Model Deployment of the Virtual Coordination Center for Multimodal Integrated Corridor Management

Final Report

for the Advanced Transportation and Congestion Management Technologies Deployment Program

Washington State Department of Transportation
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Contact

Travis Phelps
Management of Mobility Division
Washington State Department of Transportation
travis.phelps@wsdot.wa.gov
206-715-9887
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Executive Summary

The Virtual Coordination Center (VCC) is a digital collaborative environment for integrated multimodal corridor management. Under the Federal Highway Administration project “Model Deployment of the Virtual Coordination Center for Multimodal Integrated Corridor Management,” an operational community of state, city, and county agencies including law enforcement, transit, and transportation departments developed, deployed, and evaluated a VCC for interagency management of the Seattle urban corridor.

Led by the Washington State Department of Transportation (WSDOT) and the University of Washington, this project produced an innovative collaborative environment that now supports Seattle Fire (SFD), Police (SPD), and Transportation (SDOT), King County Metro Transit, Sound Transit, Washington State Patrol (WSP), and WSDOT in their interagency management of incidents that impact the regional transportation system. The work accomplished under this project will be sustained and enhanced with funding by the state legislature and under WSDOT guidance.

The VCC provides daily operational value and is designed to support the management of high-impact situations that put unusual stress on the Seattle-area transportation corridors. The VCC supports increased shared situational awareness, enhanced incident and congestion management, and coordinated population movement. Key VCC features and capabilities include:

- An Integrated Dispatch Feed which provides a running account of dispatch events from three computer-aided dispatch systems (SFD, SPD, and WSP), operational dispatches from the King County Metro Transit Control Center, and information from the WSDOT Traffic Management Center Log.

- A Situational Map linked to the dispatch feed and with numerous informational layers such as cameras, traffic, and construction sites.

- Incident Models launched by users or the system indicating that a high impact event is likely in progress and providing information for coordinated action.

- A Population Movement Hub to help coordinate public messaging.

- A Records Management Capability that enables agencies to address issues of data retention and management.

From February 27 to September 30, 2023, the VCC model deployment underwent operational evaluation. During this time, 354 Incident Models were launched either manually or by the system. Some of the key conclusions from this initial evaluation were that the VCC:

- Improved operators’ ability to get accurate information from other agencies.
• Delivered information that was highly trusted by operators.

• Encouraged operators to leverage information and resources from other agencies.

• Contributed to increased shared situational awareness.

• Has not significantly changed operator use of existing legacy systems.

• Reduced reliance on one-to-one phone calls.

• Encouraged operators to find VCC uses that were not the focus of initial design.

• Benefits of rapid incident clearance and congestion management will likely outweigh the costs of implementation.

Beyond the operational evaluation, several critical lessons and recommendations emerged from the overall project effort. These lessons and recommendations are especially relevant to future expansion and enhancement of the VCC or other VCC-like endeavors:

• Community-centered design is essential; this means that partnering and community building must precede technical development.

• Sharing a new operational environment will impact how people work together, but operators will not jump into a new concept of operations; operational changes must be built on the ways that agencies and operational roles currently interact.

• Managing multi-jurisdictional areas such as a state highway that also functions as a city street or ramps that connect city streets to interstate highways is a driving force behind VCC adoption and use.

• Community buy-in and time commitment is more significant than dollars. Any direction that lost engagement and buy-in of the operational community was too costly, no matter how seemingly beneficial or economical the effort.

• Expansion of VCC scope will require some modifications of interface and display features. A mobile VCC application and improvements to the system generated alerts are also desirable.

• The model deployment produced many community-generated ideas for future enhancements of VCC. These have been captured in an ideation log for future use.

• Now that a city-based, urban corridor VCC has been produced and evaluated, possible next steps would be a rural corridor VCC and an interstate corridor VCC.
1. Introduction

Eight and a half years before he was sworn in as the 19th U.S. Secretary of Transportation, the Mayor of South Bend, Indiana said,

In local government, it’s very clear to your customers – your citizens – whether or not you’re delivering. Either that pothole gets filled in or it doesn’t. The results are very much on display, and that creates a very healthy pressure to innovate.

– Pete Buttigieg, August 5, 2013

The project “Model Deployment of a Virtual Coordination Center for Multimodal Integrated Corridor Management” (VCC)\(^1\) stemmed from this healthy pressure to innovate, and it is perhaps not a coincidence that one of the more intensive VCC events during the project’s operational evaluation involved the urgent filling of a massive hole on a ramp from the West Seattle Bridge.

The healthy pressure to innovate that led to VCC stemmed from a series of incidents that made for brutal transportation experiences for Seattle area travelers. These incidents had unique complications that required coordination among agencies that went beyond their usual interactions – a 2015 fish truck rollover that shut down a highly traveled state route and ground citywide traffic to a halt; a 2015 collision on a bridge between a charter bus and an amphibious tourist vehicle that killed 5 and injured more than 60 travelers (Figure 1); a 2016 incident where a truck dumped dozens of boxes of crab, again bringing to a halt a major state route running through Seattle (Figure 2). These incidents fueled a desire for innovation, focused on enhanced collaboration. "I definitely believe there is room for systemic improvement," said then Seattle Police Chief Kathleen O'Toole. "We look forward to planning and training with our partner agencies to make sure we have the right tools and protocols in place in the future."

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\(^1\) The VCC acronym refers to both the project and the virtual collaborative environment itself.
Perhaps the most significant incident in terms of impact on the overall Seattle area transportation system was a 2017 multi-vehicle rollover collision involving a propane tanker truck. This incident certainly could have been far worse; gasoline was leaking, and the propane truck could have exploded but that fortunately did not occur (Figure 3). Still, the tanker rollover on the southbound Interstate 5 collector-distributor lanes resulted in the complete closure of I-5 and as well as many on- and off ramps (Figure 4). Clearing this incident required extreme caution due to the propane the truck was hauling. The incident occurred late in the morning after the peak commute but since it took crews eight hours to clear the truck and reopen the roadway the regional transportation system was gridlocked for most of the day, including the evening commute (Figure 5).
Figure 3 Propane Tanker Rollover, February 27, 2017. (WSDOT)

Figure 4 Map of propane tanker rollover and closed roads. (Mark Nowlin, The Seattle Times)
There was general agreement on the need to examine existing practices and explore innovative improvements to multi-agency management of major incidents. Beginning March 2017, Challenge Seattle\textsuperscript{2} brokered a series of initial meetings with relevant agencies, held at the University of Washington’s (UW) Center for Collaborative Systems for Security, Safety and Resilience (CoSSaR) and including the Washington State Department of Transportation (WSDOT), Washington State Patrol (WSP), King County Metro Transit (KCM), Seattle Department of Transportation (SDOT), Seattle Fire Department (SFD), and the Seattle Police Department (SPD). Participants determined that most detrimental impacts of recent events had resulted not from insufficient or ineffective efforts occurring at the incident sites – onsite responses were heroic and timely – but rather from interdependent stresses such as the shared impact on ramps that connect city streets to the Interstate. Interdependencies like these played out across the entire transportation system. The most promising areas identified for innovation involved improved collaborative management of these stresses. An initial project was launched, focused on enhancement of the interdependent activities of the complex community of agencies who managed the various components of Seattle’s regional I-5 corridor.

Between 2017 and 2020, representatives from these regional transportation agencies met to better understand and consider how to improve their collaborative efforts. An evolving vision emerged – a vision of a shared coordination center that would enable and enhance multi-agency management of the Seattle area transportation system. The VCC was seen as a desirable enhancement to regional mobility and safety and was supported by leadership from WSDOT, WSP, SDOT, SPD, SFD, KCM, and Sound Transit. In 2018, these agency leaders

\textsuperscript{2} A consortium of local private sector partners led by former Governor Christine Gregoire.
executed a charter establishing the Seattle Area Joint Operations Group (SAJOG), committing to work together to advance interagency collaboration and the VCC vision.

In addition to the major incidents mentioned earlier, there were other significant elements that contributed to this vision which became the VCC. Perhaps foremost of these elements was the rapid growth of cloud computing, which more than doubled during this period. A cloud-based environment and accompanying Infrastructure as a Service model could provide partner agencies with on-demand access to computing resources such as servers, storage, networking, and virtualization. Agencies did not need to acquire servers, run software, or manage data storage devices; their personnel would simply log in and access common capabilities and shared data.

Partners also recognized that integrated transportation management involves far more than technology – it is a complex socio-technical system of people, policies, practices, organizational structures and cultures, jurisdictions, missions, strategies, and, yes, technology. Cloud computing could make it easy to share data, but data governance and agreements were still necessary, and they could be far more complex to achieve than the technology. This was especially true since the partners were extremely diverse, including both law enforcement and non-law enforcement agencies, each with differing city, county, and state governments.

