Capital Gains: Leveraging Human-Centered COPs for More Effective Incident Management in DC and Beyond

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ABSTRACT

The District of Columbia presents one of the most complex emergency response environments in the country—dense urban infrastructure, high-profile federal assets, overlapping jurisdictional authorities, and frequent large-scale events, demanding real-time coordination across agencies. Yet, even in this data-rich setting, fire and EMS operations often lack the integrated systems and operational culture needed to translate information into timely, actionable insight. A Common Operating Picture (COP) offers a transformative opportunity to close this gap, but within the region, it has not been commonly adopted as a solution. Drawing on operational observations, stakeholder feedback, and pilot initiatives conducted within the District of Columbia Fire and Emergency Medical Servies Department (DCFEMS) and its interagency partners, this paper explores how COPs can enhance situational awareness, resource deployment, and command decision-making in the National Capital Region (NCR). It outlines a practical, field-informed roadmap for developing, testing, and institutionalizing fire service COPs tailored to the operational realities and intergovernmental demands of Washington, DC. Through real-world examples and lessons from pilot initiatives, it outlines a practical pathway toward building, deploying, and sustaining effective COPs that align with the realities of modern emergency operations for all levels of the fire service, within the NCR and beyond.

ABOUT THE AUTHORS

Katelynn A. Kapalo, Ph.D. is a research psychologist and national instructor whose work bridges human performance, technology, and public safety. With prior roles at the U.S. Navy, Brown University, NIST, and DCFEMS, she specializes in decision-making under stress, immersive learning, and systems design for emergency response. Kate is nationally recognized for her work on firefighter wearables, immersive training evaluation, and common operating pictures in high-stakes environments, as well as her work to improve firefighter health and safety.

Timothy Hutchison is a Public Safety GIS Analyst with the DC Office of the Chief Technology Officer, supporting the DCFEMS and EMS Department. He designs geospatial dashboards and data solutions that enhance situational awareness and decision-making for emergency responders. Tim received the 22nd Annual Cafritz Team Innovation Award for his role in advancing data-driven operations through civic technology. Tim is an accomplished GIS analyst with the ability to translate technical information for public safety stakeholders and ensure operational efficiency in every situation. Tim was a critical asset to ensuring efficiency in the recovery operation from the recent Potomac Aircraft Collision.

Jeffrey Lenard is a veteran firefighter and maritime operations specialist with DCFEMS. He serves as a Rescue Swimmer, Master Public Safety Diver, and Maritime Communications Unit Leader. Jeffrey supports interoperable communications and situational dashboards across agencies in the National Capital Region, helping integrate GIS technology into real-time emergency operations. Jeff's expertise has directly improved DCFEMS' ability to receive real-time information in critical situations, including NSSEs and the recent Potomac Aircraft Collision.

Thomas Chenworth is Deputy Chief of Information Technology for DCFEMS, with over two decades of operational and leadership experience. A former HazMat Unit Captain and Special Operations Battalion Chief, he now leads IT modernization efforts for the department. Chief Chenworth plays a key role in regional preparedness, cybersecurity, and multi-agency coordination, including planning for National Special Security Events and leading COVID-19 response logistics. He is also an expert in deployable technology for denied and degraded environments.

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INTRODUCTION

The District of Columbia (DC) presents a uniquely demanding environment for emergency response operations. As the seat of the federal government and home to numerous critical infrastructure assets, national landmarks, high-density residential neighborhoods, and international diplomatic facilities, the National Capital Region (NCR) requires a level of coordination and operational readiness equivalent to broader federal agencies. Fire and EMS personnel in the district must routinely respond to incidents under conditions shaped by multi-jurisdictional complexity, evolving threat landscapes, and a constant need for interagency collaboration. Despite these evolving demands and the growing availability of digital tools and data streams, many emergency operations continue to rely on fragmented systems, siloed information, and inconsistent situational awareness practices. These gaps pose real risks to responder safety, operational effectiveness, and public trust.

