. However, dead spots were commonly encountered during mobilization of resources through Glenwood Canyon and on county roads that passed through narrow canyons. Some resources were more affected by these dead spots than others and, while the CoE was unable to investigate this discrepancy in detail, it is likely that some fire apparatus were equipped with cellular boosters which improved the existing cell signal, while other apparatus lacked this equipment. Additionally, some TAK phones may have been placed in fire packs located in cargo storage areas on the vehicles, which would have provided less service than phones that were placed in the cabs of apparatus.

Quantitative Feedback

CoE staff attempted to catch up to firefighters at the end of their assignments to collect smartphones and equipment that had been issued and to survey firefighters on their experiences with the TAK app. The CoE used the incident's demobilization list to plan when to make these visits prior to the resource's official demobilization time. This worked well, but failed to account for resources that were reassigned from night shift or Division N to other areas of the fire. In these cases, the resources turned their phones in to their supervisors, the Pelican case, or other locations.

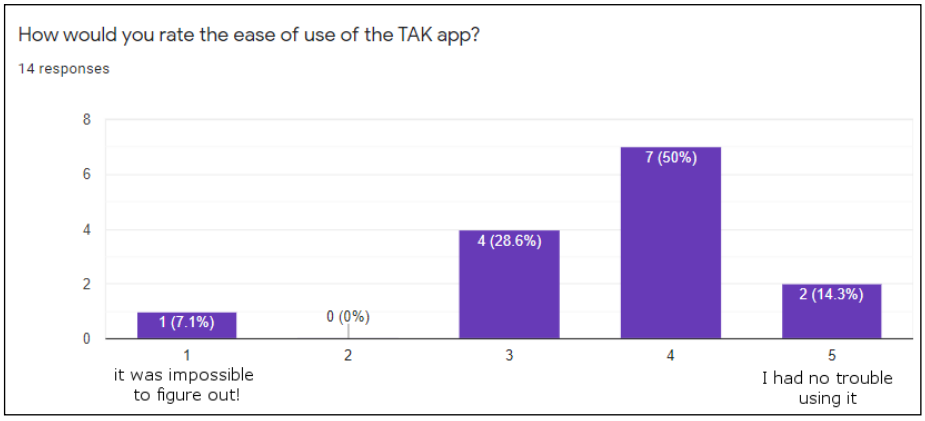
When the CoE was able to intake the TAK smartphones in person, they provided a QR code link to a web-based survey on the TAK pilot project. The QR code was also posted at the charging station on Division N. A total of 14 survey responses were received, which was a 50% response rate considering that 28 total phones were issued. Survey responses were received from 5 overhead, 4 engines, 2 handcrew, 1 medic, 1 heavy equipment, and 1 water tender.

The surveyed firefighters had broad prior experience using smartphones and tablets on previous fire assignments. 13 out of 14 had previously used their phone to view static maps of fires using apps such as Avenza Maps™. However, only 8 out of 14 had previously viewed fire maps that dynamically update as new data is received using apps such as ArcGIS Collector or EGP.

All participants reported that this was their first experience using TAK and all agreed that TAK enhanced their situational awareness. All participants used TAK to view the locations of others and 12 out of 14 agreed that this was TAK's most useful feature. 13 out of 14 agreed that they were able to make decisions more quickly using TAK.

When asked to rate the ease of use of the TAK app, with a score of 1 indicating that TAK was impossible to figure out and a 5 indicating that it was no problem at all, the average score was 3.67. The participants agreed that the app accurately depicted the location of firefighters when it was operating in areas with cell service. 9 firefighters believed they used TAK in areas without cellular service during the pilot project and 2 were unsure if they had.

Chart 2— Responses to survey question on the ease of use of TAK



10 firefighters stated that their battery died more than once during the pilot project, with 4 stating that it never died. All firefighters who stated their battery had died (and 3 of the 4 who stated the battery never died) were issued the Samsung Galaxy S9 phone, which is equipped with a 3000 miliamp hour (mAh) lithium ion battery. While the CoE has determined that this phone can run the TAK app for a 16-hour shift in ideal conditions without completely depleting the battery, TAK does drain the majority of the battery over this time, leaving little spare capacity to account for missed charging opportunities, high temperatures that further drain the battery, or the use of other apps. Only one user who was issued the Sonim phone completed the survey, and this user indicated that their battery never died. While more data needs to be collected on the battery performance of various phone types while running the TAK app on real incidents, the Sonim phone does have a larger battery with a 4900 mAh capacity, which should allow it to run the TAK app for a longer period of time without depleting the battery.