In 2020, WSDOT was awarded a Federal Highway Administration’s Advanced Transportation and Congestion Management Technologies Deployment award which has enabled the successful model deployment and evaluation of the VCC. COVID impacted this effort in both negative and positive ways. The face-to-face meetings that had been so essential to agency community building and collaborative visioning of VCC moved online. This made it more challenging to sustain the exciting synergy of face-to-face interagency design scrum sessions.

Figure 6 A pre-pandemic VCC interagency design session. (UW)
(see Figure 6). However, the shift to online interaction made it easier to include more people with less disruption to their busy schedules. More importantly, the shift to online interaction enforced the central vision of an online community collaborating within a virtual environment. The VCC was timely.

This report contains considerable information, analysis, and evaluation of the VCC itself; the agile, community-centered methods employed to design and develop it; and the use and impact of VCC during the model deployment period. This information is extremely valuable and especially applicable to potential future expansion or the initiation of similar projects in other cities and regions. The goal of VCC was to co-create a virtual collaborative environment that would become an ongoing, sustainable component of the region’s multimodal integrated corridor management. This has already happened. In April 2023, the state legislature provided funding for continuing operations of the VCC and to expand operations to up to five additional jurisdictions in King County. With this funding, the VCC is now a state program, managed by WSDOT.

Today, the Virtual Coordination Center is an evolving yet robust cloud-based system that enables multi-agency, multimodal, integrated corridor management. The VCC:

- Securely ingests data from multiple public and private sources into a common data lake\(^3\) for shared use with appropriate permissions, retention, and access;
- Enables real-time information flow to allow shared map-based situational awareness;
- Facilitates joint action in a virtual workspace to speed incident response, mitigate traffic impacts, and manage congestion both on a daily basis and, especially, during major incidents when interagency collaboration is especially critical;
- Provides actionable information and alerts to a trusted community of agency operators responsible for various aspects of regional mobility; and
- Enhances coordinated regional planning and operations through data analytics and predictive modeling.

The Project Team believes that the VCC demonstrates a new and innovative approach to collaborative, multimodal management of a regional transportation corridor.

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A data lake is a centralized repository that allows you to store all your structured and unstructured data at any scale. You can store your data as-is, without having to first structure the data, and run different types of analytics—from dashboards and visualizations to big data processing, real-time analytics, and machine learning to guide better decisions.
2. The Virtual Coordination Center (VCC)

Chapter 2 describes the VCC as of December 2023. In addition to the scope and capabilities of the virtual environment, this chapter includes lessons learned during the design and development of this groundbreaking regional initiative. Evaluation of the current implementation is in Chapter 3, and lessons learned and recommendations for the future appear in Chapter 4.

2.1 The Current Implementation of the VCC

The VCC is not a fixed tool; it is a flexible, evolving operational environment that houses capabilities and information that supports multimodal integrated corridor management. The VCC described below is the state of this evolving environment after operational evaluation of the model deployment and transition from a model deployment to a permanent program.

2.1.1 Scope of the VCC

The VCC enhances integrated mobility management along the I-5 corridor of the greater Seattle area as shown in Figure 7. The VCC provides value on a daily basis but is especially geared towards providing infrastructure for more intense collaboration and coordination during major incidents. The primary goal is to support the management of complex situations that put stress on the Seattle-area transportation system and that call for interagency collaboration beyond that usually required. Agencies engaged in addressing these diverse and dynamic circumstances use the VCC to enhance their existing processes for collaborative operations and communication.

The VCC operational environment is scoped around three interdependent functional components of transportation management, each of which has related features and capabilities described in this chapter:

1. Shared Situational Awareness: Shared situational awareness is key to coordinated operations. VCC partner agencies have well-defined internal processes and organizational structures for tracking evolving situations. The processes for achieving shared situational awareness among multiple agencies, however, have been less clearly defined. During a major incident that requires coordination among two or more agencies, regional transportation managers now use VCC to access and track relevant computer-aided dispatch (CAD) events from all participating agencies, inform partner agencies of their evolving perspectives and actions on the situation, and share status updates. This shared awareness enhances the collective ability of agency operators to define and coordinate strategies to address the situation.
2. Traffic Incident Management and Congestion Management: The traffic incident and congestion management components of VCC support regional deployment of coordinated response and traffic/transit management plans, in order to improve safety, clear roadways more quickly, guide first responders to incident sites more efficiently, and ensure regional mobility. VCC traffic incident and congestion management features enable agency operators to share their plans and coordinate their actions as they are taken to alleviate congestion.

3. Population Movement: The population movement component supports secure, trusted interagency communication on public messaging. By assisting public information officers in the development and coordination of timely and unified messaging about mobility...
disruptions and the status of recommended solutions, the VCC supports agency personnel responsible for helping to make travelers part of the solution, rather than the problem.

2.1.2 VCC Roles and Permissions

A key component of VCC interagency operational practices are the user roles and permissions built into the VCC environment. These roles and permissions were worked out in design sessions with agency operational leaders. The current defined roles and permissions are outlined below in Table 1.

Table 1. Roles and Permissions.

<table>
<thead>
<tr>
<th>Roles</th>
<th>Permissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic User</td>
<td>Provides view only access to the VCC. All users receive the basic user permission, but this is primarily geared towards higher-level management and executives informed.</td>
</tr>
<tr>
<td>Incident Contributor</td>
<td>Allows users to add notes to Incident Models and pin dispatch events to their private view of the Dispatch Feed. Primarily for operational personnel with selected views of an incident, but not the big picture.</td>
</tr>
<tr>
<td>Incident Manager</td>
<td>Allows users to create, edit, close incidents, annotate Incident Model Situation Maps, and create and edit Mobility Strategies. Allows users to view and re-open closed incidents, but not deleted incidents. If a user is set as an Incident Manager, they should also be set as an Incident Contributor. Primarily for operational managers with a big picture of an incident.</td>
</tr>
<tr>
<td>Incident Records Manager</td>
<td>Allows users to view the Incident Model Records Management page. Primarily for Incident Managers who view and finalize records reports.</td>
</tr>
<tr>
<td>Public Information Officer</td>
<td>Allows users to create, edit, and close Scheduled Outreaches and Talking Points in the Public Information Hub. Primarily for PIOs and other personnel with public information responsibilities.</td>
</tr>
<tr>
<td>Site Administrator</td>
<td>Allows users to view the Admin page, add, remove, or edit any VCC users, and update user roles.</td>
</tr>
</tbody>
</table>

2.1.3 Shared Situational Awareness

The VCC Dashboard (Figure 8) has several features that contribute to shared situational awareness of the VCC user community.
2.1.3.1 The Integrated Dispatch Feed

The Integrated Dispatch Feed provides a running account of dispatch events from five sources: three computer-aided dispatch (CAD) systems (SFD, SDP, and WSP), operational dispatches from the King County Transit Control Center (TCC), and information from the WSDOT Transportation Management Center (TMC) Log delivered as an augmentation of the associated WSP CAD dispatch. A “Recent Dispatch Events” view of the Integrated Dispatch Feed is visible within the VCC Dashboard represented in the middle column of Figure 8, and a full-screen version is available via a link. The Integrated Dispatch Feed provides a link to the dispatch event on the accompanying Situation Map (2.1.3.2), the event number (an ID generated by the originating agency), time of last update, originating agency, event type, event location, and associated Incident Model (2.1.4.1), if applicable.

By selecting the event number, users can view more detailed information associated with each dispatch event (e.g., active response vehicles on scene) via a popup modal window (Figure 9).

Figure 8. The VCC Dashboard.

Left is the Situation Map, the center panel is a view of the Integrated Dispatch Feed, and the right panel has Active VCC Incidents. The green box represents redacted information and does not appear on the user’s screen.
Figure 9. Event Information modal for a dispatch event. The green boxes represent redacted information and do not appear on the user’s screen.

By default, events are pulled directly from the originating agency’s feed every 30 seconds. The feed can also be manually updated by users, which may be useful during rapidly evolving situations.

The Integrated Dispatch Feed is designed to be comprehensive and near real time, allowing users to stay aware of a wide variety of current response activities happening within the Seattle I-5 corridor. If a user wants to keep an eye on a specific dispatch that they are not yet ready to bring to the attention of others by creating an Incident Model (2.1.4), they can pin that dispatch to the top of their Integrated Dispatch Feed (Figure 10).

