Emerging EMS Technology:

Use Case Analysis of Broadband Capabilities to Support Operations and Patient Care

August 10, 2020

Joint Working Group on EMS Communications and Technology
National Public Safety Telecommunications Council
National Association of State EMS Officials

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Executive Summary

It has been 8 years since Congress passed legislation authorizing the creation of FirstNet and funding the buildout of a nationwide, high-speed, prioritized data network designed for first responders. Today, the FirstNet public safety broadband network is a reality and is in daily use by law enforcement, fire rescue and EMS agencies across the U.S. For the first time, EMS agencies have access to a reliable data network that will support a multitude of applications and services.

These public safety centric applications and services are demonstrating their value as they allow field personnel to access critical information that was previously only available in the Emergency Communications Center. The 9-1-1 system is also going through a similar evolution as it transitions to an Internet-Protocol (IP) environment that will support an entire suite of new capabilities and features, including live video communication with the caller and receipt of patient sensor data.

The Joint EMS Communications and Technology Working Group brought together subject matter experts to examine the emerging role of advanced technology and its impact on EMS. The Working Group identified multiple ways in which technology may enhance both operational efficiency and the delivery of patient care. However, a closer examination revealed dozens of issues which must be addressed before any given technology solution would be fully functional.

Working Group members found both significant benefits and challenges in the following areas:

Detection of Medical Emergencies:
EMS agencies must adapt to manage the receipt of sensor-based alerts that automatically detect a medical emergency. In addition to consumer type devices, like the Apple4 Watch, other sophisticated devices are being deployed by hospitals and home health care agencies to monitor patients. Sensor based alerts, which may indicate that the patient has fallen and is not moving or that the patient is experiencing a life-threatening heart arrhythmia, must be reliable and provide actionable information to EMS agencies.

Activation of the EMS System:
The EMS agency Emergency Communications Center will need new technology solutions to receive data alerts and to manage new methods of interacting with 9-1-1 callers. The rapid availability of more clinical information and live video data will dramatically change the way EMS calls are classified and the way in which prehospital medical care is delivered.

EMS Response:
New applications are being developed to optimize how EMS responds to the incident, including

better unit selection and routing decisions made possible by aggregation of external datasets. Unmanned Aerial Systems (UAS, also known as “drones”) may also play a pivotal role by providing rapid situational awareness at the incident scene, including sensor and imagery data prior to the arrival of any first responder. UAS may also be used to help locate patients, deliver AED’s and epi pens, and transport MCI supplies to the scene of a major incident.

Patient Care and Scene Management:
Patient care may be enhanced by the ability of EMS personnel to remotely access patient care records from remote databases. This would allow personnel to view the patient’s last 12 lead EKG performed in their physician’s office or access a list of current medications and drug allergies. Voice Activated EMS Assistants, like Amazon’s Alexa, could transcribe the patient care report based on the conversation of the EMS crew. These devices could also provide guidance on medication dosages, assist with treatment protocol compliance, automatically transmit patient care information to the selected hospital, and answer questions regarding the closest available Emergency Department. The expanding adoption of communications apps and services is allowing field personnel to transmit voice and data to emergency departments while also allowing them to generate medical alerts for trauma, stroke, STEMI, and sepsis which automatically notify specialized clinical teams.

Patient Transport:
Patient destination decisions may be enhanced through data aggregation and analysis which could identify that most appropriate receiving facility (based on patient type, based on selection of in-network provider, based on identification of the “most available” emergency department). Artificial Intelligence solutions can be queried by EMS personnel and will provide answers based on an analysis of real time data (e.g., “what is the closest Emergency Department that has less than three EMS units waiting for patient offload for a stable medical patient?) Emergency Departments would benefit from real time data dashboards showing inbound EMS units, with display of patient severity, vital sign alerts and ETAs.

More study is needed to determine what EMS patient care data and telemetry should be transmitted to the Emergency Department, to determine who the actual custodian is for the data, and to determine which data enters the Emergency Department patient record.

Data Management:
New technology solutions bring not only potential benefits for EMS agencies, but also large volumes of data that must be managed. EMS agencies should collaborate on a regionwide basis to avoid implementation of multiple, disparate applications. Multiple applications create a burden on Emergency Departments who may need to monitor several screens for the same data, but which originate from different EMS providers. Aggregation of non-standardized data is complex and negatively impacts the sharing of that data with other users.

General Findings:

There are multiple governance, technology, cyber-security, and policy issues relating to the operationalization of new technology. These issues are best addressed on a regional basis with strong collaboration among all stakeholders.

EMS agencies who service rural areas have highly unique needs and would benefit from access to additional technology. However, funding, training, and staffing barriers typically stand in the way of adoption.

The Working Group identified five high priority recommendations to accelerate the development and adoption of advanced technology to support EMS. A full description of each item is provided in Section 7.

1. There is a need for ongoing collaboration between EMS agencies and industry to ensure that new technology solutions are designed for mission critical response and patient care.

2. There is a need for ongoing regional collaboration between EMS agencies and all stakeholders who are involved in EMS response. This includes hospitals, ECCs, fire rescue, law enforcement and other first responder organizations.

3. While technology will enable the transfer of large amounts of data to EMS personnel at the patient's bedside, further analysis is needed to identify specific elements that are of value.

4. EMS agencies need to collaborate with hospital emergency departments and similar entities to examine how patient and incident data flows from the scene to the Emergency Communications Center and on to EMS responders and then to hospitals. There is a need to address what data should be shared, when should it be shared, how it is stored and who is the custodian.

5. EMS agencies should be cautious as they adopt new technology solutions and fully understand all aspects of purchasing, installing, and managing those systems.

Finally, it is important to note that this report only focuses on a small set of technologies that directly impact EMS. There are other critical technology issues not specifically addressed in this report which impact all first responders, including the ability to locate victims and public safety personnel in a vertical plane (Z-Axis) and the need for robust cybersecurity to protect data and networks. New problems are also facing first responders, including the need to manage ingress and egress of personnel and emergency vehicles from highly mobile large-scale demonstrations in addition to managing the response to new transportation technologies which include autonomous vehicles, high speed passenger trains and unmanned aerial systems (UAS).

Introduction

Significant progress has been made in the development and deployment of public safety broadband services and applications. The First Responder Network Authority (FirstNet) continues their work with AT&T to complete the build out of the Nationwide Public Safety Broadband Network (NPSBN). EMS agencies are uniquely positioned to benefit from the availability of a prioritized high-speed data network.

The National Public Safety Telecommunications Council (NPSTC and the National Association of State EMS Officials (NASEMSO) Joint EMS Communications and Technology Working Group (Working Group) studied the role of existing and future technology and its impact on EMS response.

This report identifies EMS specific technology issues that were developed following the comprehensive evaluation of four use cases which focused on different aspects of emergency medical response. The use cases examined a basic EMS response to a home, a vehicle crash response, a multi-agency response to a house fire with injuries and a treat in place scenario to study the new ET3 guidelines published by CMS.

This report documents the observations of multiple subject matter experts as they assessed the potential role that technology will play during the receipt, response, treatment, and transport of EMS patients. It should be noted that some of the technology described is already commercially available while other technologies represent a pathway needed to solve gaps in EMS response and patient care.

Chapter 5 of this report highlights the important differences between urban and rural EMS agencies and provides additional context on the important role that technology will play to support rural first responders.

Finally, Chapter 6 of the report presents a summary of the key conclusions and recommendations noted by the Working Group.

2. Use Case Development

The Working Group identified several elements deemed necessary in each use case to ensure accurate assessments and consistency throughout the evaluation process. Each use case was based upon the following principles:

- They are about a specific type of EMS **activity** (e.g. response to a medical emergency in a private residence, response to a multi-patient incident, response with multiple agencies to a vehicle crash, etc.).
- They identify the different public safety broadband **capabilities** needed to support EMS response (e.g., video consultation with a base station physician).
- They examine real time "**tactical**" uses as well as "**strategic**" uses of broadband data which will support both incident response and future analysis.

Each use case was based on the following outline:

- **Use Case Focus –**
  A notation regarding the type of EMS response this use case addresses and the specific area of study.
- **Use Case Overview –**
  A short summary of the use case.
- **Use Case Narrative –**
  The full narrative of the use case divided into specific response time segments:
    - Detection of the Medical Emergency
    - Activation of the EMS System (receipt/processing/dispatch)
    - Response to the Incident (travel)
    - Patient Care and Scene Management
    - Transport (transport and arrival at destination)
    - Data Management (report generation, storage, sharing, analysis)
- **Working Group Discussion**
  Comments and observations of the subject matter experts.

3. EMS Related Technology

The following types of emerging broadband technology were identified as having a significant impact on EMS and are further detailed in the use case analysis.

Sensor Integration

Patient lives are saved through early detection of a medical emergency and rapid notification to, and response by, EMS. Vehicle crash telemetry may alert the Emergency Communications Center of a head-on collision on a rural road which resulted in both drivers being knocked unconscious. A patients' internal pacemaker may detect ventricular tachycardia and generate a data alert either to a third-party monitoring agency or directly to the EMS agency's communications center. Consumer level devices, like the Apple4 watch, may detect that a patient has fallen and is not moving or that the patient has a high heart rate. Home health agencies are routinely placing advanced technology into patient's homes for remote monitoring that may detect a life-threatening emergency.

Live Video Consultation (between 9-1-1 caller and EMS)

Currently, voice communication is the dominant method used to interrogate a caller to determine the type and severity of the emergency. The inability to visualize the patient results in a less than optimal response decision. Rapidly emerging technology will bridge this gap and allow for live video streaming from the scene of the emergency to the Emergency Communications Center. This will allow for better clinical assessment and more appropriate triage of the call to match the proper resource. Video consultation also allows for better monitoring of the application of prearrival medical instructions, including the ability to detect poor CPR or inadequate bleeding control.

Live Video Consultation (between EMS and Medical Control)

As with the processing of emergency EMS calls, voice communication is the primary method of interaction between EMS personnel and online medical control. Patient care may be enhanced, and an agency's risk management exposure lowered, when live video consultation occurs between EMS personnel and the physician or between the EMS patient and the physician. NPSTC published a comprehensive report[1] on telemedicine and video use by EMS in 2016.