This paper explores the development and application of a *Common Operating Picture (COP)* framework designed to enhance situational awareness, decision-making, and coordination within the District of Columbia Fire and Emergency Medical Servies Department (DCFEMS) and its regional partners. Drawing on field-based pilot initiatives, operational observations, and practitioner feedback, it articulates the rationale, design principles, and implementation roadmap for a fire service–specific COP grounded in joint command-and-control doctrine and human-centered design. The paper argues that a well-designed COP is not merely a technical upgrade but a strategic capability—one that supports decentralized decision-making, improves resource deployment, and enhances the effectiveness of both routine and large-scale incident responses. By contextualizing the COP within the realities of DCFEMS operations and aligning with established military and homeland security standards, this work contributes a practical model for advancing unified command and operational resilience in complex urban environments.

BACKGROUND

Across military, homeland security, and public safety domains, the ability to maintain a shared understanding of the operational environment, referred to as COP, can be a decisive factor in mission success or failure. Despite widespread interest within the fire service, COP adoption remains limited. This paper builds upon a series of field-based initiatives and operational assessments aimed at identifying the barriers and enablers of COP implementation in the fire service located with the NCR. It presents a conceptual and applied framework for translating COP principles, drawn from military command and control (C2) systems, into actionable tools for emergency response. The goal is to improve operational coordination, enable real-time data integration, and support adaptive decision-making at all levels of the incident command system.

Despite the availability of advanced data systems and smart technology, most fire service agencies still operate without a truly integrated COP. Situational awareness is commonly constructed through verbal updates, radio transmissions, and siloed software tools, none of which provide a consolidated, real-time view of the incident. This lack of cohesion not only slows decision-making but can increase operational risk and reduce effectiveness of coordination, particularly during multi-agency responses (Bunker et al., 2014). This was a key concept identified early by our stakeholders and one that has resonated with members of all aspects of the fire service, including structural, technical rescue, marine, and wildland firefighters within and outside the NCR.

Based on our review of the extant literature, we prioritized these key concepts as the most important for our goals. By using existing models, we were able to discern what worked in most situations and the pitfalls that other parallel professions have identified in high-stakes environments (Danielsson et al., 2014; Steen-Tveit & Munkvold, 2021; Steen-Tveit, & Radianti, 2019).

The final list of prioritizations included the following key areas:

- **Multidimensional** – integrating personnel, hazards, infrastructure, and status reports
- **Shared** – accessible across roles, ranks, and agencies
- **Contextual** – customized for the needs of field operations, command staff, etc. and not just personnel in headquarters
- **Adaptive** – capable of incorporating new data streams as needs evolve

Observations across multiple agencies within the fire service have revealed common issues with technology for situation awareness across the board (Dawkins et al., Kapalo et al., 2019). Within the extant literature, themes emerged across 4 key areas specific to the fire service:

- **Disparate systems**: Computer-aided dispatch (CAD), GIS, building data, and resource status platforms often lack integration.
- **Manual personnel tracking**: In high-tempo incidents, accountability systems are either pen-and-paper or reliant on verbal radio updates.
- **Delayed information flow**: Real-time data—such as sensor alerts or situational updates—rarely reach all stakeholders simultaneously.
- **Limited visualization**: Existing dashboards serve reporting needs but do not support live decision-making under time constraints.

Despite increased digitalization across the fire service, many fire departments operate without a true COP. To address these issues identified previously in the literature, we outlined in more detail below our approach to managing these challenges through specific, fire-service-focused case studies conducted with the DCFEMS personnel.

APPROACH

To assess the feasibility of COP implementation in the fire service, we conducted a pilot initiative in partnership with a metropolitan fire department. The goal was to co-design and test a scenario-based COP prototype for use during two complex, resource-intensive incident types that pose substantial command and coordination challenges. Thus, we focused specifically ***on rail and maritime incidents*** and employed a participatory design methodology, incorporating feedback from command staff, safety officers, operations personnel, and technical rescue/special operations personnel.