A dispatch event can be selected and pinned, putting that dispatch of interest in the upper portion of the Integrated Dispatch Feed, separated from the other dispatches. These pinned dispatches remain in the upper portion, highlighted yellow for visibility, until they are unpinned by the user who pinned them, or the event is closed. A user’s pinned dispatches section displays only those dispatch records that the user has pinned in both the Integrated Dispatch Feed and the Dashboard. The yellow box in Figure 10 represents the pinned dispatches section.
However, in addition to providing a quick way of bookmarking interesting dispatch events for an individual user to track, the pin feature also contributes to shared situational awareness. Any user can switch from View All to View Noteworthy in the upper left of the screen. Noteworthy shows only those dispatches that have been pinned by other users or used to launch an Incident Model (2.1.4.1).

Another feature of the Integrated Dispatch Feed is that it integrates valuable WSDOT information from the Transportation Management Center (TMC), even though WSDOT does not have a unique dispatch system. This information, known as the TMC Log, provides unique, valuable comments that are matched with a WSP dispatch record. WSP dispatches that have a corresponding TMC Log record display that record, with potentially personally identifiable information redacted, under More Information in the Event Information modal.

2.1.3.2 The Situation Map

The Situation Map (Figure 11) provides different layers of data overlaid on a map. Many of the map layers are linked to information in the dispatch feed and the Incident Model. For example, selecting the map icon on the event in the Integrated Dispatch Feed will zoom the map to the location of the incident. The VCC pulls in data from partner agencies and displays them on the map. The current set of data layered onto the map includes agency traffic cameras, INRIX Construction Data, and Mapbox Traffic Data.
The map shows all active dispatch events as well as active VCC-level incidents (see 2.1.4.1). Dispatch Events and VCC-level incidents appear on the map at coordinates provided in the Integrated Dispatch Feed or derived from descriptive information in dispatches or Incident Models. In combination with an Incident Model, the Situation Map can be used to identify relevant conditions and dispatch events in the area surrounding a VCC-level incident. Additional future layers might show agency construction closures, WSDOT Incident Response Team (IRT) and SDOT Response Team (SRT) locations, tow trucks, non-roadway transportation systems such as ferry and rail traffic, and, when needed, a power outage map layer from local utility companies.

2.1.3.3 Incident Model Summaries

A final element of the VCC Dashboard is a column that displays summaries of any currently active Incident Models (see right-hand column of Figure 8). An active Incident Model indicates an ongoing situation that either a user or the system has determined is worth bringing to the
attention of all other VCC users. Active Incident Models also appear on the Dashboard Situation Map as red pins (Figure 11).

Together, the Integrated Dispatch Feed, Situation Map, and Incident Models (described below) enhance shared situational awareness across agencies and roles. This shared awareness is the foundation for collaborative, coordinated action.

2.1.4 Collaborative Incident and Congestion Management

The VCC offers several key features that help break down operational silos and support collaborative action to better manage serious incidents and severe congestion. During incidents and situations that require close coordination among two or more agencies, regional transportation managers use the VCC to share information management, strategies, and actions that enhance their collective ability to understand and address the evolving situation. These features are not designed to replace existing agency operational processes, but rather to enhance, leverage, and integrate them. Most importantly, the information within the VCC is instantly shared with a broader range of operators and managers than current agency systems reach. Following is a brief overview of the Incident Model and Mobility Strategies features.

2.1.4.1 The Incident Model

A VCC-level incident is a transportation situation that may require enhanced collaboration across agencies and roles to address. The existence of a VCC-level incident is indicated by the initiation of an Incident Model, which sends an email alert to all users with a link to the Incident Model in the VCC. An Incident Model can originate in one of three ways:

- A user with permission to launch an Incident Model uses one or more dispatches in the Integrated Dispatch Feed to launch an Incident Model with pre-populated data from those dispatches. Because evaluating a situation as a VCC-level incident sends a strong signal to all VCC users, the ability to initiate Incident Models has only been assigned to an informed subset of VCC users, such as operators in the operations centers.

- An authorized user is aware of a situation that triggers them to launch an Incident Model without pre-populated data from the dispatch feed.

- An Incident Model is automatically generated by the VCC Rules Engine, which was developed with the stakeholder community. (For more information with an eye towards future enhancements, see Appendix G. Enhancing System-generated Incident Models and Alerts.) System-generated Incident Models start with a Status of “Open” and are verified by someone with authority to do so. An Incident Model is created according to the following rules:
  - Events from Seattle Fire Department that Include “Tunnel MVI”, “Car Fire Freeway”, or “Fire Response Freeway” in event type
- Events from Washington State Patrol in Area “I5” that Include “Road Closure”, “Fatal Traffic Collision”, “Disabled Vehicle Fire”, or “Possible suicidal pedestrian on bridge or overpass” in event type
- Events that include “bridge” in location and “blocking” in event type

The Incident Model captures information from associated dispatches (if applicable) and allows VCC users to manually input additional information, such as estimated clearance times and incident notes, as the situation evolves. In this way, the Incident Model becomes a shared digital space for the pooling of evolving interagency knowledge.

Some of the key components of an Incident Model are:

- **Pre-populated information:** When a user creates a VCC incident from one or more dispatch events, or when the rules engine creates a system-generated incident, some information from the pertinent dispatch events is automatically inserted into the newly created VCC incident, such as location and incident type. These values in the Incident Model can be modified by authorized users, without any impact on the originating dispatch record.

- **Contributing Factors:** Based on extensive user feedback and guidance, the Project Team identified several factors that, if they apply to an incident, tend to exacerbate incident severity, duration, and/or the need for interagency collaboration. These factors are Crime, Hazardous Materials, Fire, Fatality, Rollover (that is, one or more vehicles have rolled over), and Commercial Vehicle. Users who can edit Incident Models can select any or all of these factors where they appear prominently near the top of the Incident Model details page. When selected, these factors appear in blue for visibility.

- **Details:** There are four tabs across the top of the Incident Model: (1) Details, (2) Notes, (3) Mobility Strategies (2.1.4.2), and (4) Public Information Hub (2.1.5.1). The Details page is the default view of an Incident Model. It provides fields for an overview of key information including location, lane impacts, incident type and details, incident commander, lead agency, lead PIO, estimated clearance time, other response details, and an overview and quick access to associated dispatch events. Some of these fields are pre-populated from dispatch events; all can be entered or revised by users with appropriate permissions.

- **Notes:** The Notes page allows users to add pertinent, free-form incident information that does not easily fit into the detail fields. In practice, this enables a more fluid conversational communication across agencies during incidents. Users with the appropriate permissions can add text-based notes and/or upload image files.

- **Map Annotations:** Like the Dashboard, each Incident Model has a Situation Map on the left of the screen. The Incident Model Situation Map has the same information as the Dashboard Situation Map, plus specific map pins for the location of the VCC incident.
plus any dispatch event associated with the incident. Most importantly, the Incident Model Situation Map provides an "Annotate Map" tool. Using this tool, visual information specific to the incident, such as detour routes and an operational perimeter, can be drawn on the map. These map annotations are visible to anyone viewing the Incident Model but can only be added or removed by users with the Incident Manager role.

- Incident Status and Closing: At the top of an Incident Model is a status field which indicates the progress of resolving the VCC-level incident through multiple states until it is closed. When an authorized user deems the incident's work to be completed, road conditions to have sufficiently stabilized, and all responders have either left the scene or moved vehicles and debris off to the shoulder such that traffic is no longer blocked, they can close the Incident Model by setting the status field to “Closed.” This disables editing of the Incident Model and removes it from the Active VCC Incidents card on the VCC Dashboard. After an Incident Model is closed, it can be temporarily viewed in the Records Management page by users with the Records Manager role.

2.1.4.2 Mobility Strategies

The Mobility Strategies tab of an Incident Model supports interagency, collaborative work of users engaged in congestion management. Users with the Incident Manager role can indicate their use of various strategies, such as managing traffic flow via ramp metering or signal timing, bringing special equipment to the scene, or posting messages on electronic roadway signs. Users can add a strategy in the Create Mobility Strategy modal (Figure 12) and share a mobility strategy being employed during an incident. Users can also indicate others as collaborators on their actions, automatically sending a notification to any collaborator who has been added.

![Create Mobility Strategy modal](image)

*Figure 12. Create Mobility Strategy modal.*
2.1.5 Population Movement

The Incident Model includes a Public Information Hub tab that supports coordinated messaging and public information engagements across the partner agencies.

2.1.5.1 The Public Information Hub

The Public Information Hub is a dedicated space within each Incident Model for use by Public Information Officers (PIOs) and other individuals responsible for communicating with the public. Two types of information are shared within the Public Information Hub: (1) coordinated outreach events and (2) shared approved talking points. The goal of the Public Information Hub is coordinated messaging across participating agencies. All users can view the Hub, but only those with the Public Information Officer role can add and edit information.