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[1] NPSTC Telemedicine and EMS Video Report: http://npstc.org/download.jsp?tableId=37&column=217&id=3612&file=EMS_Telemedicine_Report_Final_20160303.pdf

Remote Access (patient care databases)

The FirstNet network provides a large data pipe that EMS agencies may use to query and retrieve patient data and records which reside in external databases and systems. This network will support data interoperability and sharing. EMS personnel would be able to access the patient's medical records, including diagnosis, medications, and allergies, as well as the result of recent diagnostic testing. This would allow on-scene personnel to compare the patient's historical 12 lead EKG with the EKG that was just recorded in their living room.

Data Aggregation and Analysis (vehicle routing, ED selection)

Access to a high-speed data network will also support data aggregation and analysis in the field. Using a mix of artificial intelligence and cloud computing, EMS personnel would receive more in-depth information and could make more appropriate decisions. For example, in an urban environment with multiple nearby hospitals, the system could identify the most appropriate destination facility by examining traffic data impacting transport times and which hospital emergency department is at saturation (based on ED census data or the number of EMS units enroute to or at the facility).

Voice Activated Assistant

Voice activated assistants, like Amazon's Alexa and Google, are changing the way in which everyone interacts with the world and can also have a positive impact on EMS. They provide a hands free communications solution that can execute commands ("Alexa, transmit EKG to Harborview Medical Center"), set up voice and video communications ("Alexa, ring the online medical control physician"), respond to queries ("Alexa, what's the pediatric dose of epinephrine for a child weighing 12 kilos in cardiac arrest"), prompt crews if a protocol deviation is detected, (Alexa would announce, "Attention! Recheck Atropine Dose") if it monitored that the crew was about to give 10 Mg instead of 1 Mg.

UAS Response

Drones will be able to provide a multitude of services to support EMS response and patient care. These UAS may be launched by the Emergency Communications Center during the initial dispatch of other resources allowing them to reach the scene in minutes. UAS can provide visual imagery of the scene as well as calculation and analysis and provide that data to the responding personnel at the same time it is received by the communications center. A UAS arriving at a rural traffic crash may detect that there are four patients, two of which are not conscious and that patients are entrapped in the wreckage. This early assessment could result in faster alerting to additional resources including extrication teams and aeromedical support. UAS may deliver an AED to the scene of a cardiac arrest several minutes faster than the arrival of a first responder. UAS may also deliver an Epi pen to a school playground where a child has been stung by a wasp and is having an anaphylactic reaction. They may also transport MCI supplies rapidly to the scene of a major incident or shuttle blood products and intercept an EMS unit transporting a critical trauma patient in a rural area.

4. EMS Use Cases

The following use cases were reviewed by the Working Group with special attention to specific focus areas that might warrant different types of technology.

1. **Basic Medical Emergency**
    - Examination of a typical EMS response to a medical emergency.
2. **Vehicle Crash**
    - Examination of a vehicle crash response by EMS with a focus on crash sensor technology and telemetry data.
3. **Multi-Agency Response**
    - Examination of an emergency response involving multiple public safety agencies and multiple patients.
4. **Alternative Pathway Referral (CMS ET3)**
    - Examination of an EMS response to a complex medical care patient utilizing the new guidelines issued by CMS regarding Treat in Place (TIP) care.

These four use cases represent the classifications used for most EMS responses and allow the Working Group to study the impact of technology. Each subsequent use case in this report builds on the discussions in the prior case. Common technology systems were not duplicated across each use case, allowing the Working Group to focus on the aspects that were unique to each scenario.

4.1 Use Case #1: Basic EMS Response

Use Case Focus:
This use case involves the response of an EMS crew to the scene of a basic medical emergency, which does not involve multiple agencies or multiple patients.

Use Case Overview:
A woman collapses at home with a life-threatening heart arrythmia and is treated by fire department first responders and EMS personnel.

Use Case Narrative:
Mrs. Jones is a 72-year-old woman who was recently released from the hospital following a mild heart attack. She was equipped with a medical sensor IOT device that monitors her heart rhythm. The sensor transmits data to the physician's office once a day to summarize her status. This allows the physician to confirm that Mrs. Jones' new medication is controlling her abnormal heart beats.

Detection of Medical Emergency:

On Sunday evening, the medical IOT sensor detects a sudden change in Mrs. Jones status and determines that she is experiencing a life-threatening heart rhythm called Ventricular Tachycardia. The sensor further detects that Mrs. Jones is motionless and is not breathing. The IOT device automatically executes the following actions:

- The IOT device activates a loud audible alarm to alert those in the immediate area that someone is in trouble.
- The IOT device sends a high priority data alert to a medical validation server.

Working Group Comments on Detection:

- *What network connection is being used to relay this critical data? LTE, Home WiFi, relay through another device? This type of service relies on a readily available, reliable connection.*
- *The ASAP to PSAP program has demonstrated the efficiency of automatic call routing to Law Enforcement Communications Centers with automatic call entry.*
- *NG9-1-1 provides for automatic routing of specified data alerts to targeted locations.*
- *Physicians and hospitals may provide home health monitoring for selected patients.*
- *Analytics and human verification, using additional metrics other than the cardiac rhythm would be needed to reduce false alarms.*
- *What is the threshold for EMS activation? High heart rate, low heart rate, runs of VTACH. This would need to be customized to each patient.*

- *Physicians who manage these devices would have to program them with additional EMS alerting parameters, placing further burden on their administrative workload.*

Activation of the EMS System:
The Medical Validation Server confirms that this IOT device is registered and that the heart rhythm diagnosis from the sensor is accurate. The Medical Validation Server then transmits a data alert into the Next Generation 9-1-1 system (NG9-1-1) which includes the following information:

- Location data from the sensor
- Profile information for Mrs. Jones (home address, physician, etc.)
- An assessment of her heart rhythm with date and time stamp
- An image of the heart rhythm tracing.

The NG9-1-1 system acknowledges receipt of the Medical Emergency Data Alert and indicates which EMS agency dispatch center the call has been routed to (based on the location data provided by the medical sensor).

The Public Safety Answering Point (PSAP) receives the EMS data alert via the NG9-1-1 network. An interface connecting the NG9-1-1 system with the agency's Computer Aided Dispatch (CAD) system automatically generates a high priority call for service. The PSAP call taker reviews the information and accepts the emergency incident, routing the call to the dispatcher.

The Medical Validation Server sends a data alert to Mrs. Jones' physician's office noting that 9-1-1 was activated; that the NG9-1-1 system acknowledged receipt of the call; and which EMS agency would be responding.

A few moments later, Mrs. Jones' daughter dials 9-1-1 to report that her mother has collapsed. The PSAP follows standard procedures and instructs the daughter on how to perform CPR[2]. Information received from the daughter is added to the incident record in the CAD system.

[2] This use case does not explore the implications of using cell phone video to enhance the provision of pre-arrival emergency medical care, as enabled in a Next Generation 9-1-1 environment.

Working Group Comments on EMS Activation:

- *Does the EMS Communications Center send an acknowledgment message back to the device to confirm that EMS is responding? Family members need some assurance that an automated alert has been processed.*
- *Does the device provide a call back number, so the EMS communications center can make voice contact with the emergency scene?*
- *The ability to reduce the time from patient collapse to treatment would be very good.*
- *A drone may fly an AED to the scene (Reno, NV trial ongoing now)*
- *Automatic activation of crowd responders, using PulsePoint or other technology*
- *Need enhanced ability to manage foreign language translation of 9-1-1 calls from non-English speaking callers, including both voice calls and text messages. There are also video interpreter services available, via video chat, which are more accurate in many cases, based on cultural observation.*
- *Philips Medical and other companies are providing home monitoring and will be detecting medical emergencies that require EMS response. How are they integrated into the emergency response system?*

EMS Response:

An Advanced Life Support (ALS) ambulance, MEDIC 2, is dispatched in addition to the closest Basic Life Support (BLS) fire engine, ENGINE 1.

Working Group Discussion:

- *Can the home connected device also flash the front porch light or lights in the home to alert EMS to the correct location? This expands to access to gated and secure communities.*
- *Intelligent routing of EMS vehicles using updated maps with current traffic data.*
- *GPS based traffic signal priority.*
- *Auto detection of other emergency vehicles responding along same route, either to this incident or to other incidents.*
- *System that broadcasts data toward vehicles that will mute their car stereo and entertainment systems, so they can hear the siren (industry examples: Rumbler and Howler).*
- *Access to building plans and maps which will direct EMS personnel to locations inside large facilities and multi-family residential housing.*
- *In a mobile environment, can the device transmit a location-sensing beacon to help EMS personnel locate the patient?*
- *Local query into Health Information Systems would be helpful (query existing patient medical records, drugs, recent visits, tests).*

- *Data may need to route to different locations, based on "need to know", (e.g. available information on access to incident location should be available to the Communications Center and the EMS crew, while patient medical data should only be available to EMS personnel).*

Patient Care and Scene Management:

ENGINE 1 arrives at the home first and takes over care of the patient from the daughter. They attach additional patient care sensors to Mrs. Jones which will monitor her vital signs, including her blood oxygenation, percentage of exhaled carbon dioxide, blood pressure, pulse rate, breathing rate and EKG rhythm. An Automated External Defibrillator (AED) is attached to Mrs. Jones and a shock is performed which restores her heart rhythm and pulse. She begins to breath on her own and regains consciousness.

MEDIC 2 arrives and takes over management of the medical emergency and switches on an EMS Analytics Hub. The various patient care sensors automatically connect to the hub and aggregate patient status data. This includes the home monitoring device worn by Mrs. Jones and the devices attached by the first responders. The Hub provides patient care recommendations based on an analysis of the data compared with EMS treatment protocols.

The Hub prompts the lead paramedic to perform authentication of his identity. Once the identity is confirmed, the Hub then connects to a master Health Information Network database to retrieve medication and treatment records on Mrs. Jones. The EMS crew can view a summary of her health record and access specific components, including a full list of current medications, which helps guide their treatment. They also confirm that a nearby hospital is the one which recently treated Mrs. Jones for her heart attack. Patient medical telemetry and treatment information is transmitted to the receiving hospital once the paramedic selects their intended destination.

