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INTEGRATED VOICE & DATA
A PILOT PROJECT CONDUCTED BY THE CITY OF ST. CLOUD

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What is Integrated Voice & Data?

Integrated Voice & Data is a limited pipe of data that utilizes your existing Land Mobile Radio (LMR) system. For this pilot project, the LMR system utilized is the Allied Radio Matrix for Emergency Response (ARMER – The statewide Minnesota public safety radio system) network, more specifically the St. Cloud Simulcast (towers for the ARMER network that serve the St. Cloud area). When utilized on your voice LMR system it allows for a limited amount of data to pass from the radios (subscribers) to the LMR infrastructure. From the LMR system, depending upon the feature utilizing the IV&D there would be either two-way transmission/receive (tx/rx) of data or only receive (rx) and sending it to an application connected in the Customer Enterprise Network (CEN).

Why Test Integrated Voice & Data?

For many years, the City of St. Cloud has had a desire to implement Integrated Voice & Data (IV&D) on the St. Cloud Simulcast. The City of St. Cloud representatives wanted to utilize Over the Air Programming (OTAP) to more efficiently program radios (subscribers) remotely, rather than connect a physical cable to complete the update. Programming a fleet of subscribers via in-person cable connection can be a significant cost and take weeks or months to complete. Utilizing OTAP would alleviate some of those aspects.

IV&D was recognized as being a pipe of limited data throughput, but enough to complete some important tasks like OTAP, Location, Over the Air Rekeying (OTAR) and many others. Motorola Solutions sales and engineers advertised to the City of St. Cloud and other Local System Administrators in the State of MN, that voice will always supersede data activity.

Some of the features offered with IV&D may not be suitable as a statewide solution; but a solution identified as beneficial for specific areas of the state.

What is Over the Air Programming?

Over the Air Programming (OTAP) is a feature that can be utilized on an existing IV&D capable LMR system to provide programming updates to subscribers that are registered to the St. Cloud Simulcast.

The interface to send these updates can vary by utilizing Customer Programming Software (CPS) and executing a programming job one at a time. The other way is to use the Motorola Solutions Radio Management database tool to schedule many jobs for different subscribers.

Radio Management is a Motorola Solutions tool that provides server-based subscriber programming and allows for a database to schedule programming updates. These programming jobs can sit in a queue until the subscriber is cable connected, Wi-Fi connected or connected via OTAP. Radio Management maintains information regarding the existing codeplug that is currently in a subscriber and can send just the changes in the codeplug to the subscriber.

Note - After a Central MN Regional meeting, a regional member offered to ask an EF Johnson/Kenwood vendor if there was a desire to provide equipment to test non-Motorola Solutions subscribers for the OTAP feature. The regional member conveyed to the City of St. Cloud that the offer was declined by the vendor.

What is Location?

Newer subscribers (of any manufacturer) are increasingly coming with Global Positioning System (GPS) capabilities on the subscriber. Having this feature on the subscriber allows the user to have access to their GPS coordinates when the subscriber has a satellite lock; for use outdoors.

This feature can be used on IV&D by using the data pipe to send the GPS coordinates from the subscriber back to the St. Cloud Simulcast. It then utilizes the Motorola Solutions Intelligent Middleware (IMW) server that can have connections to other customer mapping services to provide location for that customer and their subscribers.

At the time of this pilot; static, time-based GPS updates were utilized. Settings in the IMW also offered GPS updates based on distance travelled. This distance setting was not tested.

Prerequisites for the Pilot Project

Before a pilot of IV&D could begin, there were many meetings with Motorola Solutions for quotes, understanding the magnitude of software, licensing and capabilities/constraints. Meetings with the Central Minnesota Regional committees and statewide committees were also coordinated. The Statewide Emergency Communications Board (SECB) Steering Committee was involved to discuss what the City of St. Cloud wanted to accomplish, what features were to be tested and a request to pilot this technology. There was an expectation that a report would be delivered to the committee at the close of the pilot.

At the November 2016 Steering Committee meeting, the City of St. Cloud was approved to pilot the IV&D with the Location and OTAP features.

At the February 2017, Central MN Owner's & Operator's Committee and the Central MN Regional Advisory Committee (RAC) the pilot was approved.

The pilot was also approved at the March 2017 SECB Operations & Technical Committee (OTC) as well as the Statewide Emergency Communications Board approved the pilot.