![Figure 13. The Public Information Hub with one Scheduled Outreach and one Talking Point.](image)

Figure 13 shows:

- The Scheduled Outreach information box which can be used to help coordinate meetings, debriefs, press releases, executive briefings, or other types of public information events associated with a VCC incident. In this space, users share details about their planned outreach opportunities.

- The Approved Talking Points information box which helps agencies share and coordinate messages and talking points regarding the associated VCC Incident. The goal is to align partner agencies and create a unified public message.
2.1.6 Security and the VCC Trusted Community

The VCC supports a trusted community of agency personnel. Users must be granted access by their agency. The VCC user community needs both to trust each other and to trust the technology they are using to share information and conduct community operations. For this reason, the VCC has a number of layers of security.

The VCC is built on Amazon Web Services (AWS) using AWS managed services. AWS is architected to be a secure global cloud infrastructure on which to build, migrate, and manage applications and workloads. Using a cloud-based infrastructure allows the project team to focus on creating operational value for the transportation community, leaving AWS responsible for maintaining the functioning of the VCC. The cloud-based infrastructure also assures that public agency partners have a mechanism for equal access to VCC data and capabilities. Infrastructure as a Service is a cloud computing model that provides on-demand access to computing resources such as servers, storage, networking, and virtualization. Individual agencies do not have to acquire equipment or worry about compatibility. Access and security are managed centrally and equally and easily distributed.

The VCC is a secure web application. Access to the VCC occurs through SecureAccess Washington (SAW), a central login that provides multi-factor, password protected access to the online services of multiple Washington state agencies (Figure 14). VCC users must create a SAW account using the email address associated with their VCC account, and sign into the VCC by first signing in to SAW. This helps administrators avoid the challenges of VCC passwords being lost or stolen. SAW’s multi-factor authentication ensures an extra level of security for VCC accounts.

![Figure 14. The login screen for SecureAccess Washington.](image)
The VCC environment securely integrates independent data from partner agencies in support of collaborative awareness and operations. The VCC is not meant to replace existing agency partners’ systems; partners decide how the VCC fits into their existing systems and processes.

While the VCC's interface and data are built with secure technology, the VCC trusted community is not built upon a purely technical system. Equally if not more important as the technical security services are the guidelines and operational principles by which these services are used. The project team continually works with and guides the user community in discussion and implementation of how the various agencies want to work together, both within the virtual environment and in operational practice.

### 2.1.7 Records Management

During the process of creating and working VCC incidents, users generate valuable data and correlate existing data. However, the VCC as a shared, collaborative operational system is not intended to permanently retain this data. Therefore, issues of data retention and management had to be considered in the light of shared creation, use, and ownership of VCC data across several agencies. In particular, Washington state’s public disclosure laws require that all public records maintained by state and local agencies be made available to all members of the public, with very narrow statutory exemptions. Each agency has different policies and processes for data retention and management that they must follow.

To address these challenges and comply with state public records laws and agency policies, the Project Team created an interface for finalizing VCC incident records after work on them had concluded. After a VCC Incident Model is closed, an Excel spreadsheet containing a report of incident activities (e.g., field value updates and text notes) is generated automatically. This report is available for inspection in a page within the VCC only accessible to those users with the Incident Records Manager role. Once a Records Manager has verified the report is complete and correct, they click a button to finalize the incident record. If the report is not finalized within 96 hours, it is automatically finalized.

Upon finalization, the generated report and any images uploaded to the Incident Model is emailed out to each agency. This allows each agency to retain and classify VCC incident data according to their own policies and procedures. Thirty days after finalization, the VCC Incident Model and its report are deleted from the VCC's backend systems.

### 2.1.8 User Administration

The User Administrator page on the VCC is where individuals with the Site Administrator role can manage the users from their agency. Each agency is responsible for deciding which roles to give to each of their users and each agency is responsible for designating at least one person to be their agency’s Site Administrator. Site Administrators can add a new user, edit an existing user, and change a user's access within and to the VCC.
Site Administrators are not System Administrators who can make changes to the overall VCC system. Site administrators are only responsible for editing user information, not making structural or technical changes to the VCC. System Administrators are those who can view and edit the code and other structural elements of the VCC directly. When the VCC was in development, Pariveda provided system administration services. Now that VCC has transitioned to a State program, WSDOT Technology Services Division manages the system administration of the VCC.

2.2 Lessons Learned from Design and Development

Prior to the evaluation, the project team learned much about designing and developing a collaborative environment that enables multimodal integrated corridor management. There were especially vital lessons on how to successfully accommodate the diverse operational and organizational needs of the many agencies who manage and maintain a regional transportation system. This chapter describes key lessons learned during VCC design and development; lessons that should be useful to others planning a similar initiative. Chapters 3 and 4 describe results, conclusions, and lessons from the evaluation, as well as recommendations for moving the current implementation of VCC forward into the future.

2.2.1 Employ Community-Centered Design Methodologies

It was clear from the outset that VCC could not take a one size fits all approach. VCC agencies share overlapping goals, but they are motivated by unique missions, cover different jurisdictions, follow agency-specific policies, work within specialized organizational structures, and develop individual agency cultures. The VCC brings together agencies that are law enforcement and non-law enforcement, some with transportation focuses and others with missions whose scope goes well beyond transportation, and all housed within diverse city, county, state, and multi-county governmental structures. Each agency brings something to the table, and each must have ownership and agency in how they participate.

Some agencies have strong natural connections, but even where this is the case there are still key differences. WSP and SPD are both law enforcement agencies, yet different in mission and jurisdiction. WSDOT and SDOT are both transportation departments but with significant differences in jurisdiction and organizational home. KCM and Sound Transit are transit agencies with different operational focuses and jurisdictions. SFD is a city agency with a primary mission (save lives, protect property, provide emergency medical services) that is much larger than transportation, yet is a critical component of many transportation incidents. No outside organization or single agency could articulate and enforce a common solution for all these partners, let alone future additional partner agencies.

Over the years of working with partner agencies, the project team established processes and structures that give active ownership of design and development processes to the entire VCC community. See Appendix A for details on Project Management and Governance. Empowering and facilitating a diverse group of operational agencies in a community-centered design and
development effort is no trivial task, but there are many reasons for doing this. First is the strong connection between collaborative design and development and collaborative use and operations. It is fine to bring together diverse stakeholders to discuss integrated corridor management, but is far better to bring them together to collaboratively design shared tools, processes, and information resources that fit into their existing workflow; then implement, deliver initial versions of the new tools, and collaboratively use, evaluate, and refine these capabilities and resources. During this process of collaborative, iterative design and development, discussion is sharpened by the community’s knowledge that their vision is being realized and returned to them in a tangible form. Trust is built by their shared experience of co-evolving usable, impactful operational enhancements. Adoption is promoted through the sense of ownership and responsiveness to individual agency needs. For more on the handling of VCC adoption, training, and user support issues, see Appendix C. VCC User Adoption, Training, and Support.

For example, one of the first things the community asked for was a single place where they could see all the dispatches from the various agency dispatch systems. This shared community desire led to the Integrated Dispatch Feed which became the centerpiece of the VCC Dashboard (see 2.1.3.1), but not before a series of collaborative interactions with the community finalized the design and promoted shared adoption of this feature. Some of these interactions were technical and definitional. The data streams had to be obtained and maintained, and data given sufficient uniformity for a useful, common display. Others were policy driven; agency policy differences had to be identified and accommodated, such as SPD’s requirement that the location of their responding vehicles not be shared. Through iterative use, feedback, and refinement, features like the Integrated Dispatch Feed were evolved by the community to meet both shared needs and individual agency constraints.

2.2.2 Employing Agile Development Methodologies

Closely connected to community-centered design is the use of agile design processes, segmenting the project into stages and incorporating user feedback and other new learnings at each stage. (See Appendix B. VCC Systems Engineering Approach and Agile Methodologies.)
Agile development provided the community with ongoing opportunities to influence and adjust the design and development of the VCC (see Figure 15 above). Rather than articulate a finished product and build the pieces of that product, agile development’s initial goal was the development of a minimum viable product (MVP). The goal of an MVP is to be in the position to learn as much from the user community as possible, not to design the final product that the community will use. MVP was achieved when a version of the VCC had enough features to be usable by early customers, who then provided feedback for ongoing product development. As the product evolved, so did the partner agencies’ shared sense of ownership and trust that their perspectives would be represented and respected.

Using agile methodologies also had a significant impact on the nature and use of the Concept of Operations document, as described in Appendix E. Use of an Agile Concept of Operations.

While agile methodologies created an environment where design and development danced together towards a shared viable product, there were still practicalities associated with establishing a sustainable state-funded program that needed to be addressed. As agile development cycles approached initial product status (i.e., the operational model deployment that would be evaluated), two key milestones were: (1) transition of technical management from the project team’s sub-contractor, Pariveda, to WSDOT; and (2) transition of the day-to-day
operations of the VCC from the project team to the WSDOT program team. For information on the handling of these transitions, see Appendix D.