The paramedic needs to give Mrs. Jones drugs to stabilize her heart rhythm and to treat her ongoing severe chest pain. An IOT sensor-based inventory control system is used by the EMS agency which allowed the paramedic to confirm that all necessary equipment, supplies, and medication were present at the start of their shift. The paramedic uses a two-factor authentication system to open a secure container that holds injectable narcotics. Data alerts are sent to the on-duty EMS field supervisor and the agency's medical supply center noting that a specific medication has been used and will need to be restocked.

Working Group Discussion:

- *Need enhanced ability to access foreign language translation services at the scene.*
- *VitalTag concept, providing diagnostic ECG and other vital signs from application of a band aid sensor (expand use from MCI to everyday calls). Need ability to eliminate*

the traditional BP cuff. Wireless connections to remote monitoring devices eliminate tangling of cords.

- *EMS personnel, like fire personnel, need environmental monitoring sensors to auto detect proximity to hazardous conditions (e.g. CO detection), as well as safety sensors (automatic detection of a hard fall, automatic detection when the employee is not moving or in a struggle).*
- *EMS personnel also need on scene location tracking, so the dispatch center is aware of their true location (as they enter a building). Motorola APX radios have a Bluetooth connection "Critical Connect" that provides a location sensing beacon.*

<u>Transport:</u>

MEDIC 2 begins transport of the patient to AnyTown General Hospital and transmits an updated set of vital signs including an additional 12 lead EKG. The paramedic makes voice contact with the AnyTown General Hospitals' Emergency Department to provide a summary of the patient's condition and to confirm that they received the patient telemetry.

Onboard navigation systems suggest the most appropriate route to the hospital based on current and projected traffic and roadway conditions.

Upon arrival at the AnyTown General Hospital, the patient is transferred to the care of their medical team. An updated version of the EMS Patient Care Report, including all vital signs to the point of transfer, are sent to the EMS agency's data system and to the Hospital-EMS Records Interface where it is received and appended to the patient's hospital record.

Working Group Discussion:

- *Need development of patient "backboard" with embedded wireless monitoring and defibrillation capabilities.*
- *Need development of patient transport device that counteracts patient weight (anti-gravity solution used in the TV series Star Trek), allowing easier movement of large patients.*
- *Destination hospital selection should be based on analysis of real time data, traffic patterns, travel time, etc.*
- *Emergency Departments should have access to an EMS Dashboard that displays all EMS units transporting to their facility, color coded by patient severity, and with accurate ETA data. The Hospital Availability Exchange Standard (HAVE, developed by OASIS) is intended for MCI use, but could be expanded to support this capability.*

<u>Data Management:</u>

All data collected during this medical emergency is stored by the EMS agency. This includes data and voice logs from the Communications Center as well as data and voice logs involving Engine 1 and MEDIC 2 (including patient care data and telemetry).

Agency personnel, based on their authorization level, can access all data associated with a particular incident. Stored data may be reviewed using a single application for all data types and can be organized in a chronological sequence, allowing an agency to reconstruct an emergency incident.

Working Group Discussion:

- *Technology is needed to mine needed data from a wide variety of sources and databases, aggregate the data and display it in a meaningful way for EMS to use.*
- *Incident scene patient data needs to be immediately available to the Emergency Department, but the EMS crew must review, edit, and approve the final patient care report. This is especially important is automated systems are generating some of the patient care data and patient care narrative.*
- *Many prehospital medical reports do not make it into the hospital patient care management system. Other EMS reports are attached as a PDF file to the patient care record, making the data not easily accessible to physicians. Full integration of prehospital patient care records, including EKG and vital sign telemetry, requires a customized interface to the specific software used by the hospital and is expensive, (limiting its implementation).*

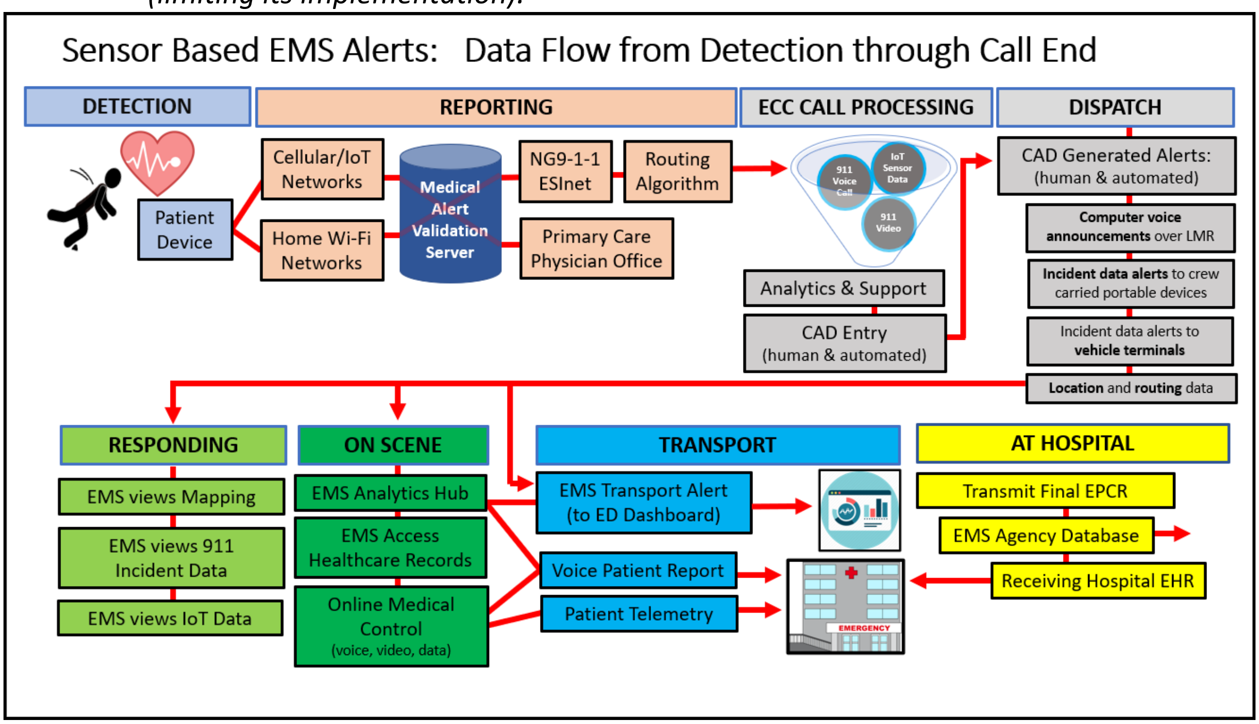

Figure 4.1 Example of sensor data flow.

See Appendix A for larger view and description of chart elements.

4.2 Use Case #2: Vehicle Crash

Use Case Focus:
This use case involves the response of an EMS crew to the scene of a vehicle crash with injuries and examines vehicle crash sensor technology. This use case does not include a rural response component, which will be addressed in a later use case.

Use Case Overview:
A vehicle traveling at high speed skidding on a rain slick roadway and struck a tree, ejecting the driver. EMS personnel respond and treat the patient before transferring him to a specialty hospital Emergency Department.

Use Case Narrative:
A vehicle traveling on Highway 101 during a thunderstorm failed to negotiate a curve and struck a tree, ejecting the driver when the force of the crash popped open their door. The driver is knocked unconscious by the impact.

Detection of Medical Emergency:

Sensors in the crashed vehicle detected abnormal movement of the car and the impact into the tree, triggering an automatic data alert to the designated local Emergency Communications Center. Data from multiple sensors in the car is analyzed by a crash algorithm to determine the number of occupants, impact velocity, and vehicle condition.

Two other vehicles traveling on Highway 101 drive past the crash scene a few minutes after the incident occurred.

Working Group Comments:

- *DOT and other traffic cameras can aid in incident detection. Not all traffic camera data is available to communications centers and most camera systems do not have automatic event detection.*
- *Rural areas may have poor cellular connectivity, impacting the ability to activate 9-1-1 or transmit crash telemetry.*
- *V2V and V2I (Vehicle to Vehicle and Vehicle to Infrastructure) would allow for a relay of crash data from the impacted vehicle.*
- *OnStar, ATX, and other fleet and hazmat traffic solutions also provide for automatic crash detection and alerting.*
- *Increased us to autonomous vehicles my citizens may provide enhanced communications solutions to support automatic alerting.*

Activation of the EMS System:

The Adams County Emergency Communications Center received a data alert within seconds of the vehicle's crash. The data alert includes the following information:

1. Vehicle Crash Event
2. Vehicle Description (make, model, year, color, description)
3. Vehicle Owner Data (name, address, phone number)
4. Location Data (GPS coordinates and translated street address)
5. Crash Type (head-on, broadside driver, broadside passenger, rear end)
6. Crash Movement (vehicle roll over) "*NO*"
7. Final Crash Movement (vehicle on side, vehicle on roof, vehicle on wheels)
8. Number of Occupants (based on seat sensors and seat belt connections) "*1*"
9. Crash Intensity Score (vehicle speed vs. deceleration) "*HIGH*"
10. Injury Severity Index (calculation of injury potential) "*HIGH*"

Two callers dial 9-1-1 to report that they have just driven past a vehicle crash on Highway 101 and that a car appeared to have struck a tree. Neither caller stopped at the crash scene nor could not advise if anyone were injured.

Working Group Comments:

- *Need better solution for occupancy tracking than seat belt use (occupants may not be wearing seat belts and cargo items may falsely identify as occupants).*

<u>EMS Response</u>:

An Advanced Life Support (ALS) ambulance, MEDIC 2, is dispatched in addition to the closest Basic Life Support (BLS) fire engine, ENGINE 1. The vehicle sensor data indicates a high potential for serious injury, so an additional engine company with extrication equipment is also dispatched (SQUAD 1).

Law enforcement personnel are also dispatched and launch a rapid response UAS to the scene.

Enroute to the scene, EMS personnel access mapping data with real time traffic conditions to guide their response. GPS data from the EMS units is passed to the regional traffic management network which changes intersection signals to prioritize public safety unit response.

The law enforcement drone has arrived over the crash site in three minutes from its simultaneous dispatch with the EMS and law enforcement units. It provides EMS personnel with access to live stream video of the crash site as well as access to several still images automatically collected by the drone to show different angles of the crash scene. The drone's camera captures the vehicle license plate. The drone also hovers at the level of the vehicle windows to determine if any patients are inside the car. The drone then hovers above the patient laying on ground and uses video analytics to detect if the patient is breathing and/or moving. Additional still images are collected to assess patient injuries.