Once approval by the different committees and board were gained, procurement of the equipment and licenses began. Updates were provided to the Central MN Region committees on a regular basis via written report and to SECB committees when requested.

It was important to be sure that not only were infrastructure licensing procured, but also the proper features purchased and installed in the subscribers. The City of St. Cloud conducted a subscriber fleet-wide replacement with Motorola Solutions APX model subscribers. Part of the

City's radio project included adding two channels to the St. Cloud Simulcast to bring the total channel count to 12.

Installation Experiences

This IV&D pilot project was the first installation and use of IV&D on the ARMER network. There are other LMR systems in other states and counties throughout the United States that utilize IV&D to different degrees and on different LMR system versions. The Motorola Solutions project manager worked to coordinate different personnel needed from the Motorola Solutions side for network needs and specifically, configuration of the IMW server.

The configuration of the IMW server was coordinated carefully with a Motorola Solutions employee and completed remotely. Configuration took approximately 1-2 days. After configuration was completed, it was determined that the network was in such a way that any other agency connecting to the IMW would need to traverse the City of St. Cloud network. The network was changed so that other agencies would connect directly to the IMW. It is understood that this network design was utilized at the other zones in the state.

Connectivity was made between the IMW and the City of St. Cloud network, where the GIS server and OTAP device programmer computer were located. Once the IMW was configured and the IV&D network was live, some settings needed to be programmed in each subscriber and tested to verify they were connecting properly.

Over the Air Programming – Testing

Once the IV&D was up and running, it needed to be tested. OTAP was tried via CPS. An issue was found that did not allow the function to be successful. It was determined that specific values needed to be entered in the IMW to allow for OTAP operations to commence.

Read & write operations via CPS were completed to prove functionality and program settings in the IMW and subscriber. When Radio Management was utilized, it was identified that a special Advanced System Key (ASK) was needed for the OTAP device programmer computer. This ASK allows the OTAP operation to continue and does not function as a typical ASK that most radio programmers are familiar.

There were also other products from the CPS suite that were needed that was tested via trial and error to see what would allow Radio Management to complete OTAP functions.

Over the Air Programming – Results

Testing was completed over a long duration with different subscribers and different changes in the codeplugs. As expected, an OTAP job via CPS will send the whole codeplug. This is due to CPS not having a database or record of the current codeplug in that subscriber.

Testing with Radio Management found that if the current codeplug for a subscriber was in the database, only the changes to the codeplug were sent to the subscriber. Thus, a much faster program update.

Different combinations were tested: updates in the Unified Call List (aliases), talkgroup names, adding voice files. No standardized time to completion was noted based upon the changes sent to the subscriber. Voice files took longer than a talkgroup name change in the Zone Channel Assignment heading. Subscribers updated with OTAP would complete as quickly as 30 seconds or take as long as a few hours.

A setting was programmed into the subscribers to prefer voice over data on the selected talkgroup and for priority scan. Subscribers on busy talkgroups would take a long time to send the whole codeplug package.

The first large-scale OTAP update sent to police mobile radios produced many complaints. It was later found working with Motorola Solutions that a subscriber that moves from the voice channel to the data channel (automatically with no user action) will have some hang time and could potentially miss voice traffic on the selected talkgroup. This was the case while it completed the transmit session on the data channel. The police officers complained of missing voice audio on their selected talkgroup from dispatch. The subscriber(s) that missed the voice traffic were the ones that were in-process of receiving an OTAP job.

After much discussion with Motorola Solutions it was determined that this situation of lost audio could occur whenever a subscriber was conducting a transmit data session.

Some potential actions to alleviate the issue suggested were to schedule jobs for subscribers when the St. Cloud Simulcast wasn't as busy. Another was to have the user steer the subscriber to a quiet talkgroup or a "programming" talkgroup with no voice traffic.

Radio-based Geolocation

Setup for the subscribers and on the IMW were straight-forward. Whenever settings needed to be changed, the City of St. Cloud was dependent upon Motorola Solutions to make any adjustments to the location settings. It was conveyed to the City of St. Cloud via Motorola Solutions that MnDOT requested that the login credentials not be provided to city staff since there was a potential that it would become a statewide asset. This greatly restricted the ability to adjust or add radios to the IMW or to receive location data.

There are two protocols for the subscribers to submit location data via IV&D. One is what Motorola Solutions calls "Classic Data" which is the P25 protocol. The other is a Motorola Solutions protocol called Enhanced Data. Enhanced Data is what was utilized for this pilot project. It is advertised that it allows more subscribers per data channel to send location data than that of classic data. Other manufacturer's radios were not available to test this feature.