This section describes the methodology, stakeholder engagement process, and design decisions that guided the pilot. It also details the specific components prioritized for inclusion in the COP prototype, such as unit tracking, hazard overlays, and resource status visualizations. Through iterative testing and structured debriefs, we captured actionable insights into user needs, interface design preferences, and system limitations. These lessons inform the practical recommendations outlined in the remainder of the paper.

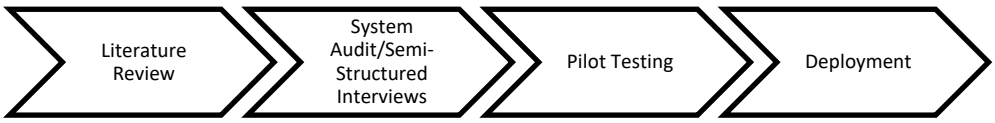

Figure 1. Our Approach to Integrating COPs

System Audits and Semi-Structured Interviews

To understand the operational, cultural, and technical factors affecting COP adoption within the fire service, semi-structured interviews were conducted with 38 personnel across command, operations, and technical/special operations roles. The interviews were designed to elicit both strategic perspectives and on-the-ground insights about current challenges, system limitations, and perceived needs for improving situational awareness and interagency coordination. Questions were open-ended to allow for narrative exploration, but each interview included key areas as outlined below.

Interview Themes and Sample Questions:

1. Current Operational Practices
- *How do you currently leverage technology during a large-scale incident?*
- *What tools or systems do you rely on, and how effective are they?*

2. Information Flow and Gaps
- *Can you describe a time when information breakdown impacted operational decision-making?*
- *What information do you need during a critical incident that you typically don't have?*

3. Interagency Coordination
- *What are the biggest challenges when working with outside jurisdictions on incidents (e.g., Potomac, federal property)?*
- *How well do you think current systems support joint operations?*

4. Technology Use and Integration
- *What systems (CAD, GIS, sensors) are used daily, and how well do they integrate?*

5. Human Factors and Usability
- *What would make a situational awareness tool easier or more effective to use?*

6. Training and Implementation
- *What would help build trust and fluency with new systems like a COP?*
- *What information do you typically have to report out on after an incident?*

7. Vision for Future State
- *If you could design your ideal command interface, what would it include?*

We provide a summary below of the participants in our pilot study below in order to better paint the picture surrounding the impact of COPs on the department more broadly.

Table 1. Participants by Rank

Command Level	Title/Role	Number Interviewed
Strategic Command	Assistant Fire Chief	1
	Deputy Fire Chief	3
	Battalion Chief (Special Ops/Admin/Safety)	4
	Subtotal	**8**
Tactical Command	Battalion Chief (Field Operations)	6
	Captain (Company Officer)	7
	EMS Supervisor	1
	Subtotal	**14**
Operational (Task) Level	Lieutenant (Company Officer)	11
	Firefighter/EMT or Paramedic	13
	Rescue Technician/Squad	2
	Subtotal	**16**
	Total	**38**

Pilot Testing Use Cases

DCFEMS operates in a uniquely layered operating environment, surrounded by federal land, bridges, tunnels, and national monuments, all under the jurisdiction of different agencies such as the U.S. Park Police, Secret Service, U.S. Capitol Police, National Park Service, Metro Transit Police, and neighboring fire departments from Maryland and Virginia. The two case studies focus on the areas that function as the operational nerve center where these agencies coordinate during high-profile incidents, special events, and large-scale emergencies. For DCFEMS, this means **real-time alignment on resource deployment, incident command roles, and communication protocols**, which is essential in preventing redundant or conflicting actions during time-sensitive operations.

Rail Operations Command and Control (ROCC) Center Pilot Testing (*n* = 5)

The Rail Incident Management Dashboard created a unified picture of all rail transportation within the capital. One of the major challenges firefighters and emergency responders face in the NCR is a lack of access to tailored location data. For example, during metro incidents, it's often difficult to pinpoint locations because callers do not have clear information about their location, or they may be calling in something they saw during their daily commute, etc.