Using the name of the vehicle's registered owner (provided by the crash sensor alert and the vehicle license plate), EMS personnel initiate a search for a patient care record in the regional healthcare network. The vehicle owner information is submitted to the State Department of Motor Vehicles (DMV) and a copy of the owner's driver's license is displayed which includes their picture. This information will be used to confirm if the unconscious driver is the registered owner and will assist with confirmation of a potentially matching patient care record.

Prior to EMS arrival, a vehicle stops at the crash site to see if anyone is hurt. Personnel in the Adams County Emergency Communications Center activate a two-way audio/video link on the UAS and communicate with the citizen[3], asking them to assess the patient's breathing and providing instructions on how to stop the bleeding coming from a wound on the patient's upper arm.

Responding EMS personnel are updated via voice radio and data messages. Based on the new information that a patient has been ejected from the vehicle and is unconscious, EMS personnel query the Regional Hospital Status Network to view Emergency Department availability at the nearby Level 2 trauma center and the more distant Level 1 trauma center.

Based on local protocols, the closer Level 2 trauma center received a data "pre alert" that EMS was responding to a vehicle crash with a high injury severity index. That information was updated to note that a patient has been ejected and is unconscious.

Working Group Comments:

- A UAS could also lead first responders to the scene, especially helpful if the incident was an off-road emergency.
- Could a public safety UAS "flag down" a passerby to provide medical aid? UAS have this capability, with loudspeakers, spotlights and other signaling systems.
- The EMS crew-initiated search for patient care records could be an automated process.

Patient Care and Scene Management:

EMS personnel on MEDIC 2 arrive on scene simultaneously with ENGINE 1 and begin assessing the patient's condition while firefighters check for any immediate hazards at the vehicle.

[3] This bystander interaction could also occur via a 9-1-1 call, leveraging voice, data, and video capabilities of NG9-1-1.

EMS personnel use a variety of monitoring systems to assess the patient's vital signs and injury status. An EMS Analytics Assistant (EMSAA) records the paramedic's spoken patient assessment and automatically generates the Patient Care Record. The paramedic may also do a voice query to the EMSAA to recheck hospital status, to access the patient's master healthcare record, or to obtain assistance with drug dosing and other treatment protocols. The EMSAA will also prompt the EMS personnel if the announced patient care appears to be out of alignment with the EMS protocol or if EMS procedural steps are missed (e.g., the next dose of a drug is due for administration).

The paramedic on MEDIC 2 uses a body worn camera to record video of the incident scene and to document patient care. The paramedic can also create snapshot still images for inclusion in the Patient Care Record, including an image of the vehicle's bent steering wheel.

Based on the location of the crash, the use of aeromedical helicopter is not indicated. The patient's condition requires transport to the closer Level 2 trauma center for further stabilization.

The paramedic attempts to set up a video link for consultation with the Level 2 trauma center but has difficulty because the crash site is in a small ravine off the roadway. The paramedic's device offers to automatically reconnect using a relay through the EMS vehicle's wireless access point or via the overhead drone.

The paramedic provides a brief overview of the patient's condition and patient telemetry data is automatically routed to the Level 2 trauma center physician's console.

Working Group Comments:

- *Patient ID information from the scene should flow directly to Hospital ED registration personnel to expedite creation of patient event.*
- *Paramedic report, including voice and telemetry, may trigger "downstream" alerting to other specialty care teams (e.g. Pulsara and E-Bridge applications are examples).*

Transport:

MEDIC 2 loads the patient into their unit and supplements their crew with a firefighter EMT from ENGINE 1.

Real time mapping data helps plot the faster route to the Level 2 trauma center and GPS data again prioritizes traffic signal control to expedite the transport.

Patient telemetry data is streamed to the Level 2 trauma center. ED personnel are alerted to any significant change in the patient's status[4].

GPS data from MEDIC 2 is also sent to the Regional EMS Transport Monitor which provides each hospital in the region with a real time display of data on EMS units transporting to their facility. This display includes:

1. UNIT AGENCY (Adams County EMS)
2. UNIT ID (MEDIC 2)
3. INCIDENT TYPE (VEHICLE CRASH)
4. PATIENT TYPE (ADULT TRAUMA)
5. PATIENT TRIAGE CODE (RED)
6. ETA to the ED (updated as unit travels)
7. Map display of units

Working Group Comments:

- *Public Safety mapping applications would provide additional data of relevance to first responders, including access to incident scenes via contra-flow on one-way streets, notification of bridge weight restrictions impacting emergency vehicles, etc.*
- *Extensive discussion on streaming of patient care telemetry, and how much of this continuous data is stored (and by who), and what type of alarm thresholds should trigger an update/alert to the receiving hospital. Should the ED be notified that the patient's heart rate went to 170 or their PO2 fell to 80 while intubated? When multiple patients are inbound, how is this data displayed? Can the ED select which patients it would like to monitor? Can the paramedic manually "push" an alert to the ED easily, during a patient collapse?*
- *Patient telemetry (including video segments) need to be aggregated in an easy way for inclusion in the EMS Patient Care Report.*
- *EMS vehicles may need to automatically select the best available network to support telemetry and video consultation.*
- *As noted in the earlier use case, patient data and telemetry may trigger "upstream" alerting to other specialty teams in the hospital (e.g., CT Scan, Neuro, OR, etc.)*
- *Accurate ETAs are especially important, letting the ED know how many minutes they have to prepare for the arrival of a critical care patient. Current "estimated" times given by EMS personnel are subject to wide variation in accuracy. An audible and visual alarm should occur for "arriving in two minutes" and "arriving now". Visual and color coding to allow a glance to indicate key pieces of information (ETA and Status).*

Data Management:

[4] Emergency Department personnel will not monitor ongoing patient telemetry because there is minimal clinical significance to do so, and ED personnel will be busy preparing for the trauma patient's arrival.

MEDIC 2 arrives at the Level 2 trauma center and transfers their patient to the awaiting medical team. The paramedic provides an overview of the incident and details the patient's injuries and their treatment.

Patient care data from MEDIC 2 is automatically transferred into the hospitals' electronic patient care record but noted as a "draft". This includes patient telemetry as well as patient assessment and treatment data. The paramedic reviews the EMS patient care record, as created by the EMSAA, and makes necessary edits. The paramedic also selects which still images and video segments to upload to the records management system. The paramedic then transmits a "final" patient care record to the EMS system Records Management System and to the Level 2 trauma center.

Working Group Discussion:

- *Patient care data is transmitted from the scene to the ED prior to the arrival of the patient (before they are registered as a patient in the hospital system). This data will have to be in a "parking lot" before it can be transferred to the actual hospital record. There is a question on when does the ED patient care record start. Once a high priority emergency is confirmed, then initial data gets routed to those who need it (e.g. patient registration, etc.)*
- *EMS personnel need to edit the data and confirm the accuracy (e.g., if they were using voice dictation), and then finalize the report – which would then export in a standardized data format – and be available to other health systems (e.g. available for retrieval).*
- *EMS data is displayed for the ED, and at some point, crosses over into the Hospital patient care record. There are many issues involving interfaces, draft data vs. final data, the need to avoid referring to dual screens (an EMS app and the hospital app). What data is brought over? (regarding streaming data, only collect alarm triggered data plus 12 lead EKG, etc.). There are local control issues into what portions are collected by the hospital and EMS agencies need to decide which data is saved to the EMS report*
- *A lot of raw data is collected, and the EMS crew needs to determine which pieces are relevant (or an AI application may do this), then the hospital needs to determine which pieces they want to collect.*
- *Some data is needed for emergent treatment decisions and other data is needed for formal documentation, QA, etc. So, a filter may be needed to determine which data is transferred to the hospital and which data remains for EMS use.*
- *Patient outcome data should be available to EMS in a formal feedback process, which is being mandated by recent changes to Joint Commission standards.*
- *Concern about the time commitment needed for EMS personnel to do the final editing of their patient care report, including review/edit of telemetry and video records.*

4.3 Use Case #3: House Fire with Multiple Patients

Use Case Focus:

This use case involves the response of a third service EMS agency, with fire and law enforcement, to a house fire with three patients suffering from smoke inhalation and burns. It examines data sharing with other responders and agencies as well as multi-patient management. This use case builds on the technology discussed in prior use cases and attempts to avoid duplication.

Use Case Overview:

A lightning strike starts a fire in the attic of a single-family residential home and quickly spreads to the rest of the structure. Two people are injured escaping the fire and an unconscious child is found by firefighters inside the home and rescued. EMS, Fire Rescue and Law Enforcement are managing the scene.

Use Case Narrative:

During a fast-moving severe thunderstorm, lightning strikes the home of the Smith family blowing a hole in the roof and starting a fire in the attic. The strike knocks the power out, but the Smith family believes that the power failure is due to a transformer explosion in front of their house. Bob and his wife go outside to investigate the sound but cannot see the smoke coming from the attic of their home. Several minutes later they see heavy fire coming from the eves of their home and they both rush back inside to rescue their five-year-old daughter who is asleep in a bedroom.

<u>Detection of Medical Emergency:</u>

A next-door neighbor, who also went outside to investigate the explosion, sees thick smoke and heavy fire coming from the roof and dials 9-1-1 to report the emergency. He is unsure if anyone is at home but sees the Smith family vehicles parked in the driveway.

<u>Activation of the EMS System</u>:

The Emergency Communications Center (ECC) receives three 9-1-1 calls from neighbors reporting the house fire. No caller can confirm if anyone is inside the home. Smoke and fire sensors in the Smith home activate and transmit an alarm signal to a third party monitoring center, which verifies their activation and transfers the data alert to the ECC, which dispatches fire department units and, by local policy, also sends an EMS unit and law enforcement. Several minutes later, another 9-1-1 caller reports that two injured adults are outside the home and screaming that their daughter is trapped inside. The ECC adds two additional EMS units to the response, increases the fire response and notifies the responding units of the updated information. A UAS has also been dispatched and arrives overhead of the incident scene approximately three minutes later.