Radio-base Geolocation – Results

It was difficult to properly test aspects of the subscriber location as the City of St. Cloud did not have a mapping solution that could consume the data the IMW received. Review with the current mapping and CAD vendor proved to not be a viable solution. Another GIS vendor that the City of St. Cloud has had a long relationship worked to create an Application Program Interface (API) between the current City ESRI database and the IMW location data. This API proved that data from one subscriber was received and updated with the pre-programmed cadence in the IMW.

Another vendor was consulted and created an API to consume the IMW location data. Emergency button testing was successful in unmasking the subscriber on the map at any zoom level to show a large orange strobe to signify the radio declared an emergency.

After the proof of concept with the second mapping vendor; a real-world use was brought to the attention of City of St. Cloud staff. A radio was reported as potentially stolen. The vendor was contacted and they provided information on a history of location reports (typically called breadcrumbs) by the subscriber over the course of that day and the last known location report. City of St. Cloud staff responded to that location and located the radio.

A constraint of the location reporting is that the subscribers are only capable of reporting location as fast as every 30 seconds. There are fields to condition the rate of cadence based upon distance traveled. This setting was not sufficiently tested to verify functionality.

Considerations – Technical

The pilot project was unique, that the capabilities and features were not anything that had been utilized on the ARMER system before. There were many meetings and coordination with Motorola Solutions and the City of St. Cloud throughout the project.

Motorola Solutions engineering staff worked with city staff to collect data from the St. Cloud simulcast regarding the busiest hour of usage and number of subscribers that would be using data at any one-time. This data was used to create traffic analysis charts reflecting the greatest number of data-enabled subscribers on the simulcast. This analysis centered around the location feature and subscribers utilizing enhanced data protocol. The recommendation by Motorola Solutions was to add two channels to the simulcast. This suggested channel add was already planned with the City's overall radio project.

There was discussion to conduct traffic analysis to reflect OTAP transmissions. This analysis was not completed.

Other topics discussed during the project included decisions to enable data on the channels in the simulcast. Enable enhanced data on the channels and whether to protect data. Enabling data allows data transmissions to utilize those channels when not being used for voice transmissions. Protecting a channel for data saves that channel for data transmissions except in

a situation where an emergency is declared by a subscriber and then that “hot mic” voice transmission will supersede the data transmission.

Acceptance testing was conducted with city staff, Motorola Solutions and MnDOT personnel present at the Master Site. (MnDOT personnel were not present specifically for acceptance testing but assisted with the test). City staff and Motorola Solutions personnel viewed Zone Watch at the St. Cloud Simulcast site for a current data transmission. When the data session was occurring eleven subscribers transmitted on eleven different talkgroups to utilize all the voice channels. The data session was interrupted and voice transmission was allowed on that channel (when there are no protected data channels).

There can be times when a subscriber is not able to successfully transmit its location to the system due to data congestion. There is a feature that was not tested due to it being an additional purchase that allows system administrators to make what are called Agency groups. These groups were described to city staff that an Agency group can be given a certain value to save bandwidth for subscribers that are assigned that Agency. Example, Agency group 1 is given 30% bandwidth and Agency group 2 is given 15% bandwidth; on a site with significant data congestion, the Agency group 1 subscribers will have a better location transmission success rate than Agency group 2. This feature if utilized would also be one for consideration in governance.

Considerations – Governance

While working with Motorola Solutions engineering, the City of St. Cloud was provided documentation regarding IV&D and other feature licenses at the zone and system level. This document has been shared with regional and statewide committees. It was also provided to conference attendees when they attended the City of St. Cloud breakout session for IV&D at the MN Public Safety Communications conference (2018).

Presence: Also known as Context Activation. Current limit of 48,000 per system. This license allows a subscriber to register with the IV&D and receive an Internet Protocol (IP) address.

Location: Current limit 48,000 per system. Presence license required, allows the subscriber to report GPS location via Classic Data.

Enhanced Data: Current limit 48,000 per system. Presence license required, allows the GPS location data to utilize the Enhanced Data protocol.

Additional licensing required includes but not limited to: site controller(s), simulcast subsite(s) controller for each feature desired (location, OTAP...etc). Regarding OTAP, there is also a constraint of one Radio Management server connected to an IMW.