Qualitative Feedback

Survey recipients were asked if they could remember any occasions where the TAK app helped them accomplish their assignment quicker or more efficiently. The following responses were received:

- "Know location of widely dispersed resources during night shift. Make best use of available resources."
- "Was the Night DIVS (Division Supervisor) and the first few nights had no other overhead. Showed where my resources were and helped me keep a better track of them."
- "Knowing resource locations in case of an emergency."

- “During an initial attack I was able to track others to the correct location, enabling me to save time and confusion.”

The initial attack fire that was referenced in the fourth bullet point was the Red Canyon Fire, which ignited at approximately 4:00 p.m. on August 19 and was fought by Grizzly Creek Fire resources as well as local firefighters. During a conversation that a CoE staff member had with the night safety officer, he stated that he was able to navigate to the fire by looking for a cluster of dots in TAK indicating other resources and following the map to reach them.

The Division N supervisor also related an anecdote involving one of the hotshot crews that deployed the app with the crew superintendent as well as with squad bosses, each of which supervised several firefighters. One of the squad bosses asked the crew boss over the radio if they should start constructing fireline at their location. The crew boss, who was scouting ahead, checked the TAK app and instructed the squad to keep hiking another couple hundred feet to reach his intended location. This type of coordination of resources using the TAK app was seen several more times by CoE staff during the pilot project.