Working Group Comments:

- *ASAP to PSAP program currently allows for high speed transmission of data alerts over the National Law Enforcement Telecommunications System (NLETS).*
- *It would be difficult for a UAS to use thermal imaging to look inside a structure for occupants, since this is a "line of sight" technology.*
- *The UAS could land and deploy small entry robots which would move throughout the structure to identify the seat of the fire and the location of any occupants and provide location data to arriving fire personnel.*

EMS Response:

An Advanced Life Support (ALS) ambulance, MEDIC 1, is initially dispatched. The local fire department provides first response BLS support as well as firefighting capability. Law enforcement personnel are also dispatched.

Enroute to the scene, MEDIC 1's onboard mobile computer map display provides directional assistance and routing[5] while also displaying the location and movement of other emergency vehicles heading to the house fire (or to other emergencies in the area).

The ECC updates the Computer Aided Dispatch (CAD) system's incident report with information from other 9-1-1 callers. A nearby law enforcement unit arrives quickly and reports that the house is engulfed in fire, that there are two adult patients with burns and smoke inhalation, and a child is trapped inside. These updates appear as urgent messages on MEDIC 1's MDT, flashing in red and sounding an audible alert. The messages also appear on each of the MEDIC 1 crew members handheld devices. The law enforcement officer enters the home to rescue the child but retreats due to the intense heat and smoke.

The law enforcement drone has arrived over the house fire following its simultaneous dispatch with the other responding units. It provides all responding units with access to live stream video of the scene as well as access to several still images automatically collected by the drone to show different sides of the property[6]. The UAS also captures several images of two injured adults laying in the front yard. A Rapid Response Summary[7] of the data is transmitted to all responding units, which includes abbreviated text and a few images. This allows the first

[5] See Use Case #2 for additional discussion on enroute assistance, which was not duplicated in this use case.

[6] The drone's camera and onboard analytics visualize the size the home, the percentage of fire, and the intensity of the fire while also highlighting other critical attributes, including two cars in the driveway, a large LP gas tank on the side of the structure and distance to a nearby home that is threatened due to the fire spread

[7] A Rapid Response Summary (RSS) is a concise data message including text and a small video clip or still imagery that conveys the critical components of the scene to responding personnel. First responders gain important insight into the event without having to view raw data and video, which is time consuming and a distraction from other duties. RSS is an acronym created for this use case and does not refer to any known system.

responders to quickly gain insight into the UAS interpretation of the scene, including recommendations to dispatch additional fire and EMS units to the scene.

Based on the updated information, MEDIC 1 confirms with the dispatcher that two additional ALS transport units had been dispatched and requests that an EMS field supervisor be notified.

Incident information from the EMS portion of the CAD system is exported to the Regional EMS Transport Monitor[8] system. Artificial Intelligence (AI) and machine learning algorithms scan the data in real time and provide each hospital Emergency Department with a visual display of EMS units transporting to their facility. The AI system detects the house fire response which may involve three critical patients involved in a specialty care event (burn care). A 'pre-alert' message is sent to the two hospitals closest to the scene and to the regional trauma center which is also a burn center. MEDIC 1 and ECC personnel also receive the pre-alert message.

Moments before MEDIC 1's arrival, an urgent data message is received noting that fire department personnel are treating three patients, one of which is coded as a triage category red patient (critical care) and two which are coded triage category yellow (urgent care). This confirmation message is sent to the other responding EMS units and captured by the Regional EMS Transport Monitor interface and distributed to the proximity hospitals.

Working Group Comments:

- The UAS interaction could be enhanced to support EMS functionality. Could camera vision calculate the body surface area of the burns?
- Stand Off Vital Signs could be collected by the UAS as well as detection of breathing and movement.
- The UAS could drop a Vital Tag sensor for application by a first responder or citizen (especially useful in a rural setting)
- Discussion on value of pre-alert data going to hospitals in the vicinity of the emergency. In rural areas or areas with less critical care capacity, this may be helpful. Transmission of this data should be governed by local control policies.
- AI could help identify critical patients, but what is an appropriate trigger threshold that would require operational response? Patient data may originate from the EMS Communications Center (e.g. CPR in progress on an infant) or from on scene personnel.
- In a future state, EMS would use an Ambulance Drone to transport the patient, with or without crew (based on patient condition).

Patient Care and Scene Management:

[8] See Use Case #2 for a description of this system.

MEDIC 1 arrives at the scene to find three patients being cared for by firefighters who are providing basic life support service, including delivery of oxygen. Two adults are suffering from smoke inhalation and burns to their face and arms which occurred during attempts to rescue their daughter. The third patient is an unconscious five-year-old child whose respirations are being assisted with a bag-valve-mask resuscitator.

Vital signs data on all three patients captured on the fire department monitors is automatically transferred to the MEDIC 1 devices when the units are in close proximity to each other (after the MEDIC 1 crew presses the “CONFIRM TRANSFER” button on their tablet).

Fire department EMTs continue assisting with patient care and can use the MEDIC 1 technology based on the adoption of common software applications, common User Interface display screens and common symbology.

Two additional ALS transport units arrive on scene. Patient care data from fire department and MEDIC 1 monitors is seamlessly transferred to their systems when they select the specific patient they are going to treat.

Patient care is supported using the EMS Analytics Assistant (EMSAA)[9] and through video and telemetry systems noted in Use Case 2. Access is gained to each patient’s existing medical record to identify known health issues, allergies to medications, and other information important for emergency treatment.

The broadband network supporting the incident can accommodate the simultaneous video and data streams originating from three paramedics as well as the UAS and video and data streams generated by firefighting crews and law enforcement.

Working Group Comments:

- *There are special mapping and routing requirements for emergency vehicles accessing a multi-casualty scene, including the need to identify patient collection and patient transportation areas, as well as staging locations for incoming units.*
- *Automatic sync of patient care telemetry between different crews and devices should only happen when activated by EMS personnel. How are patients identified when data is transferred to another crew? Patient #1?*
- *MCI patient tracking systems use arm bands and other technologies to assign Unique Patient Identifiers to each patient, which facilitate rapid transfer of data between EMS providers and hospitals.*

[9] See description of EMSAA in Use Case 2, which involves a voice activated, cloud-based decision support system.

- *Patient tracking systems are not always interchangeable between various EMS systems operating in the same area. Regionally coordinated numbering schemes could identify the agency that the tag came from (e.g., the State of Tennessee)*

Transport:

Each patient is loaded into a separate MEDIC unit for transport. Firefighters will be used to drive two of the EMS units, allowing the dual paramedic crew to be in the patient compartment. Each Firefighter EMT swipes their ID badge/Prox card across the Mobile Data Computer screen in the MEDIC unit and their identity is added as a crew member for this emergency vehicle and they are removed as a crew member from their engine company.

The pediatric patient and one of the adults will be transported to the regional trauma burn center while the second adult patient will be transported to a Level 2 trauma center for initial evaluation[10].
As soon as the hospital destination is selected (or announced), the onboard mapping system identifies a preferred route based on traffic data received from multiple sources. When the route is confirmed by the vehicle driver, route data is fed automatically to computers at the Regional Traffic Monitoring Center which will change the timing of traffic signals as each EMS unit nears an intersection. The system will alert each unit of any conflicts in prioritization (e.g., where two ambulances need competing priority at the same intersection at the same time).

The Regional EMS Transport Monitor system will automatically change each unit's status on the hospital display board from "AT SCENE" to "TRANSPORTING". Each MEDIC units ETA to the hospital will be updated on the display board as they travel closer to the hospital and the ED will receive an arrival warning alert when the EMS unit is one minute out.

Working Group Discussion:

- Discussion on use of alternate vehicle operators. There are two concepts with the use case description, (1) the EMS agency has a protocol with the fire department for FD personnel to drive their ambulance to the hospital while the EMS "driver" helps with patient care. This could be a case where the MEDIC 1 unit had two paramedics on-board, and it would make more sense to have two PM's in the back than a single PM and a Firefighter EMT. (2) Accountability for who is in the EMS unit, to show that there are three crew members on board the ambulance (this helps in the event of an ambulance crash and it also reduces the crew assignment on the fire engine – so the dispatcher is aware that Engine 1 only has two crew members – and you can't send them to a call by themselves).

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[10] In most cases, all three patients would be transported to the same facility if it is capable of managing multiple patients (in order to keep the family together). In the use case, different hospital destinations were chosen to highlight the need for diverse routing technology.

Data Management:

Each MEDIC arrives at the hospital and transfers their patient to the awaiting medical team. The paramedic provides an overview of the incident and details the patient's injuries and their treatment.

As noted in prior use cases, patient care data is automatically transferred into the hospitals' electronic patient care record but noted as a "draft". Following final editing and approval, the paramedic then transmits a completed patient care record to the EMS system Records Management System which also exports a copy of the final report to the hospital.

4.4 Use Case #4: CMS ET3 Treat In Place Response

Use Case Focus:
This use case involves the response of an EMS agency to medical emergency in which the patient is evaluated and treated, without transport to an Emergency Department (or other alternate destination). It examines new types of technology, including additional telemedicine systems that would be used to manage the patient as envisioned in the new CMS ET3 protocols[11] (Emergency Triage, Treat and Transport). ET3 is a pilot project that will allow the testing of different approaches in delivery EMS care. There are three components: PSAP Triage, Transport to Alternate Destination (AD), and Treatment-In-Place (TIP). This use case builds on the technology discussed in prior use cases and attempts to avoid duplication. This incident occurs in a rural area.

Use Case Overview:
Mr. Jones is a 41-year-old patient with a history of diabetes and renal failure who also has a baseline cognitive deficit resulting from a traumatic brain injury following a car crash last year. While being cared for at home, his family notices a significant decline in his mental status and dials 9-1-1 to report that he may be having a diabetic emergency. The EMS response involves immediate dispatch of an ALS unit with additional assistance provided by a Community Paramedicine team, which determines that Mr. Jones can be safely managed at home.

Use Case Narrative:
Mr. Jones was injured in a motorcycle crash last year and suffered a traumatic brain injury which severely limits his ability to communicate. Most of his interaction is done by nodding his head to indicate yes or no. Mr. Jones is an insulin dependent diabetic who also receives home dialysis to manage his renal failure. He is cared for at home by his family and receives additional assistance from a home health care agency which includes at home telemetry monitoring of his condition. Mr. Jones lives in a rural area and his “home” hospital is approximately one hour away.