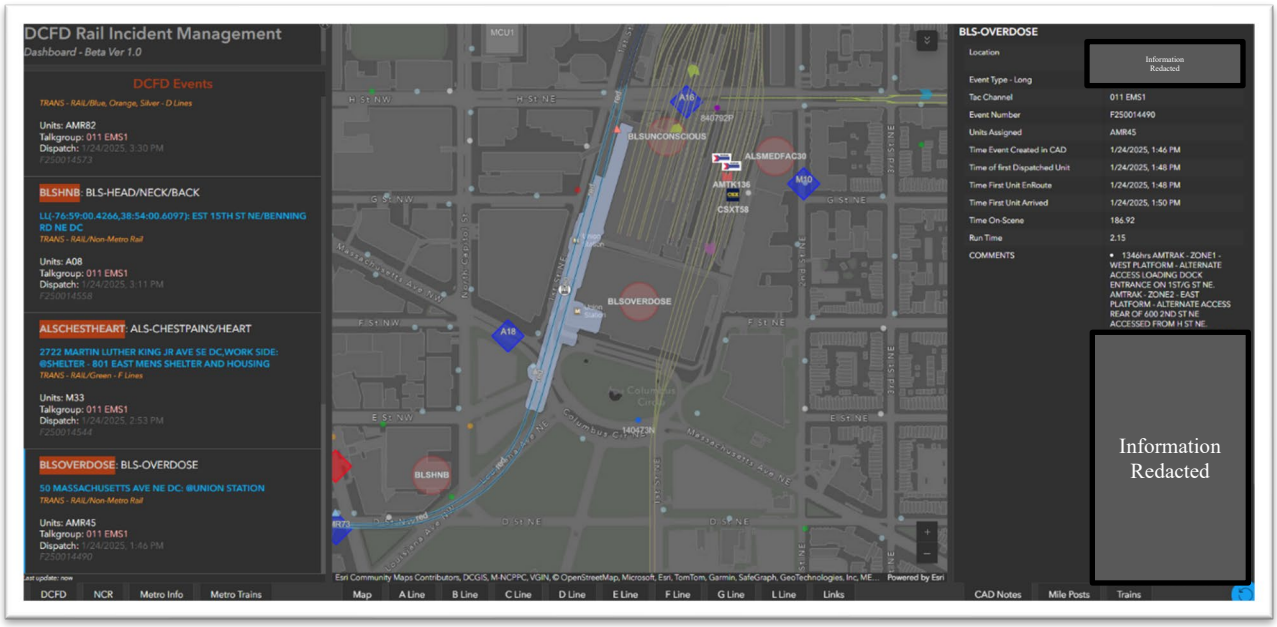

Figure 2. Rail Operations Center (ROCC) Dashboard

Maritime Joint Operations Center (MJOC) Pilot Testing (*n* = 5)

The Potomac River presents one of the most operationally complex geographic features in the NCR. While it serves as a natural boundary, it also cuts across multiple jurisdictions, including the District of Columbia, Maryland, Virginia, the U.S. Park Police, and several federal oversight bodies such as the National Park Service and the U.S. Coast Guard. This multi-agency ownership results in overlapping authorities, fragmented communications protocols, and inconsistent expectations around command roles and response priorities. During routine operations, these complexities may remain latent, but during high-risk incidents, such as a water recovery operation, the consequences of jurisdictional ambiguity can become immediate and operationally disruptive.

During large-scale incidents like multi-alarm fires, mass casualty incidents, or severe weather emergencies, the MJOC can rapidly activate liaisons, coordinate mutual aid, and facilitate strategic resourcing. For example, if a response requires air support, mass decontamination, or waterborne operations on the Potomac, the MJOC enables those requests to be validated and fulfilled efficiently. This positions DCFEMS not as a siloed responder, but as a fully integrated component of the district's emergency operations, integrating with the US Coast Guard, law enforcement like Harbor Patrol, and other critical federal and regional partners.