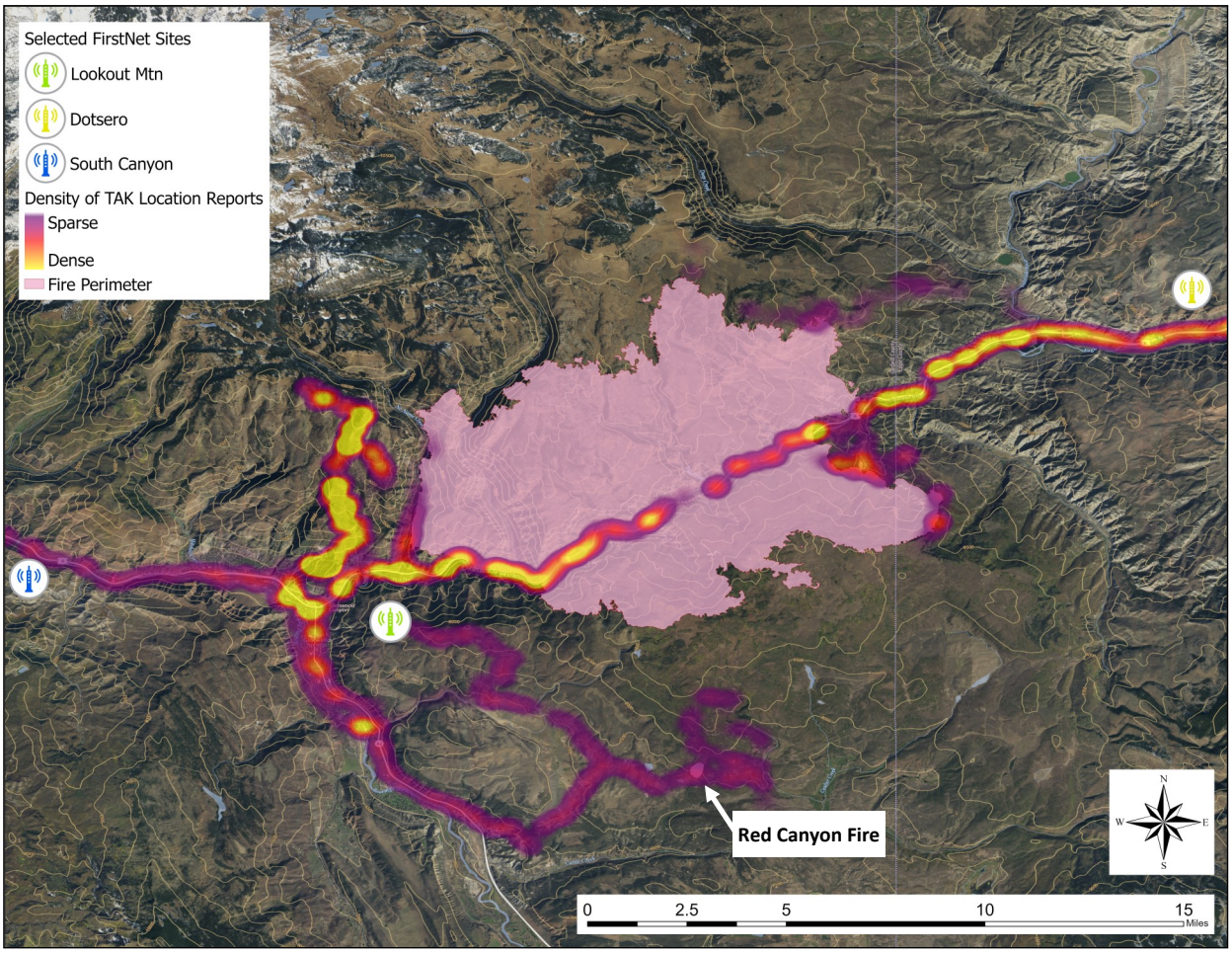


Figure 10— Heat map depicting areas of dense and sparse location reports across the Grizzly Creek and Red Canyon Fires, and the locations of select FirstNet cell sites

In the survey the CoE asked recipients to share any additional feedback. The following responses were received:

- "I would like to see TAK used at all incidents."
- "Looking forward to it becoming available with enhanced features."
- "The app has WAY to(o) many features and capabilities. I'm not a tech guy, I don't get it, and I don't understand it. TAK needs to be DRASTICALLY dumbed down so that it is easy for those of us who are less tech savvy to use."

Figure 11— Heavy equipment boss tracing a proposed dozer line in TAK

Next Steps

This report will be submitted to DART for their feedback and consideration as part of future resource tracking initiatives within interagency wildland fire. The CoE is also incorporating lessons learned from the development of the EGP TAK server and from the Grizzly Creek Fire pilot project into plans for future work with resource tracking and situational awareness for wildland firefighters. The following four priority areas for development or enhancement of the TAK app for the wildland firefighting use-case have been identified by the CoE based on lessons learned prior to, and during this pilot project:

1. Development of common resource identification standards that are applicable for the TAK app and external tracking system
2. Further integration of TAK with fire mapping systems, both for static map products and for dynamically updating map services
3. Ensuring that TAK devices can function throughout a wildland fire assignment without battery disruptions
4. Simplifying the user interface of TAK, while maintaining the advanced capabilities that make the app compelling

These priority areas will be addressed through ongoing partnerships between the CoE and the TAK Product Center, USDA Forest Service, Department of Homeland Security Science and Technology Directorate, and others. While additional work needs to be performed to optimize TAK for wildland fire use, the CoE believes that the technology can immediately improve the situational awareness of wildland firefighters and will advocate for its adoption in Colorado and nationwide.

Appendix 1: TAK flyer provided to incident management teams to promote pilot project

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Department of Public Safety

Team Awareness Kit Mobile App

Real-Time Wildland Fire Situational Awareness

Background

The Team Awareness Kit, or TAK, app runs on Android and Windows devices and is coming soon to iOS. The TAK app was originally developed by the U.S. military and is used by over 150,000 soldiers and law enforcement officers.

As part of the Dingell Act initiative to modernize wildland fire technology, the Team Awareness Kit is being piloted to provide resource tracking of firefighters and real-time situational awareness to personnel on the fireline and elsewhere.