<u>Detection of Medical Emergency:</u>
Following lunch, Mr. Jones’ family notices that he is not interacting with them as expected. He is having a hard time keeping his eyes open and is not smiling or using facial gestures to communicate with them. The family suspects that Mr. Jones may be experiencing a diabetic emergency and checked his blood sugar using their home monitoring device. That test showed a blood glucose level of 50.

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[11] The federal Centers for Medicare and Medicaid Services (CMS) program is releasing guidance documents to EMS agencies on how to implement three new options for EMS care that will be eligible for billing. They include Treat in Place (TIP), Alternate Destination (AD) and PSAP Triage and call diversion. Pilot projects are being used to evaluate the three programs.

Activation of the EMS System:

The family decides to activate the 9-1-1 system after discussing Mr. Jones condition among themselves and determining that his current condition falls outside the guidelines for accessing the home healthcare nurse.

The Emergency Communications Center (ECC) receives a 9-1-1 call from Mr. Jones daughter reporting that "something is wrong" and that her father is not responding. The ECC telecommunicator asks a series of questions to assess the patient's severity and to determine the appropriate EMS response configuration. While Mr. Jones is awake and breathing, it is not possible to determine the presence (or absence) of other important clinical signs (e.g., is Mr. Jones having chest pains, difficulty breathing, blurred vision, headache, etc.).

A "Video to 9-1-1" session[12] is initiated by the ECC staff who note that Mr. Jones appears very lethargic but that he is breathing normally, and his skin color is not cyanotic. The family reports that they can feel a strong pulse in Mr. Jones wrist, indicating that his blood pressure is not low.

An ALS response is indicated, and a paramedic ambulance is dispatched[13].

Personnel in the ECC enter Mr. Jones name, birthday, and home address into their CAD system which will pass this information to a regional health exchange network to determine if any physician or hospital health care records are available. The presence of available Electronic Health Records (EHR), based on a probable match, will be sent to the responding EMS personnel[14].

EMS Response:

MEDIC 1 is dispatched to a report of a patient with an altered level of consciousness[15]. Personnel in the ECC have coded this a "Charlie Response[16]" indicating a high priority call.

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[12] A future use case will focus on Next Generation 9-1-1 technologies including "Video to 9-1-1".

[13] Each EMS agency establishes their response configurations based on available resources and the level of care necessary for a particular patient (as determined by the agency's EMS medical director). For this use case, an ALS transport unit was dispatched by itself because the patient was awake and appeared to be breathing normally. In other circumstances, a BLS (or ALS) engine company or another first responder might respond also.

[14] Based on the services provided by the Emergency Communications Center, which may include triage and referral processes, EHR data may be available to qualified ECC personnel.

[15] This use case will not duplicate the prior discussion on mapping and guidance technologies to assist the EMS crew with their response.

[16] Many EMS agencies categorize calls into different levels of severity, which determines the number and types of units that will be sent. The most common categories nationwide are Echo (immediate life threat priority), Delta (high priority), Charlie (high priority), Bravo (low priority), Alpha (non-emergency response). There is also an Omega category for no response or referral to another agency.

Enroute to the call, MEDIC 1 personnel use their onboard Mobile Data Computer (MDC) to view the text information entered by the ECC personnel, including a description of Mr. Jones current problem and an overview of his medical history (as provided by the family). MEDIC 1's MDC notes the availability of a clickable link that will access a 10 second video clip captured during the 9-1-1 call, showing Mr. Jones.

MEDIC 1's MDC indicates that there have been prior EMS responses to this address and the MEDIC 1 crew notes that a Community Paramedicine team has previously responded to treat Mr. Jones.

MEDIC 1's MDC alerts them that a response has been received from the regional health exchange network indicating the availability of EHR records for a patient that matched the information entered by the ECC. The paramedic on MEDIC 1 does a cursory glance at the data to determine what types of information are available.

***Working Group Discussion**:*

- *An "Emergency Health Record" standard has been created and each EHR provider should make this overview record available. It was specifically developed for EMS use and includes current medications, allergies, current health status. It is designed as a quick read report.*
- *Data should be pushed to the device that is used by EMS for their electronic patient care record (ePCR), to auto-populate information. Voice to Text should also be available to facilitate data entry, as well as Text to Voice allowing the system to read critical information to the crew when necessary.*
- *In this use case, there wouldn't be time to review the patient record, since the EMS response to Mr. Jones' home would only take approximately six minutes and the paramedic should be assisting the driver of MEDIC 1 as they navigate in an emergency mode to the scene. MEDIC 1 personnel will need to verify that the patient they are treating is the same patient that was matched to the available EHR records.*

Patient Care and Scene Management:

MEDIC 1 arrives on scene and assesses Mr. Jones, while interviewing the family to better understand the characteristics of his normal cognitive state. MEDIC 1 personnel also confirm that Mr. Jones identity matches the electronic health records in the network portal.

The home monitoring devices, which collect vital signs and blood glucose information on Mr. Jones, allow the EMS personnel to view the last 72 hours of data.

MEDIC 1 contacts the online medical control physician and presents their case and their recommended treatment plan, which includes IV dextrose. The physician requests a telemedicine video session to better understand Mr. Jones current cognitive state and requests that the crew recontact him after administration of the dextrose.

Following treatment, MEDIC 1 personnel recheck Mr. Jones vital signs, blood glucose level, and his cognitive state. While his blood sugar level is now in the normal range, his cognitive state has only improved slightly. A follow up telemedicine video session is conducted with the medical control physician to discuss Mr. Jones' condition and the appropriate next steps for his care. Everyone agrees that a more comprehensive assessment is needed and that a Community Paramedicine unit should respond. Mr. Jones condition is currently stable and a lengthy EMS transport to a distant hospital is not yet indicated.

MEDIC 1 requests a non-emergency response from a Community Paramedicine unit. The ECC advises that unit MIHC-1[17] is currently available, and their ETA should be approximately 20 minutes. The Medical Control physician transfers their notes, vital signs telemetry, and video session data to the Community Paramedicine Medical Control Center (CPMCC), where it will be available to the online physician supporting those units.

MEDIC 1 calls MIHC-1 by phone and provides a detailed briefing on Mr. Jones condition. Data collected by MEDIC 1, including the EMS Patient Care Record and vital signs telemetry, is transferred to MIHC-1's systems. The MIHC crew is also able to review Mr. Jones Electronic Health Care records, including prior physician visits and documentation on Mr. Jones baseline cognitive state.

MIHC-1 arrives on scene and the MEDIC 1 team then completes their handoff of the patient to them. MEDIC 1 returns to service for emergency calls.

The MIHC crew completes their review of the EHR data, including a review of Mr. Jones most recent blood work and 12 lead EKG. They also review the notes from the last Community Paramedicine response to Mr. Jones, which occurred two weeks ago. They then contact the Community Paramedicine Medical Control Center (CPMCC) to speak with a physician and discuss Mr. Jones' case. The CPMCC physician accesses Mr. Jones prior medical records and views the vital signs telemetry collected by MEDIC 1 and MIHC1. The MIHC-1 team draws blood and conducts Point of Care (POC) testing. The results of the POC analysis are viewed by the MIHC-1 team and are also transmitted to the CPMCC physician for interpretation. Information from Mr. Jones Complete Blood Count (CBC) and Liver Function Tests (LFT) indicate that the home dialysis treatment may not be working as efficiently as necessary. Mr. Jones blood levels in several categories are elevated beyond what is noted in his regular baseline testing. Over the course of the past hour, Mr. Jones cognitive state has slowly continued to improve and is almost back to a normal level.

A telemedicine video session is initiated allowing the CPMCC physician to interact with Mr. Jones and his family. A discussion ensues over various treatment options and the risks and

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[17] Mobile Integrated Health Care (MIHC)

benefits associated with each course of action. A decision is made that transport to a hospital is not necessary. The home health care agency will be contacted to have a nurse stop by later this evening to validate Mr. Jones' medications and a technician will stop by to assess Mr. Jones home dialysis equipment. The family is encouraged to call 9-1-1 if they detect anything of extreme concern. They may also reach out to the CP/MIHC program center, the home health agency or the patient's physician. Interactions with any of these entities results in data sharing and collaboration.

The MICH-1 team then contacts Mr. Jones' home healthcare agency and asks for his assigned nurse to contact them. They also confirm that their patient care data has uploaded to the regional data sharing network and is available for review by the home health care team. When Mr. Jones' nurse returns their call[18], they will discuss today's incident and the treatment plan.

***Working Group Discussion**:*

- *Patient trend data from home health care systems may be valuable in better understanding the patient's condition and should be available from home monitoring devices to EMS.*
- *Portable ultrasound technology would be useful in this case to help identify an appropriate vein for IV access.*
- *The patients' family will have interacted with the patient's physician, the home health care nurse, EMS, and the Community Paramedicine team. There needs to be clear cut instructions to the family on when they should contact each provider, based on the situation.*
- *There is a need for automatic and real time data sharing between all the various entities that were involved in Mr. Jones' care.*

Transport:
Mr. Jones is not transported and is able to remain at home.

Data Management:
Patient care data entered by each provider and patient telemetry aggregated from various devices is all available through one of several online databases[19].

There is the ability to transfer data seamlessly between different providers, even if they are using different application software. Information will flow from, and between, the following places in this use case:

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[18] The designated home health care nurse may return the call after MIHC-1 has left the scene.

[19] EMS incident reports may be available in one database and hospital and clinician data may be stored in a separate database. However, it is envisioned that a single inquiry can be made to determine if records exist in either database.

1. Emergency Communications Center (text, video)
2. MEDIC 1 (PCR, patient telemetry, video)
3. MICH-1 (PCR, patient telemetry, video)
4. EMS Online Medical Control Physician
5. CPMCC Online Medical Control Physician
6. Prior EMS Responses (one or more agency CAD systems)
7. Prior EHR Responses (hospitals, physician office)
8. Home Health Care Agency clinical staff

The presence of new data indicating an emergency response to Mr. Jones will generate a proactive notification to his primary care physician and his home health care provider.