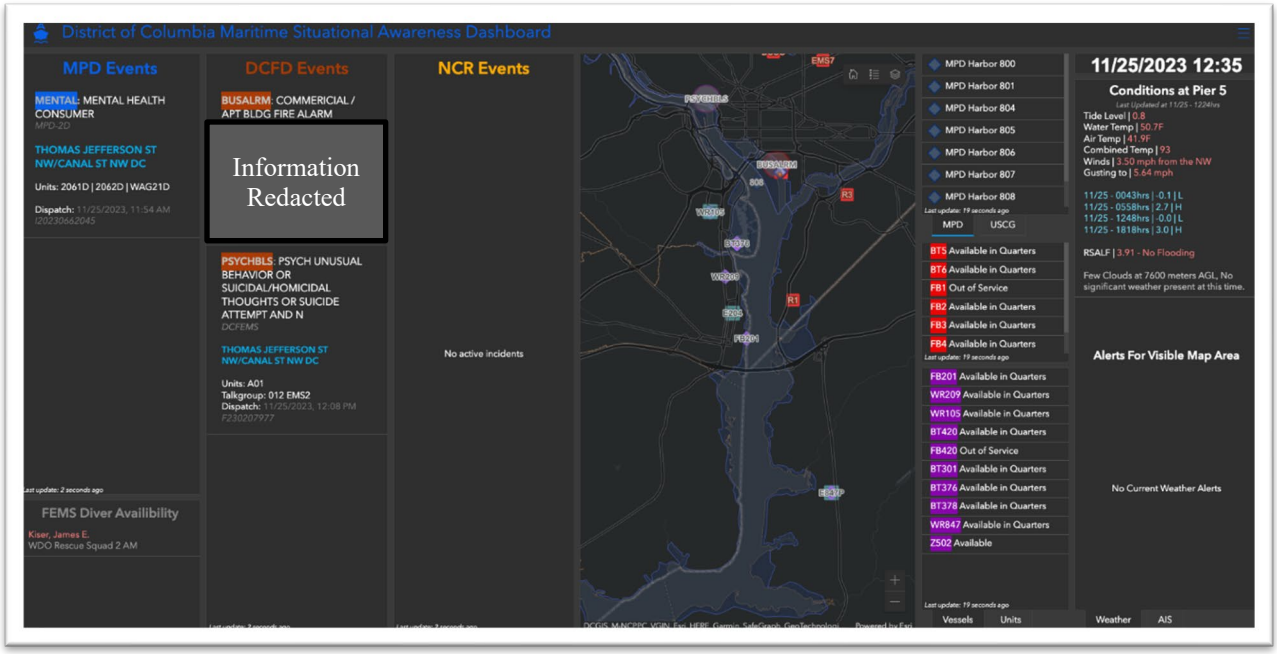

Figure 3. Maritime Joint Operations Center (MJOC) Dashboard

RESULTS

This section presents a synthesis of the system audits and field observations conducted across the department. It highlights the systemic fragmentation that currently characterizes fireground data ecosystems, identifies common breakdowns in information flow, and outlines how these gaps contribute to degraded performance.

System Audits: Barriers Identified

We conducted a thematic analysis of semi-structured interviews to identify key themes, limitations, and areas for immediate feedback. Understanding these limitations is essential for making a compelling case for COP adoption and to design solutions that are both functionally relevant and operationally feasible. Limitations in system design increase cognitive load, fragment situational awareness, and inhibit coordinated response, particularly during multi-alarm or multi-jurisdictional incidents, which is what we sought to mitigate through the use of context-aware dashboard tools. Based upon our work, it was clear that three major concerns surfaced during our semi-structured sessions across all levels of personnel (both operations and command staff):

- **Information existed but required transformation**: Data was present across multiple systems but not formatted or visualized for real-time use, this presented challenges related to delayed information sharing and duplicative efforts.

- **Role-based customization was critical**: A single-view COP proved less effective than filtered views aligned with user responsibilities. This is because different people in the organization have different roles and do not always have the same assignments for every event. For example, a chief in charge of safety may be reassigned to a different area command at the next event. Therefore, making these dashboards accessible to everyone regardless of their assigned role for one event is critical to ensure that they have the information they need to be able to run their specific role for the event and for future events.