GPS locations of handcrew squad bosses viewed on an IAP map in TAK

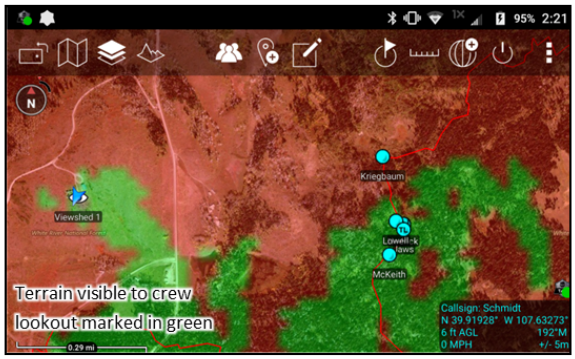
Resource Tracking

The TAK app is similar to Avenza or Collector in that it displays a moving map of the incident with a dot for your location, but the TAK app will also display the GPS locations of other TAK users. The app connects over cell service when available, or can tie firefighters directly to each other using a 3-ounce mesh-networking radio that is carried in line gear and wirelessly connects to a smartphone running TAK.

Real-Time Situational Awareness

TAK uses imagery and map overlay information to support real-time information flow, communications, and enhances overall collaboration and situational awareness. With TAK firefighters can:

- Create and send points and shapes
- Measure distances
- Determine distances and bearings to map objects
- Calculate terrain visible from a lookout point
- Activate an emergency distress signal with the real-time location of the sender
- And many more tools and features…



2020 Pilot Project Support

TAK specialists from the Colorado Center of Excellence can deploy the TAK app on incidents during the 2020 fire season. Up to 20 phones preloaded with the TAK app can be deployed, along with mesh-networking radios to enable use in areas with no cell service. Specialists will also provide support to charge devices, as well as onsite training for field and ICP personnel on the basic operation of the TAK app.

Specialists will be self-sufficient when on incident and will follow the NMAC 2020-17 COVID-19 checklist. By allowing a deployment your team will receive real-time GPS locations of key personnel, and an archive of data for use in AARs.

To learn more about the TAK app, visit tak.cofiretech.org or scan:

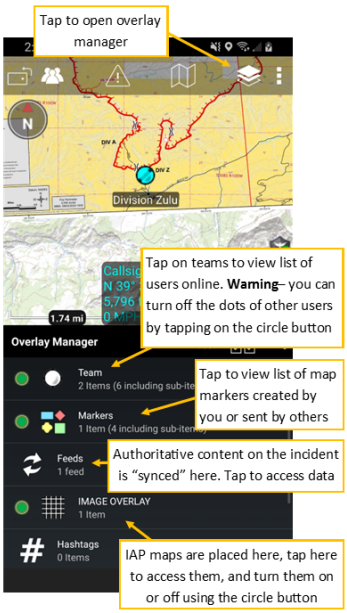
For inquiries on incident support: [redacted]

Appendix 2: Tri-fold pocket guide provided to firefighters as a training aid

goTenna Tool

If you have no cell service, you can connect directly to other nearby resources using the goTenna. In this mode the only functions of ATAK are: GPS tracking, chat, sharing points, and sharing 'simple' shapes with 8 vertexes or less.

Overlay Manager



ATAK Pocket Guide

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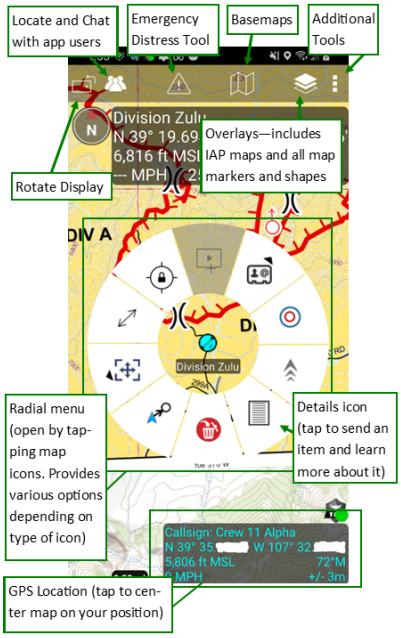
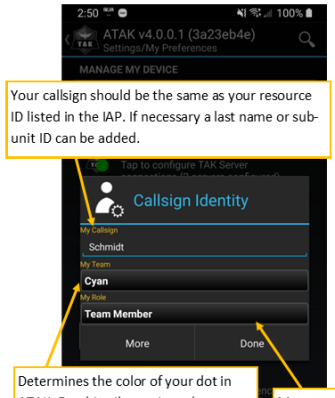
For help contact [redacted]

ATAK BASICS



CALLSIGN SETUP

Set callsign by tapping ⋮ then 'Settings,' and 'My Callsign'



POINT SHARING