2.2.3 Build on Existing Operational Relationships and Partnerships

While VCC is a groundbreaking approach to integrated corridor management, it still must be built upon existing relationships and partnerships that extend beyond agency boundaries. In some cases, these partnerships stem from having similar geographic jurisdiction, such as between state agencies like WSP and WSDOT, and among city agencies like SFD, SPD, and SPD. While these organizational partnerships are significant, the team found that operational roles and relationships provided the strongest basis for cutting across agency boundaries and developing strong collaborative connections. Three operational roles became the backbone of VCC community-centered design: (1) responders, (2) congestion managers, and (3) public information officers, or population movers. Collaboration within these three communities relies not so much on organizational structures, but rather on active relationships and processes built and maintained during daily operations. These operations are supported by the VCC.

Responders meet at the incident site and together take heroic action to save lives, clear obstructions, and return the system to normal functioning. From a VCC perspective, incident responders are as much potential information sources as information users. Responders can use the VCC to become aware of an incident and to help identify the best routes to the scene, but once they arrive on-scene, they become aware of information that could be of significant use to others who are not on the scene. Generally, responders are too busy with urgent response activities to also be sources of information for the community, but the VCC can alter that equation, or at least make it easier to share information once pressing needs are met.

The activities of congestion managers revolve largely around traffic and transit management centers. In the Seattle area, the city’s Transportation Operations Center (TOC) and WSDOT’s Transportation Management Center (TMC) became natural hubs of VCC use and application. While these two centers had previous collaborative activity, they lacked a common platform for leveraging this activity and extending it to other users outside the centers. VCC provided this and shared useful operational information that was either new to the VCC (e.g., running notes under the Incident Model Notes tab) or had previously been unavailable (e.g., the TMC log). Through the VCC, a partnership previously based largely on phone calls made during major incidents was extended to a shared virtual environment that could be accessed and added to in real time.

The population movement community (largely Public Information Officers) came to the VCC as the most connected interagency group. This group had already developed a shared concept of operations which the VCC attempted to build upon. Given this existing relationship, the Public Information Hub was envisioned as a place where up-to-date information on what was being said and who it was being said to was available. This not only helps align messaging and activities across agencies, but also allows administrators and the other operational communities to see what information is being shared with the public and provide input as necessary.
By building on existing operational relationships, the VCC both increases collaboration within those communities and across all operational communities.

2.2.4 Build Trust

The VCC is designed to support a secure, trusted community of transportation-related agencies and personnel. There is no access outside the agencies and operational groups that make up this community. The goal is an openness of information and operations across all VCC users. In practice, trust building is an ongoing activity that cannot be achieved all at once.

In general, the VCC has been highly successful at achieving a level of trust that supports a common presentation of relevant shared operational information. Where there are constraints on information sharing, they come from differences in agency mission and scope. City law enforcement in particular was reluctant to share response information such as the type and location of responding vehicles. This reluctance stemmed from both security and privacy concerns in the context of a mission that extends beyond transportation.

Ongoing use of the VCC should include a focus on building trust through a “one team” approach to complex transportation issues. This does not require one cookie cutter solution; through the VCC design process, agency partners have developed sensitivity to the issues and situations where constraints like those desired by a law enforcement agency make sense and should be accommodated. Perhaps most important is building the trust that when a major regional disaster occurs such as the June 2023 I-95 collapse in Pennsylvania or the November 2023 massive freeway fire on I-10 in Los Angeles, these constraints will no longer apply and the VCC will provide a critical component of regional resiliency.

2.2.5 Managing Major Incidents and Providing Daily Value

The major disasters such as those in Philadelphia and Los Angeles are a central motivation for developing VCC-like infrastructures throughout the nation, but this does not mean that the VCC can simply be kept in reserve and employed by the operational community when these rare major and extremely complex situations arise. A virtual collaborative environment must be integrated into the daily work of the community. Employing an interagency operational environment is a complex undertaking. A community of agency transportation managers and operators cannot simply pick up a collaborative environment at will, and they will certainly not turn to a new system at a time when there is the greatest stress on the transportation facilities that they are responsible for.

It is necessary, therefore, that the VCC provides daily value; value that increases as the complexity of incidents being addressed increases. This is one reason for centering the VCC around a useful feature like the Integrated Dispatch Feed. Even when there are no active Incident Models, the VCC provides an overview of regional dispatch events and access to details about those events. One outcome of the community-centered design and development
activities was the lesson that the VCC had to combine its support for managing rare major incidents with capabilities that were useful on a daily basis.

This chapter has emphasized the importance of taking a community-centered approach to the design and development of VCC-like systems for achieving multimodal integrated corridor management. Section 6004 of the Fixing America’s Surface Transportation (FAST) Act "establish[es] an advanced transportation and congestion management technologies deployment initiative to... develop model deployment sites for large scale installation and operation of advanced transportation technologies to improve safety, efficiency, system performance, and infrastructure return on investment." The introduction of advanced transportation technologies like VCC is an intervention into a complex regional socio-technical system owned by a diverse community with overlapping missions. Only this community can successfully implement such technology.

Effective regional transportation system management is achieved through the interactions of people, organizations, missions, policies, procedures, and technologies. With so many interdependent components, a shared, foundational intervention like the VCC can be extremely challenging to effectively manage and successfully complete. VCC is a virtual collaborative environment, owned and operated by the operational community, which empowers this community to articulate how it wants to work and coordinate those operations, especially during times of stress when collaboration is key. Community-centered design and development is the key to achieving this goal.
3. Evaluation

3.1 The Evaluation Plan

An evaluation of the VCC was conducted to assess the impacts of the VCC by measuring progress towards the goals and expectations detailed in the grant application, and to assess the users’ acceptance of and experience with the VCC. A benefit-cost analysis was also performed to provide decision-makers with return-on-investment information to inform future investments and guide future deployments.

In September 2020, the VCC Evaluation Team conducted a literature review of other demonstration and Intelligent Transportation System projects. The team reviewed the “Evaluation Methods and Techniques: Advanced Transportation and Congestion Management 2019” report provided by FHWA and consulted with VCC’s expert stakeholders to prepare a first draft of the VCC Evaluation Plan. This first draft was delivered to the team at the John A. Volpe National Transportation Systems Center (Volpe) in support of FHWA on December 18, 2020. Following a review by Volpe, a meeting was held to get additional guidance on the Plan and a second draft was delivered on January 26, 2021, incorporating this guidance. Driven by the VCC’s agile development process, several modifications to the Plan were made under the guidance of Volpe and the fourth and final version was delivered and approved by FHWA on February 2, 2023, prior to the official post-deployment date of February 27, 2023.

3.2 The Evaluation Team

In December 2020, an evaluation team was assembled to execute the evaluation plan. The evaluation team included:

- Sonia Savelli, Senior Research Scientist at the University of Washington, was appointed as the Evaluation workstream lead in September 2020. As lead, she oversaw all aspects of the survey and interview designs, data collection, and analyses.
- Hannah Webster Heublein, from the University of Washington, joined the team in January 2021 to lead the qualitative evaluation activities, such as designing the surveys and the semi-structured interviews.
- Jeffrey Connor, Data Analytics Supervisor (SDOT); David Baker, Northwest Region ITS Operations Engineer (WSDOT); John Lee, Transit Control Center Chief (KCM) were the data experts identified by the Steering Committee in April 2021, and provided quantitative baseline data from their respective agencies.
- Ridley Jones LeDoux, a PhD student from the University of Washington, joined the team in January 2022 to assist with the development of surveys and interview questions and data collection.
• Bianca Johnson, a University of Washington Masters student, also joined the team in April 2021 to assist with quantitative and qualitative activities design activities.

• Donghoon Lee, a Fulbright Scholar and PhD student from the University of Washington began the benefit-cost analysis in April 2022 under the supervision of Layla Booshehri, Clinical Assistant Professor, Health Systems and Population Health, and Jerome A Dugan, Affiliate Assistant Professor, Daniel J. Evans School of Public Policy and Governance.

• Andrea Figueroa, a PhD student from the University of Washington, joined in June 2023 to conduct the analyses on the VCC user analytics and to assist with the quantitative analyses.

• Mishti Dhawan, an undergraduate student from the University of Washington, joined the team in June 2023 to assist with the analysis of the survey data and data collection during Phase 2 interviews.