- **Usability impacted adoption**: Interfaces had to be intuitive, minimal, and resilient to stress-based decision degradation. These dashboards require minimal training to use and support multiple groups of people, making them ideal for deploying across an agency where time is a commodity and staffing is impacted by removing people from operational roles for software and technology training.

Field Observations

Based on the feedback from operations personnel (n =10) using the dashboards "in the wild," we found several core areas to improve upon initial prototypes. In stressful, time-compressed environments, cognitive overload is a challenge. Based on the feedback from participants, we found the following information critically important, based on a "think aloud" protocol. These areas emerged from the behavioral data as most important:

- Reduce reliance on verbal updates: Participants indicated they wanted an audio alert to align with their existing mental models of calls and alerts.
- Present information visually and spatially: Participants wanted to see the information in context and on different map views.
- Alert, not distract: Multiple alerts in emergency response end up creating information overload
- Support distributed decision-making rather than centralizing all choices: Participants all have different roles so seeing information in context is more important for shared communication and decision-making strategies.

To illustrate the importance of this feedback, in the recent multi-agency recovery operation on the Potomac, the presence of a COP highlighted the importance of shared information. With command units responding from different departments and communication typically constrained by unaligned radio channels and incompatible incident tracking tools, in this case, responders were able to reach unified situational awareness in less time, which was aided by the development of this COP. Decisions regarding diver deployment, incident perimeter management, and victim/debris location updates did not need to be delayed or duplicated, because of the existing shared information architecture. This event underscored the urgent need for an interoperable, role-based COP that can facilitate coordinated operations across jurisdictional lines and support time-sensitive decision-making in geographically complex environments.

Implementation Roadmap

Moving from concept to capability requires a structured, phased approach. Based on our fieldwork and lessons learned, this section proposes a six-step roadmap for fire service agencies seeking to develop or adopt a COP. The roadmap is intended to support scalability and sustainability, regardless of department size or technological maturity. It emphasizes stakeholder engagement, scenario-based testing, and the integration of COP use into training pipelines and operational doctrine. By treating COP implementation as a change management process, not just a technology rollout—departments can build durable capabilities that enhance readiness and resilience.

Based on our pilot data, the following phased approach is recommended:

1. **Use-Case Identification**: Begin with a single scenario (e.g., hazmat, wildland-urban interface)
2. **Data Inventory and Integration**: Map all available internal and external data sources
3. **Prototype and Co-Design**: Develop initial interface with stakeholder engagement
4. **Validation and Testing**: Integrate COP into training and validate user input
5. **Deployment and Feedback**: Pilot in live incidents and refine the COP based on user input
6. **Policy and Doctrine Integration**: Formalize COP use in SOGs and operational manuals

While this may seem obvious to stakeholders within the broader I/ITSEC community and familiar with human factors research, it is necessary to outline this for other fire departments and agencies to understand and apply lessons learned from the military, medicine, and other parallel professions into a streamlined approach that multiple agencies can use regardless of their size or service delivery area and specific population needs. While we always recommend tailoring the approach grounded in community need, this does serve as a foundation for future departments to leverage in creating more effective COPs for large-scale, critical, security sensitive, or complex incidents.