Working Group Discussion:

- *Data management will need to address the unique components of EMS billing in these circumstances.*
    - *Under the ET3 program, the EMS service must generate an ALS level charge to CMS, equivalent to an ALS transport charge to the ED. The Telehealth interaction between EMS Medical Control and MEDIC1 is not billable. You cannot have two billings for the same patient episode. The CPMCC provider interaction with MICH1 is charged to CMS to the operator of the telehealth session as a CMS telehealth provider.*
    - *These charges were not previously possible under existing CMS reimbursement for EMS. For each call, you can only generate one treatment in place bill and one telehealth consultation/treatment bill. Even though we had two telehealth sessions, only one can be billed. The EMS medical director who did the original consultation does not bill; this is a part of their normal medical direction.*
- *Patients' Primary Care Physician (PCP) and anyone tagged as an alert recipient would be informed of this event. High priority alerts should be more prominent (vs. getting lost in the office email inbox).*

5.0 IMPLICATIONS FOR RURAL EMS AGENCIES

Prior use cases can be examined to identify issues unique to rural EMS response. A prior EMS Working Group report, "*The FirstNet and Public Safety Broadband Data, Implications for Rural EMS Organizations*" provided a comprehensive review of these issues.

Time, Resource, Incident Analysis

Comparison Table of Rural versus Urban and Suburban EMS Services

Attribute	Rural, Frontier	Suburban	Urban
TIME			
Reaction Time (From Incident to Discovery)	Delayed due to absence of a passerby or neighbor noticing the emergency incident.	Short due to presence of bystanders and others who are nearby the incident.	Short due to large number of persons in the area of the emergency and use of cell phones.
Response Time[18] **(From Station to Scene)**	Extended/Delayed due to road conditions, dispersed personnel, and incident travel distances. Typical 30-120 minutes. [19]	Short to Medium based on availability of more units and personnel and a more dense operating geography.	Short based on number of units and stations in a dense geography. Typical 4-50 minutes. [20]
Transport Times (From Scene to Facility)	30-60+ minutes	15-30 minutes	3-15 minutes
RESOURCES			
Patient Access	Roadway, aircraft, boat, ATV	Roadway, aircraft	Roadway, aircraft
EMS Responders - Training/Credentials	EMR, EMT, AEMT, some paramedics but not in all areas	EMR, EMT, paramedics	EMT, paramedics
EMS Responders - Available on Scene	1-4	2-6	2-6
EMS Responder Type	Primarily Volunteer, On-Call, Career	Primarily Career	Primarily Career
Availability of Training Courses and Programs	Low to medium	Medium to high	High
Access to new Technology and Equipment	Poor to medium	Medium to high	Medium to high
Communications Systems Performance (EMS to dispatcher, EMS to hospital)	Poor to medium	Medium to high	Medium to high

Technology solutions can provide significant assistance to support rural EMS response, yet rural agencies are the least likely to be able to afford hardware and software systems. The community paramedicine use case identifies the same attributes that would be relevant in a rural response.

In summary, the working group identified that all the technology solutions identified were applicable to rural EMS response. However, it was noted that rural EMS agencies rely more heavily on volunteer staffing and likely need technology solutions which are easy to use. Personnel in these areas experience low call volumes and do not have access to recurring training in most instances.

The working group felt that UASs would have more utility in rural areas and could support delivery of drugs and blood (via a centralized supply system). There are also advantages to having autonomous vehicles that can help sustain volunteer operations with minimal staffing.

Technology can provide "just in time" refresher training that could be viewed during the longer response time that is seen in rural areas. It was noted that many volunteer personnel operate in their own vehicle and are single operator units (which would preclude access to the training data).

Augmented Reality (AR) might also be helpful in rural areas to help guide specific interventions. A medical control physician could "paint a line" on the ultrasound screen to identify the preferred location for line placement.

Point of Care testing, as used by Community Paramedicine teams, may be expanded in rural areas to provide additional analysis. In rural areas, it is especially important to determine whether a patient needs to be transported 100 miles to the hospital (or can they remain in their home and be seen by a home health care nurse later).

Placement of specialty care units in rural areas would be helpful to provide mobile radiology, including mobile CT scans.

Health insurance providers are now encouraging patients to purchase special technology devices that augment a virtual patient care visit via your laptop or tablet. This includes an otoscope, stethoscope, and other modules that allow data to be transferred to the physician.

The Voice Activated EMS Assistant, being developed by the University of Virginia, would be especially useful in a rural setting and could provide important information on protocol compliance, drug dosing, etc. While not ideal, a virtual assistant might compensate for lack of recurring training on advanced skills.

Analytics are also needed to help ingest large amounts of data and helping communications center personnel with decisions on response. Patient crash data is important in rural areas due to a variety of factors, including high speed roadways, long response times and delays in detection of the crash. Analytics could review a stream of crash data and recommend specific response patterns. Analytics can also help with analysis of video and sensor data arriving in rural communications centers.

Technology, and the data it is producing (or receiving) also creates issues for rural agencies regarding data storage, retention, and management. Sharing of data between systems (e.g. the communications center to the EMS unit application to the Hospital ED software), requires design of expensive interfaces between the various vendors. Many solutions provide for cloud storage, but most agencies want to download images, log files, and other data to their local systems. This is an issue relatively unique to EMS, in which data generated by the communications center needs to be shared with responding units (which have their own software) and with the receiving hospital (which has its own software). Patient data needs to be seamlessly shared across the various domains. Rural agencies may be transporting to distant hospitals which all may use different software solutions, requiring multiple interfaces. In rural areas, this may be cost prohibitive.

6.0 SUMMARY OF FINDINGS:

General Findings:

- Rural areas have unique needs that would benefit from access to additional technology, but funding, training, and staffing barriers stand in the way of adoption.

Detection of Medical Emergency:

- Automatic detection of EMS emergencies via sensors will increase as this technology matures.
- Next Generation 9-1-1 will allow video access to the patient, opening an entire new paradigm in clinical assessment even prior to EMS dispatch.
- Integration between different consumer, health care and public safety networks and devices will be essential to assure real time alerting in life threatening situations.
- Sensor alerts must be reliable and actionable, including sufficient and accurate information from which to generate an EMS response.

Activation of the EMS System:

- EMS communications centers will need new technology solutions to receive data alerts and to manage new methods of interacting with 9-1-1 callers (including video chat and text to 9-1-1). This will include interfaces and modifications to existing Computer Assisted Dispatch (CAD) systems.
- This includes healthcare data and biomedical telemetry alerts flowing from a patient device to the ECC and on to responding EMS units and then to the receiving hospital.

EMS Response:

- UAS may play a pivotal role in the delivery of AED's, medical supplies, and MCI supplies to incident scenes.
- Enhanced mapping and routing solutions, unique to the public safety environment are needed. This includes both street directions and building access and floor plan data.

Patient Care and Scene Management:

- Data aggregation of information from remote health care databases will enhance on scene patient care.
- Voice Activated EMS Assistants can support creation of the EMS patient care report, provide guidance on medication dosages, and assist with treatment protocol compliance. These devices can also automate the collection of patient health data and patient medical telemetry from other networks and devices.

Transport:

- AI assisted patient destination decisions can enhance delivery of patient care and optimize EMS resource availability.
- Emergency Departments would benefit from real time data dashboards showing inbound EMS units, with display of patient severity, vital sign alerts and ETAs.
- Emergency Departments do not want to manage multiple technology platforms in order to communicate with all EMS agencies in their region and EMS agencies benefit from adoption of the same technology platform or one that is fully interoperable with that used by agencies that they work with.
- More study is needed to determine what EMS patient care data and telemetry should be transmitted to the Emergency Department, to determine who the actual custodian is for the data, and to determine which data enters the Emergency Department patient record.

Data Management:

- Data aggregation is a critical element to allow for the summarization and display of information that is needed at particular points in the EMS response and patient care timeline.
- Network service (including hardline and wireless) must be robust to support end to end rapid transfer of data. Prioritized data should maintain its relative network priority as it traverses from the field (via wireless service) through other networks (including public safety agency systems) to the final destination (e.g. hospital emergency department).
- The standardization of data streams and full data interoperability is a necessary step before patient data can be fully optimized and shared in the prehospital environment.
- There are multiple governance, technology, implementation, and cyber-security issues to be managed as new technology is implemented and as more data is collected.

7.0 RECOMMENDATIONS:

1. There is a need for ongoing collaboration between EMS agencies and industry in order to ensure that new technology solutions are designed for mission critical response and patient care.

   Like the communities they serve, EMS agencies are unique, and each service has different operational advantages and constraints. Technology solutions must adapt and scale to support small rural providers as well as large urban systems. The EMS mission is complex and requires specialized attention from the technology industry. Devices and applications designed for law enforcement and fire rescue may not be suitable for EMS.

2. There is a need for ongoing regional collaboration between EMS agencies and all stakeholders who are involved in EMS response.

   This includes hospitals, ECCs, fire rescue, law enforcement and other first responder organizations. Policies, procedures, and procurement decisions should be discussed to prevent each agency from adopting a different technology to provide the same service. Data interoperability among disparate systems is also critical to allow seamless sharing of incident data and patient care information between all providers of both prehospital and emergency department care.

3. While technology will enable the transfer of large amounts of data to EMS personnel at the patient's bedside, further analysis is needed to identify specific elements that are of value.

   The FirstNet network will allow large volumes of data to be transferred to first responders. New technology solutions create vast troves of data, including digital maps, images and video, and databases filled with incident and tactical information. FirstNet will also allow field personnel to transmit data from the incident scene to the communications center, emergency department and medical control physicians. Further study is needed to determine exactly what segments of the "information superhighway" are necessary to support clinical decision making and situational awareness. If an EMS unit is transporting a critically ill patient, should they continuously stream the patient's vital signs and EKG telemetry to the Emergency Department? Should they only transmit this data once or should this data only be transmitted when an alarm threshold is reached? While it is technologically easier to transmit all available data and let the end user figure it out, that approach has been proven to be unacceptable.

4. EMS agencies need to collaborate with hospital emergency departments and similar entities to examine how patient and incident data flows from the scene to the Emergency Communications Center and on to EMS responders and then to hospitals. There is a need to address what data should be shared, when should it be shared, how it is stored and who is the custodian.