3.3 Evaluation Timeline

The VCC Evaluation was a post-implementation evaluation to assess the outcomes and impacts of the VCC, with baseline measures collected prior to the February 27, 2023, model deployment date. Post-implementation measures were collected during three separate intervals between February 27, 2023 and ending September 30, 2023. This timing allowed the team to make comparisons to baseline performance in three separate periods, allowing measurement of any incremental improvements as users became more familiar with the VCC. The timing of the three phases was:

• February 27 - May 5, 2023
• May 6 - July 14, 2023
• July 15 - September 30, 2023

3.4 Evaluation Participants

Table 2 below summarizes the number of participants in the surveys and interviews during the various stages of the evaluation phase. Participants were from the following agencies: Seattle Department of Transportation, Washington State Department of Transportation, King County Metro, Sound Transit, Washington State Patrol, and Seattle Police Department. The participants represented a variety of roles within Congestion Management, Incident Response, Population Movement, and Executive roles. The Steering Committee identified personnel from their agencies who would be users of the VCC once it was ready to be deployed, and these users were asked to complete the baseline survey. Users received the post-deployment surveys if they had activated their VCC login. As not all users activated their VCC accounts at the same time, this led to the varying number of survey participants asked to complete the post-deployment evaluation survey as seen in Table 2.
Observations were also conducted with personnel who were available during observation periods from WSDOT TMC, SDOT TOC, KCM TCC, WSDOT Incident Response Team, and SDOT Seattle Response Team. Details regarding these participants are provided in 3.6.1 and 3.7.

Table 2. Evaluation Collection Methods and Participants.

<table>
<thead>
<tr>
<th>Evaluation Phase and Timeline</th>
<th>Collection Method</th>
<th>Number of Participants Requested</th>
<th>Final Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline: November 2, 2020 – February 26, 2023</td>
<td>Survey</td>
<td>152</td>
<td>120</td>
</tr>
<tr>
<td>Baseline: November 2, 2020 – February 26, 2023</td>
<td>Interviews</td>
<td>21</td>
<td>17</td>
</tr>
<tr>
<td>Phase 1: February 27, 2023 - May 5, 2023</td>
<td>Survey</td>
<td>51</td>
<td>28</td>
</tr>
<tr>
<td>Phase 2: May 6, 2023 - July 14, 2023</td>
<td>Survey</td>
<td>136</td>
<td>41</td>
</tr>
<tr>
<td>Phase 2: May 6, 2023 - July 14, 2023</td>
<td>Interviews</td>
<td>43</td>
<td>34</td>
</tr>
<tr>
<td>Phase 3: July 15, 2023 – September 30, 2023</td>
<td>Survey</td>
<td>137</td>
<td>41</td>
</tr>
</tbody>
</table>

3.5 Model Deployment Incident Models

During the model deployment period from February 27, 2023 to September 30, 2023, there were 354 Incident Models launched either automatically by the VCC or manually by a VCC user, an average of about five Incident Models every three days. Fifty-two (15%) of these Incident Models were “deleted” by a VCC user, indicating that they did not consider it to be sufficiently severe to be a VCC-level incident and therefore should not have been launched. Of these 52 deleted incident models, 23 (44%) were generated by the system, while 29 (46%) were launched by a VCC user in error. See 3.7.2.2 and Appendix G for a discussion of the user generated incident models, rules engine generated incident models, and recommendations for rules engine improvements. The remaining 302 were “closed” by a VCC user, indicating that these were considered valid VCC-level incidents that had been resolved.

Of the 302 Incident Models that were considered valid, 85 (28.15%) were launched automatically by the VCC, 197 (65.23%) were launched by a WSDOT VCC user, and the remaining 20 (6.62%) were launched by an SDOT VCC user. These 302 Incident Models were concentrated along the I-5 corridor as shown in Figure 16 below, and only these closed Incident Models are included in the analyses that follows.
While the average duration of these 302 incidents was five hours and 22 minutes, with a median duration of one hour and 36 minutes, these incidents were not as severe or complex as the rollover tanker truck described in the Introduction. Contributing to these longer durations was that Incident Models may not have been closed immediately upon the clearance of an incident as VCC users may have been occupied with other tasks. As such, *Incident Model Duration* is not a true measure of an incident's severity. Furthermore, VCC users created Incident Models for types of incidents that had much longer *Incident Model Durations* (see Table 3). While the team did not anticipate that the VCC would be used for these types of incidents while developing the Evaluation plan, VCC users found it helpful to add these planned types of incidents to the VCC to alert other agencies that the roadways would be impacted for a prolonged period so that they could make necessary accommodations. This lack of complex incidents made it challenging to measure some of the evaluation goals and objectives included in the evaluation plan, which are further discussed in this chapter.

*Table 3. Average and Median Durations of Closed Incident Models during the post-deployment period.*

<table>
<thead>
<tr>
<th>Incident Type</th>
<th>Number of Incident Models</th>
<th>Average Duration</th>
<th>Median Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flammable Cargo Restriction</td>
<td>11</td>
<td>10 hours 23 minutes</td>
<td>5 hours 32 minutes</td>
</tr>
<tr>
<td>Maintenance Closure</td>
<td>19</td>
<td>15 hours 12 minutes</td>
<td>3 hours 57 minutes</td>
</tr>
<tr>
<td>Traffic Hazard Blocking Roadway</td>
<td>37</td>
<td>5 hours 24 minutes</td>
<td>2 hours 0 minutes</td>
</tr>
<tr>
<td>Fire Response</td>
<td>78</td>
<td>6 hours 9 minutes</td>
<td>1 hours 56 minutes</td>
</tr>
<tr>
<td>Collision</td>
<td>142</td>
<td>3 hours 39 minutes</td>
<td>1 hours 22 minutes</td>
</tr>
<tr>
<td>Other</td>
<td>15</td>
<td>1 hour 53 minutes</td>
<td>1 hours 22 minutes</td>
</tr>
<tr>
<td>TOTAL</td>
<td>302</td>
<td>5 hours 22 minutes</td>
<td>1 hours 36 minutes</td>
</tr>
</tbody>
</table>
3.6 Baseline Evaluation Activities

To quantify improvements resulting from the deployment of the VCC, specific baseline measurements were collected. Baseline performance measures were both qualitative and quantitative and included observations collected during the design process and a survey and interviews conducted prior to the deployment of the VCC.

3.6.1 Baseline Observations

Observations of the traffic incident management team, congestion management team, and PIOs performing tasks pre-deployment were conducted during the fourth Use Feedback Refine cycle from March 9, 2022 to March 24, 2022. Observations were conducted at the WSDOT TMC, SDOT TOC, and KCM TCC. One ride-along each was performed with Seattle’s SDOT Response Team and with WSDOT’s Incident Response Team. In addition to collecting feedback on the current release of the VCC, observers asked questions during tasks to obtain more objective, unbiased assessments of activities.

Relevant Incident information. People use a wide variety of approaches and information sources to identify and understand emerging incidents, and often find ways to adapt protocols to better fit their own information-seeking preferences and needs. People contend with both too much and too little information: there is always a deluge of information coming in, but none of it is comprehensively complete. Major incidents often start as one type of situation, and often turn into something else, and handling these dynamic demands continually injected information. The Project Team noticed the broad importance of “overhearing” to manage this information overload: ambient visual and auditory information was constantly being processed both in control rooms and in vehicles on the road. Planning actions during incidents, especially for people at the SDOT TOC and WSDOT TMC, is sometimes done in reference to known or perceived incident commander intent, so a better ongoing understanding of this key data point would be highly valuable.

Procedures and Jurisdiction. While most people the team observed maintained extensive documentation on procedure and protocol, people also rely on each other to know what to do, particularly in more complex or uncommon situations. People benefit from personal relationships with trusted parties, both inside and outside their own agency, to evaluate the feasibility and acceptability of a particular option. Important work sometimes happens between procedures or through negotiation, so knowing how much a procedure can flex in a given situation is important. Jurisdiction is also complicated and can require judgment calls to address. All of this suggests that the VCC would not function optimally if it simply imported existing standard operating procedures; rather, its procedures need to develop over time through the thoughtful collaboration of its users.

Pre-VCC Impressions of Interagency Coordination. People expressed a variety of perspectives on the current (pre-VCC) state of interagency coordination during large incidents. Interagency coordination became more important when people’s own tools (two-way radio, camera feeds,
etc.) were having problems. Interagency coordination could thus be seen partly as a fallback or resilience strategy for intra-agency work. However, agencies working on a shared problem sometimes have work objectives that can come into tension with each other, such as a stalled bus driver’s need to adhere to a clear and orderly hierarchy and wait for a supervisor to arrive on scene, versus an incident response driver’s need to get traffic moving quickly by any means necessary. Tools like the VCC that enable everyone to do their own tasks as effectively as possible, and communicate more clearly about their reasoning and intent, may help with managing this tension. Considerable effort is sometimes needed to convey the same information to different audiences, since people in different settings do not all use the same terminology to describe the same things. At the time of these observations, future VCC users were already discussing the importance of creating common vocabulary in the VCC that all the disparate parties could understand and act upon. Ultimately, interagency coordination is carried out by human beings; their own relationships and personalities play a large role. If people are not currently getting valuable information from others and feel that they’re being kept in the dark, interagency coordination problems can exacerbate that frame of mind.