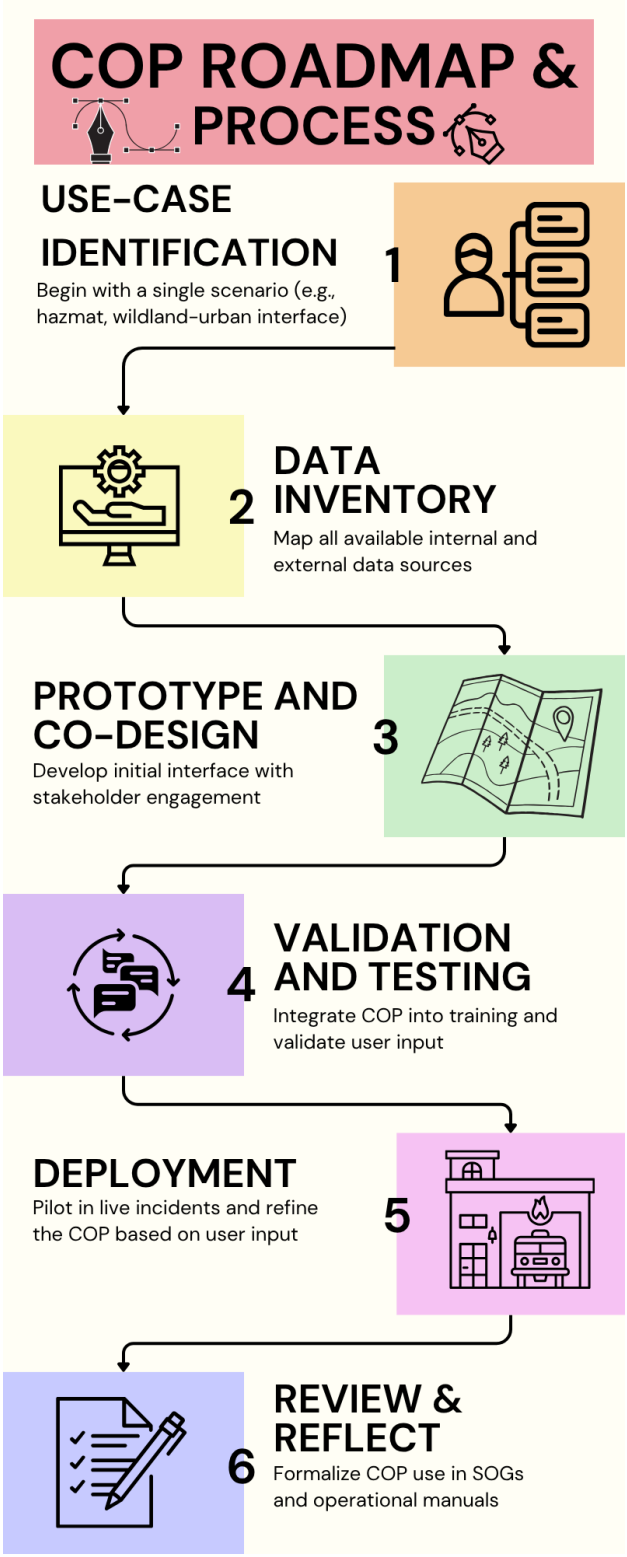

Figure 4. COP Roadmap Development from Pilot Project

DISCUSSION

Successful COP development in the fire service cannot be reduced to a procurement decision or technical integration project. It must be approached as a systems engineering task, shaped by human factors, organizational workflows, and cultural readiness. Drawing from the pilot initiative and existing research in applied cognition and mission command, this section articulates five core principles that should inform COP design and deployment in the fire service. These five principles including human-centered design, interoperability, training integration, access control, and iterative feedback are not merely best practices; they are essential conditions for sustained COP utility and adoption. Each is discussed in terms of practical implementation and relevance to high-reliability, high-consequence environments such as urban firefighting, hazmat response, and mutual aid operations as outlined below:

Human-Centered Design

In the fire service, COP interfaces must be grounded in *operational workflows shaped by dynamic, rapidly changing incidents*—from structure fires to mass-casualty events. Unlike the military, where operations may follow more structured chains of command and deliberate planning cycles, fireground decisions are made in seconds and require interfaces that match the mental models of company officers and incident commanders. Field observation, ride-alongs, and iterative co-design with frontline firefighters are essential. We found that existing off-the-shelf solutions, often designed with military or defense applications in mind, lacked the tactical granularity and speed needed to support fire and EMS personnel in the field.

Interoperability

Interoperability in the fire service is defined not only by compliance with standards (e.g., NIEM, GeoJSON, NFIRS) but also by *the reality of working across dozens of local agencies with no single unified command authority*. In the District, DCFEMS coordinates with more than 34 law enforcement agencies and multiple fire departments, often across jurisdictional divides such as rivers, rail lines, and municipal borders. This differs from the military context, where interoperability challenges exist but are mitigated by shared doctrine, joint task forces, and established command hierarchies. For fire service operations, particularly marine and rail incidents, data sharing must be vendor-neutral and flexible enough to accommodate a patchwork of partners that change from event to event.