Licensing is discussed in the governance section of this report due the limitations currently built into the IV&D product. Further discussion is needed if IV&D data services is to be adopted more fully by the SECB. In the history of ARMER there have been other system limitations, such as total subscriber limit. This subscriber limit has been increased with system upgrades due to demand. The City of St. Cloud has met with system administrators that represent agencies from across the United States of America that have city-wide, county-wide, region-wide and some

differently sized statewide systems that utilize IV&D and its features. City staff have not found other LMR systems that are as largely used as ARMER, that also use IV&D in the same volume.

Summary

This pilot project is a unique one that combines mission critical LMR voice with a limited data service to provide more efficient subscriber program updates, on-the-hip location and other potential features. A benefit of adding this level of data service to the ARMER system is that ARMER has better coverage than commercial cellular carriers. It was built for 95% mobile subscriber coverage with many local enhancement sites added for increased portable subscriber coverage. Meaning, there is a better ability to provide GPS location for squad cars, fire apparatus, ambulance or even on-hip personnel in areas of our state where cellular coverage is non-existent. If there was a need for a radio programmer to update a rural fire department's radios, but they couldn't drive hours to be on-site, the programmer could send the update via OTAP. The fire department personnel would leave the radios powered "on" to receive the update and accept the update on the subscriber once alerted. Some agencies utilize alias lists and have subscribers issued to personnel with their names or function of the user. Often, those personnel quit or retire or the function of that user changes, thus, needing an alias list update. This update requires the list to be updated in all subscribers which can be a resource strain (programmer availability). Sending these updates via OTAP is more efficient and better use of resources.

While testing these features, there were some concerns the City of St. Cloud had and brought to Motorola Solution's attention. Of those concerns is the loss of audio on a subscriber that was receiving an OTAP job while being selected on a busy voice talkgroup. The users reported loss of voice audio on their police dispatch talkgroup. They were missing the beginning couple words of the transmission. After collecting data and making setting adjustments, Motorola Solutions reported that a subscriber conducting a data transmission will complete that transmission before going back to the voice channel. There could be a loss of voice traffic due to this and it works as designed. This is a great concern, especially that there is not a roadmap that was expressed to city staff to remedy this issue. However, knowing this is a constraint, it can be pre-planned with users to remove or lessen any negative impact. There was no similar loss of audio complaints from users for location transmission. The complaint was only noted for subscribers receiving OTAP data.

The City of St. Cloud Simulcast is a heavily used sub-system in the Central MN Region. Two additional channels were added to the simulcast for a total of twelve channels. This channel addition was planned prior to this recommendation. Not all sub-systems can increase channel capacity, either due to limited frequency allocation, expense or due to other technical limits. Not all IV&D features will prove to be a solution that will work for every sub-system or site. However, it is one that could greatly benefit agencies in very rural areas. Especially those that have difficult terrain with poor cellular coverage. Allowing real-time location information to be provided to other personnel, dispatch centers or command posts. Search and rescue operations

Summary – Cont'd

or wildland fire operations could benefit from on-the-hip personnel location to coordinate activities.

Since the St. Cloud Simulcast is the only site in the state with IV&D, there are limitations to its function for subscribers that roam off the simulcast. If a subscriber roams to another site it will lose context activation (IP address) and will no longer have connectivity to transmit location data or conduct an OTAP job. It was found that if the subscriber codeplug was programmed to search non-adjacent sites, the subscriber would lose context activation on occasion. Once this setting was turned “off” the frequency of losing context activation was very little. The pilot project took longer to complete than originally anticipated. The City of St. Cloud returned to the Steering Committee in mid-2018 to request that the project be allowed to continue until the end of 2018 (also when the funding ended for the project). The reason for the long duration of the project is in part due to faulty subscribers that the city received from Motorola Solutions. It took the city approximately one year to work with Motorola Solutions on a replacement subscriber that functioned as expected so testing could begin with the IV&D.

In the summer of 2018, the City of St. Cloud received approval from the Steering Committee to also test OTAR to gather use data for updating and changing encryption keys. Changing encryption keys regularly is important to assure secure voice communications. Due to time limitations and an inability to agree on a monetary amount for piloting the equipment necessary, including installation, this feature was not able to be tested during this pilot.

Experience and information gathered from this project is invaluable. Issues were identified and when possible, mitigated. The City of St. Cloud did not note any negative impact to the St. Cloud Simulcast or ARMER system; nor were they notified of any concerns. City staff are committed to assisting the SECB and its committees with any further data or governance that would be needed surrounding IV&D and its features.