Technology and Tools. The Project Team learned a great deal about how people effectively and tactically use the technologies at their disposal to manage incidents and congestion. In particular, various agency-specific and third-party mapping tools such as Google Maps came up frequently; accurate, timely, rich information about location is core to the work of nearly every interviewee. One VCC capability people expressed interest in was a shared map whiteboarding and annotation tool, which was eventually built into the VCC in the form of Map Annotations. Others wanted to see responding units’ locations. In addition, people often use personal devices such as smartphones, or personally crafted tools outside of procedure, often as workarounds for perceived gaps in the capabilities of the tools and technologies prescribed by procedure. Some types of lower-IT-resourced stakeholders like the incident response teams expressed that “just the basics” of the VCC’s functionality could be immensely helpful. Later, during model deployment, their prediction came true, as the VCC’s Integrated Dispatch Feed and mapping tools alone helped incident response personnel do their jobs more effectively and efficiently.

3.6.2 Baseline Survey

The baseline survey was hosted on Qualtrics, a cloud-based survey platform that provides tools for creating, distributing, and analyzing surveys and research data. Post-deployment surveys were also hosted on Qualtrics, and these results will be discussed in 3.7. Appendix K includes all the questions and their response formats for the baseline and post-deployment surveys. The baseline survey was sent to those identified as future users of the VCC (see Section 3.4), and was available beginning November 2, 2022, and closed on February 22, 2023. Participants were asked to provide their agency, number of years with their agency, job title, role in incident response, and number of years in this role. Next participants were asked 21 questions concerning inter- and intra-agency communication and coordination during incident response. Finally, they were asked to indicate their role in the development of the VCC, the level of familiarity that those within their agency had with the VCC, their name, email, phone number, and any comments they wanted to provide regarding the survey.
The 120 participants who responded to the baseline survey represented all seven public agencies and had an average survey completion time of 13 minutes and 21 seconds (Standard Deviation=14 minutes, 10 seconds). Respondents had an average of 12.78 years (Standard Deviation=11.54 years) of service with their agency, and an average of 7.38 years (Standard Deviation=8.04 years) experience in incident response. More than half of respondents (57.50%) had participated in some way with the development of the VCC.

Participants were asked to rate their ability to obtain information, communication, and coordination using a visual analog scale (VAS) with endpoints as indicated in the Survey Question column of Table 4 below by moving the slider to a location between the endpoints. The location of the marker was then converted by Qualtrics to a number out of 100. For example, the location to the far left on the difficulty scale for Question 1 in Table 4 would be converted to zero while the location on the far right would be converted to 100; therefore, a rating closer to zero would indicate it was more difficult to get information while a rating closer to 100 would indicate that it was easier to get information.

Based on the ratings in Table 4, participants had more difficulty obtaining information from those outside their agency as well as more difficulty communicating and coordinating with those outside their agency. All 120 participants responded to each of the questions in Table 4.

The questions in Table 4 were repeated on all three post deployment surveys (see Appendix K. Baseline and Post-Deployment Survey Instruments). Comparisons between ratings on the baseline and ratings on the post-deployment surveys are reported in 3.7.1.1, 3.7.1.7, and 3.7.2.1.

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4 Visual Analog Scales (VAS) have been used for various psychometric assessments, including those related to subjective experiences, emotions, and perceptions, and have demonstrated validity and reliability. We used VAS as we believe them to be more intuitive for participants, require less cognitive effort than providing a numeric value, and reduce bias as participants may be less likely to choose an arbitrary number. Participants did not see any numbers when they selected their desired spot on the visual analog scale. This was intentional as we believed that showing participants the value that corresponded to the spot would negate the advantages described above and would be no different than allowing them to enter a number between 0 and 100 into a numeric write-in field.
Table 4. Baseline survey questions showing mean responses with standard deviations (SD) in brackets. All 120 participants responded to all five questions.

<table>
<thead>
<tr>
<th>Number</th>
<th>Survey Question</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>In conducting your work, how difficult is it to get necessary information about an active VCC-level incident from others within your agency?</td>
<td>66.18 (20.88)</td>
</tr>
<tr>
<td>2</td>
<td>In conducting your work, how difficult is it to get necessary information about an active VCC-level incident from others outside your agency?</td>
<td>49.87 (20.77)</td>
</tr>
<tr>
<td>3</td>
<td>Rate your overall satisfaction level with communication and coordination within your agency during an active VCC-level incident.</td>
<td>68.84 (20.18)</td>
</tr>
<tr>
<td>4</td>
<td>Rate your overall satisfaction level with communication and coordination between your agency and external partners during an active VCC-level incident.</td>
<td>54.64 (20.14)</td>
</tr>
<tr>
<td>5</td>
<td>During a VCC-level incident, how often do you reach out to someone outside your agency to coordinate work?</td>
<td>58.40 (29.52)</td>
</tr>
</tbody>
</table>
3.6.3 Baseline Interviews

Researchers augmented surveys with baseline interviews that provided greater nuance and context on VCC-relevant issues. These interviews provided a good picture of the pre-VCC operational environment. Interviewees represented a balance among operational roles, agencies, and work experience level. Twenty-one users (14%) with traffic incident management, congestion management, or public information officer (PIO) roles were selected from the 152 users identified as VCC users. These 30-minute semi-structured, online interviews included six core interview questions asked of everyone. Those primarily in a Congestion Management role were asked one additional question; those primarily in a Population Movement role were asked four additional questions. Across all operational communities, those who had indicated on the baseline survey that they were involved with post-incident reporting were also asked two questions about this topic. When possible, each interviewee was asked to describe what technology systems they used to support their work, and what their usage was like. These system usage questions are not reported in detail here; only general points of interest are described, when applicable. The full protocol, with each of its variations, is described in Appendix I.

Eighteen of the 21 users participated in interviews between December 6, 2022, and January 5, 2023. There were five interviewees from WSDOT and SDOT, and two interviewees each from SPD, SFD, KCM, and Sound Transit. Five of the interviewees had roles in incident management, four from congestion management, four had roles as PIOs, and an additional five had other roles in incident response. Half of all interviewees had between three and 10 years of experience in incident response, eight interviewees had two or fewer years of experience, and one interviewee had more than 21 years of experience.

Following are some key insights from interviewees, grouped by question set. We also offer some comments on the measures that were used during the evaluation to measure the impact of the VCC on these areas.

*Internal communication and coordination.* Interviewees described many positive aspects of their communications with internal partners during a VCC-level incident. Positive factors of internal communications were often related to personal characteristics: people working hard, being intentional and thoughtful, and being flexible. Structural factors included effective division of labor, after action reviews that enable continued learning, and strong established communication procedures within an operational community.

Negative aspects of internal communication were varied—both too much and too little information can be problematic. The most common factors were lack of clarity or of well-established procedures and roles; and logistical or other difficulties in obtaining information from relevant parties. Even when it is clear whom to contact, people are still sometimes hesitant to bother them, knowing that they are busy. Additionally, since so many groups of people, processes, and information flows are active during an incident, without putting in active effort to monitor and question, it can sometimes be easy to get out of the loop. On the other hand,
multiple people described some version of an information overload, which without careful management issues can, at times, get blown out of proportion, or someone can get drowned in extraneous details. At the time of baseline interviews, it was observed that a challenge for the VCC would be to strike a balance between making it easy to stay in the loop while avoiding information overload.

**External coordination and communication.** Regarding positive experiences with external communication, participants typically called out specific agencies they had especially effective communication with. This is not unexpected, since participants across many engagements and contexts have described high-skill, trustworthy relationship-building as a major outcome of good coordination. Beyond these specifics, participants also mentioned that having well-established protocols and direct, easy-to-maintain communication channels were helpful. Some participants further mentioned that during major incidents, having more agencies involved promoted a valuable sense of interdependence between different parts of the operational community, showcasing what unique value each agency and role could contribute or that communication tends to get better over time during a long incident.

The most common theme in people’s negative experiences with external communication was excessive time and/or effort involved in obtaining information or access to the right people: essentially, the opposite of the most common positive factors in external communication. Underdeveloped relationships or procedures with external partners were also mentioned multiple times.