Training Integration

A COP cannot be introduced in isolation. Its use must be embedded in training evolutions (live burns, table-tops, simulations) to ensure fluency under pressure. DCFEMS currently conduct simulation-based training virtual simulations of the metro platform. However, given the frequency of NSSEs in the area, multi-agency coordination is critical. Providing opportunities to train using the dashboards is important and one that we will continue to improve upon. Training needs have to be balanced with staffing needs.

Access Control and Security

For the fire service, a COP cannot be introduced in isolation; it must be embedded in training evolutions such as live burns, tabletop exercises, and metro rail simulations. Unlike the military, which has dedicated training units and extended exercise cycles, fire departments must balance training needs with constant staffing demands and emergency call volume. In Washington, DC, where National Special Security Events (NSSEs) are frequent, multi-agency coordination is a necessity rather than an occasional exercise. Providing opportunities to train with dashboards in real scenarios ensures that responders are fluent under pressure—without pulling too many units offline and compromising service delivery.

Feedback and Evaluation

Post-incident reviews and hotwash sessions are the fire service's equivalent of after-action reports, but they differ from military processes in scale and cadence. While the military may conduct lengthy after-action cycles, the fire service often has only hours or days to capture lessons before the next major incident occurs. Continuous learning loops are therefore essential for adapting COPs to emerging risks. A major barrier we observed is cultural: many fire service leaders remain skeptical about COPs, seeing them as redundant dashboards or fearing added complexity will slow operations. Unlike the military, where technology adoption can be mandated through doctrine and procurement, the fire service requires *leadership engagement, peer demonstration, and operational education* to overcome cultural resistance and establish trust in new systems.

Through our work, we identified common misconceptions encountered during COP discussions and deployments. These include assumptions about system complexity, department size requirements, and information overload. Strategies for overcoming resistance, included early wins, field-based demonstrations, and alignment with existing doctrine and training practices. Thus, creating an effective COP requires an organizational shift in the way we manage and process data in our initial pilot case studies. Future work will require us to address the needs identified by our current research:

- **Interoperability**: Gaps in vendor API integration and data standards are still a major concern
- **Human factors**: Dashboard fatigue under stress can be problematic. We are continuing to iterate on the design and functionality of the COPs in use in DC.
- **Scaling**: Cross-agency use (EMS, law enforcement) is critical, but often difficult in the sense that each agency has its own process for implementing technology.

Next steps include deeper training integration, large-scale field exercises, multi-agency exercises, and refinement of data models (O'Neil & Jackson, 2021). We hope to integrate and introduce this into the DCFEMS, as well as conduct testing with mutual aid partners and other agencies (e.g., Metropolitan Police Department), as these dashboards are currently used by multiple agencies within the DMV region.

CONCLUSION

As the fire service faces increasingly complex operational demands, the need for a coordinated, data-informed decision environment is urgent. A COP, tailored to fire service realities and grounded in joint principles of command, control, and collaboration, improves tactical awareness, strategic coordination, and responder safety. Based on our work, we found that the COPs most effectively supported incident command and emergency response in these four areas:

- **Outcome orientation**: Metrics tied to performance outcomes (e.g., time, location, patient information)
- **Stakeholder-driven design**: Built by and for users (e.g., built by responders, for responders)
- **Iterative refinement**: Feedback incorporated throughout development of the dashboards
- **Training-as-integration**: COP deployed exercises for shared incident understanding, more effective response, and adoption of new technologies within NCR agencies

These align strongly to the overall goal of addressing performance-validated, cross-domain, human-centered solutions in the context of incident command. By integrating human-centered design, open architecture, and iterative feedback, the fire service can build COPs that are not only functional, but transformational. The future of coordinated emergency response will depend not only on what we see, but on what we see together.

ACKNOWLEDGMENTS

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