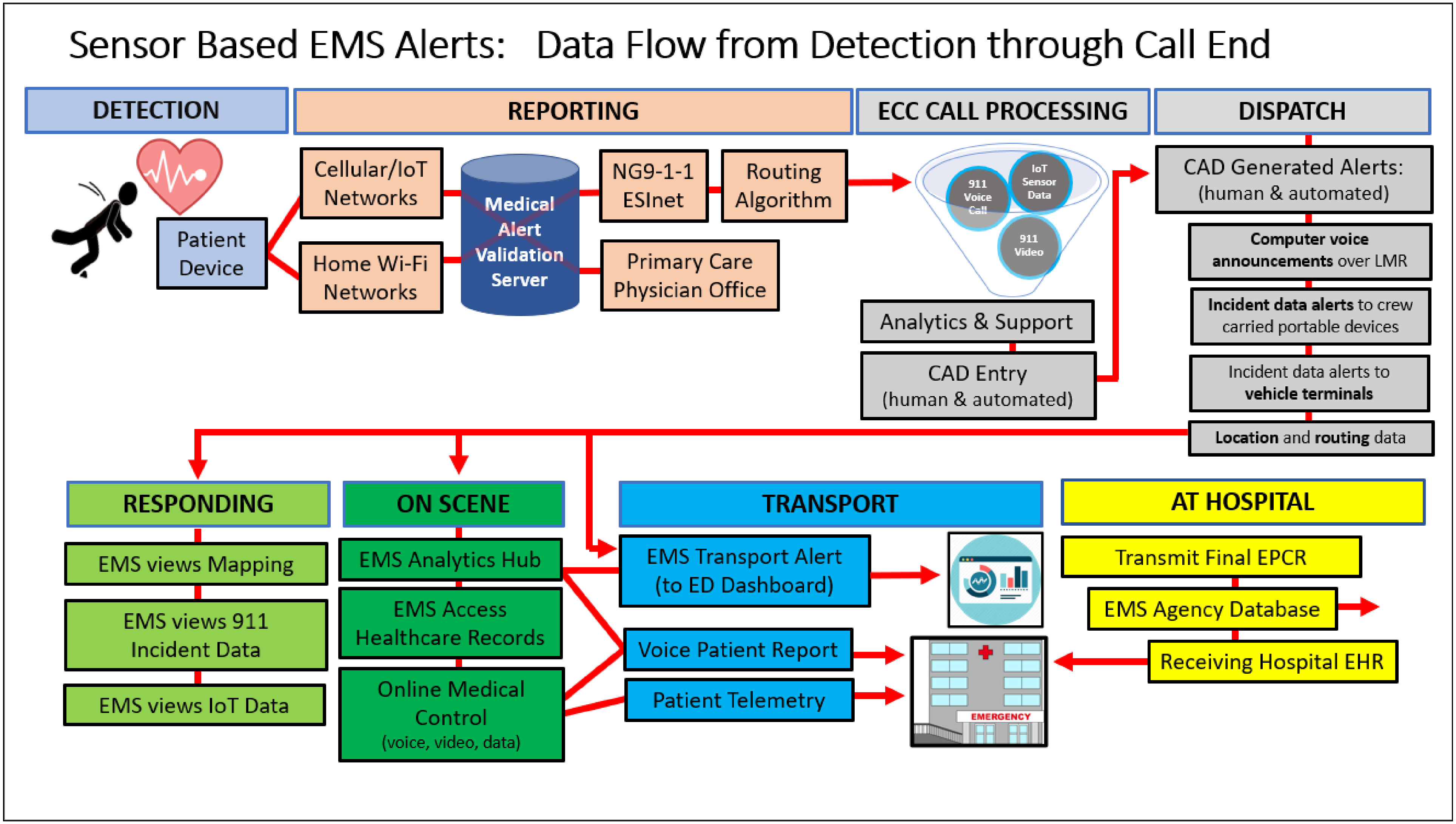
   Incident information and patient telemetry get bundled as it moves through each element in the response chain. This can be viewed as a shopping cart that is continuously filled with more and more pieces of data. All stakeholders in the emergency care continuum should be involved in the decisions regarding what data is collected, how long it is stored, who is it shared with, what other entities downstream view and/or collect the data, and what entity is the official custodian of the records. These discussions should also examine what pieces of EMS data are necessary for early decision making (e.g., a trauma patient's vital signs trend over the past 20 minutes) vs. what pieces of information should be stored by the emergency department in their electronic records systems (e.g. the trauma patient's lowest or last set of vital signs at time of arrival).

5. EMS agencies should be cautious as they adopt new technology solutions and fully understand all aspects of purchasing, installing and managing those systems.

   Public safety technology solutions are now readily available, thanks in part to the activation of the FirstNet high speed public safety broadband network. EMS agencies are embracing many of the new solutions which promise to enhance their operational and clinical performance. Public safety agencies should exercise caution during these early years in the digital "wild west" to ensure that the proposed application or service will meet their unique operational needs. Care must also be paid to the need for data sharing and interoperability with other EMS agencies and with receiving hospitals. Many of these decisions are best made on a regional basis.

NPSTC and NASEMSO sincerely thank all members of the Joint Working Group on EMS Communications and Technology for their support in developing this report. The creation of this document would not have been possible without the thoughtful input and collaboration among public safety, industry, and academic representatives.

APPENDIX A: Diagram of Sensor Alert Flow



While the diagram relates to the scenario in Use Case #1, the illustrations of data flows are common across all the use cases noted in the report. Additional context of the diagram elements is noted below.

Detection:
The patient's medical **sensor device** identifies an emergency event (such as a lethal heart arrythmia, critically low blood oxygen or blood glucose reading). The sensor may be an embedded medical device (e.g., a pacemaker or internal defibrillator) or an external monitoring device.

Reporting
The patient's device accesses an available network [20]to transmit a data alert. This may include the patient's **home Wi-Fi** network, a **cellular carrier network** on a specialized cellular carrier IoT network. Embedded devices may communicate via Blue Tooth or other technologies to the patient's Smart Phone or other hub to access a network connection. The data alert is transmitted to a **Medical Alert Validation Server** which will execute steps to confirm that an emergency actually exists. This may include an automated phone call to the patient for confirmation, secondary analysis of the patient's heart rhythm, or comparison with other available data (e.g., is the patient mobile). Validated alerts are then transmitted to the Next Generation 9-1-1 system using the Emergency Services IP Network (**ESInet**). The data alert is then routed to the correct Emergency Communications Center using a **routing algorithm**. The data alert is also sent to the patient's primary care physician notifying them that an incident has occurred. The physician office data alert is not designed to trigger real time notification and response.

ECC Call Processing
Requests for EMS may arrive in the Emergency Communications Center as Voice and Text 9-1-1 calls, IoT Sensor Alerts, and 9-1-1 Caller Video streams. **Analytics and Support** automation will route the incoming call to the appropriate team in the ECC who is trained for that function (e.g., video 911 calls for EMS may be managed by a specially trained group). Telecommunicators and other specialists will process the EMS call and enter the incident into the Computer Assisted Dispatch (CAD) system. The Analytics and Support automation will provide real time monitoring of the conversation and may prompt the telecommunicator if it detects a potential problem (e.g., a mismatch between the location the caller provided and the address the telecommunicator entered into CAD or instances in which the telecommunicator missed asking a critical question about the patient's breathing). In some instances, a validated sensor alert may bypass the call taking function in the ECC and go directly to the EMS dispatcher for immediate deployment of units. This may occur in cases of sensor verified cardiac arrest and other time critical emergencies.

Dispatch
The CAD system will process the available data and recommend the agency designated response (based on the severity of the patient's condition and their location). Rapid dispatch would occur with telecommunicator oversight and EMS units are notified by **computer generated voice announcements** over the radio system while **data alerts are sent to portable and in-vehicle devices**. GIS data is also transmitted which will provide **location and routing information** to expedite travel to the scene. GIS and GPS data may also be used to align traffic signals along each units' route to the scene.

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[20] It is recognized that these networks may not be reliable, and the transmission of a critical alert may be delayed or lost.

Responding

Personnel responding to the scene will have access to a wide range of data. **Location data** and mapping interfaces will display the preferred travel route (based on real time traffic data). **Incident and patient information** is displayed which shows the patient's status and better informs the crew on what equipment to carry to the bedside. **Sensor based patient information** is also available for review. This may include a snapshot of the patient's EKG rhythm or numeric data from the patient's blood glucose monitoring system. Depending on the travel distance to the scene, EMS personnel may not have time to review all the available information.

On Scene

EMS personnel arriving on scene will use an **Analytics Hub** to support analysis of sensor data, document patient care activities, provide protocol support and safety monitoring, access remote data, and serve as a communications network for voice, video and data transmission. The Analytics Hub may connect to the patient's home medical monitoring systems to provide EMS personnel with additional data on the patient's condition. For example, this may include the ability to review the patient's blood glucose readings across several days to determine if the patient's health was deteriorating slowly over several days or if the low reading represents an acute event. The Hub may also access the patient's **Electronic Health Record** to verify the patient's current medication list and medical history. The Analytics Hub would listen to EMS crew voice interactions and make appropriate entries into the Patient Care Record. EMS personnel could use a voice query to ask the Analytics Hub to calculate the correct drug dose of a medication. The Hub may also warn the EMS crew if the patient care is not in alignment with agency protocol (e.g., improper medication timing or dose). Upon request, the Hub would transmit telemetry information to the **online medical control** physician and/or the receiving hospital Emergency Department.

Transport

When EMS personnel select a destination hospital, an **EMS Transport Alert** is automatically sent to that facility and a summary of the case is displayed on the **ED Dashboard** (which would display the EMS Unit ID, ETA to the hospital, patient injury/illness type, and patient severity code). No further notification would be required by EMS when transporting stable BLS patients. Voice, telemetry, and video consultation systems are available to communicate the report on ALS patients. Vital sign telemetry data would flow to the ED Dashboard but would only trigger an alert in the case of an alarm threshold was reached (e.g. to alert ED personnel that the patient's heart rhythm was unstable).

At Hospital

Upon arrival at the Emergency Department, patient care is transferred to hospital personnel and an updated report is provided by EMS. The **EMS Patient Care Report** is finalized and electronically transferred to the EMS agency PCR database and to the hospital's **Electronic Health Record (EHR)**. The final version of the report replaces the draft version of the report that was made available to Emergency Department personnel in the early phases of the incident. Information obtained by the hospital, including full patient demographics and insurance data, would be transmitted back to EMS to provide for a complete record. Patient outcome data would also be made available for Quality Assurance/Quality Improvement activities.