When physical assets are impacted by an incident, it is not always immediately obvious who maintains or owns them, such as a downed light pole, and it can take time to ascertain and contact the correct party. Logistical obstacles were another key factor; incompatible radio frequencies or low staffing levels/turnover at partner agencies kept people from upholding their agreed-upon communication or coordination tasks. The VCC should provide users across all areas of incident response with a common operating picture, thereby reducing the time and/or effort involved in obtaining information or accessing it from the right people. The impact of the VCC on external communication and coordination will be measured via post-deployment surveys and interviews.

**Population Movement Questions.** When asked how quickly they were able to get messages to the public after an incident had started, the four PIOs reported that although speed in getting messages out to the public is important to them, speed is not the only concern. In fact, three participants mentioned using some deliberate form of slowing of messages or inserting a delay in the process. That is because the goal is not just speed but care, appropriateness, and accuracy—an incorrect, overly revealing, or insensitively worded message can cause more harm than a few more minutes of delay. When it came to accuracy, direct reports from trusted people on scene were often considered more valuable and reliable than information from computer-aided dispatches and can be a major factor in both the speed and accuracy of messages. Most participants said they are likely to get messages out within 30 minutes of when the incident occurred.
When describing what factors stopped them from getting messages out faster, most people mentioned some form of confirming that information is accurate or complete, which may also require that the message be reviewed by a supervisor during complex incidents. It was also common for people to talk about phrasing challenges; particularly when the incident involved sensitive topics such as fatalities, they did not want to put out information until it's carefully and appropriately worded. Informational obstacles, such as not knowing whom to contact to receive updates, or even physical obstacles, such as traffic congestion slowing the arrival on scene of personnel who were expected to report on conditions; could also slow down information transmission. Finally, as dispatch event types were not standard across agencies, interpreting another agency's dispatch event type could slow the creation of messaging for the public.

Most participants said that it was difficult to assess the impact of their messages, or that people’s true reactions were hard to infer. It is also hard to know the impact of a negative message (such as “avoid this area”). Two PIOs mentioned the possibility of using secondary statistics to infer impact (e.g., ridership statistics and congestion analytics, respectively). Also common were observable responses from the public via media (e.g., impressions, engagements, angry complaints) or the media voluntarily carrying their message forward. Given the difficulty of measuring the impact of the VCC using quantitative performance metrics such as demand characteristics or sentiment analysis on social media, post-deployment surveys and interviews were used instead.

**Congestion Management Questions.** Participants with a primary role in congestion management undertake qualitatively different kinds of congestion management activities. King County Metro, for example, can reroute buses impacted by major incidents and monitor the progress of buses along their routes. Departments of transportation, on the other hand, have less control and can only shape the environment via congestion management strategies such as signal timing changes, express lane redirection, ramp metering, etc. However, according to one interviewee, these actions have “no significant impact [on mobility],” but it is not clear what counts as a significant impact, and how much that assessment of significance is connected to measurable changes.

Congestion Management interviewees appeared to have both primary and secondary (direct and indirect) methods of assessing the impact of their actions, based on the sensing and analysis tools at their disposal and the level of resolution those tools permit. A WSDOT interviewee claimed that they could not measure the impact of congestion management strategies “in the flow of things,” but only afterward. Yet even this participant described the necessity of making tactical tweaks to such things as express lane direction, even though he wasn’t sure how to measure the benefits of such interventions. The VCC includes a Mobility Strategies component, but given the above comments from interviewees, measuring the success of this component using quantitative performance measures (e.g., highway detection loops) will be replaced with qualitative measures gathered from post-deployment interviews.

**Reporting Questions.** Participants undertook a wide variety of reporting tasks, which happened on very different rhythms. Some reporting is a regularly scheduled aggregation of all incidents in
a specific period (weekly, quarterly, etc.), whereas for others it is precipitated by a major incident or a major planned event, such as a significant construction project. Two interviewees mentioned that their agency often creates several different reports for a major incident, each focusing on one specialized source of information. These interviewees hoped that the VCC would be helpful for creating reports that aid them in synthesizing information from multiple sources into one single, coherent report. Post-deployment surveys and interviews were used to assess the impact that the VCC has on report preparation and these results are in 3.7.1.4.

3.7 Evaluation Results

Results in this section are organized by the FAST Act goals addressed by the VCC. Each goal has one or more evaluation question that indicates a desired outcome or impact. These evaluation questions include quantitative and qualitative performance metrics. Table 5 below shows the evaluation questions and measures of effectiveness from the approved Evaluation Plan (see 3.1). For a description of the performance metrics, see Appendix J Data Definitions. In some cases when quantitative data were not available, qualitative data were collected using surveys, interviews, and observations. If the desired impact or outcome was not demonstrated, potential reasons are discussed. When testing for statistically significant differences between pre- and post-deployment or between Phases was appropriate, Mann Whitney U tests with a significant p-level of 0.05 were used to assess the meaningfulness of any observed differences, such that any p-value less than 0.05 indicated that the difference between the groups was statistically significant.

Table 5. Evaluation questions and measures of effectiveness included in the Evaluation Plan.

<table>
<thead>
<tr>
<th>Question #</th>
<th>Evaluation Question</th>
<th>Measures of Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>How satisfied are you that the VCC has improved your ability to obtain accurate information from other agencies?</td>
<td>Subjective rating on post-deployment survey.</td>
</tr>
<tr>
<td>2</td>
<td>How satisfied are you that the VCC has helped you to do your job better during a VCC-level incident?</td>
<td>Subjective rating on post-deployment survey.</td>
</tr>
<tr>
<td>3</td>
<td>How satisfied are you that the VCC has increased collaboration among agencies or operation groups during a VCC-level incident?</td>
<td>Subjective rating on post-deployment survey.</td>
</tr>
<tr>
<td>Question #</td>
<td>Evaluation Question</td>
<td>Measures of Effectiveness</td>
</tr>
<tr>
<td>------------</td>
<td>------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>4</td>
<td>How does performance in the corridor improve during incident conditions?</td>
<td>Approximate time difference between when an incident occurs and when intelligent transportation system devices are activated?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Approximate time difference between when an intelligent transportation system device is activated, and users are made aware that this has occurred because it appears in the VCC.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Time between incident notification and arrival of tow truck.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Time to incident clearance (after-deployment)</td>
</tr>
<tr>
<td>5</td>
<td>Do the VCC user groups trust the incident model as represented in the VCC?</td>
<td>VCC Users trust rating for the incident model</td>
</tr>
<tr>
<td>6</td>
<td>Can the TIM team leverage other agency resources (e.g., people, equipment) when needed?</td>
<td>Perceived benefit of being able to leverage other agency resources.</td>
</tr>
<tr>
<td>7</td>
<td>Is there a reduction in the effort required to prepare management reports and after-action reports?</td>
<td>Subjective judgments of perceived effort to produce reports</td>
</tr>
<tr>
<td>8</td>
<td>Is the quality of management reports and after-action reports improved?</td>
<td>Subjective judgments of report quality on post-deployment surveys</td>
</tr>
<tr>
<td>9</td>
<td>For those events where there is an incident command post, was an incident commander or designee added to the Incident Model?</td>
<td>Percent of time an incident commander or designee was added to the Incident Model. For those incident models without an incident commander, we will check that one was assigned before including that record in the count.</td>
</tr>
<tr>
<td>10</td>
<td>How have interactions with legacy systems changed since we deployed the VCC?</td>
<td>Qualitative responses during post-deployment interviews.</td>
</tr>
<tr>
<td>11</td>
<td>What additional data sources should be added to the VCC to improve shared situational awareness?</td>
<td>Observations of VCC users and responses on post-deployment surveys</td>
</tr>
<tr>
<td>12</td>
<td>What additional groups could benefit from access to the VCC?</td>
<td>Observations of VCC users and responses on post-deployment surveys</td>
</tr>
<tr>
<td>13</td>
<td>Has communication between the VCC user groups improved (e.g., is there less reliance on phone calls to verify incident details)?</td>
<td>Number of calls logged during an incident</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Subjective judgments of number of calls needed to verify or clarify incident information</td>
</tr>
<tr>
<td>Question #</td>
<td>Evaluation Question</td>
<td>Measures of Effectiveness</td>
</tr>
<tr>
<td>------------</td>
<td>-------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>14</td>
<td>Do users feel sufficiently confident about the accuracy of the incident clearance time estimates to include them in the VCC?</td>
<td>Number of times a clearance time estimate was entered/updated divided by the total number of VCC Incident models.</td>
</tr>
<tr>
<td>15</td>
<td>Is the CM team able to leverage shared data to assess the effectiveness of response strategies and make future improvements?</td>
<td>Approximate time between incident notification and response vehicle and tow truck arrival at the incident</td>
</tr>
<tr>
<td>16</td>
<td>Does the incident model improve the CM team’s ability to monitor and manage I-5 corridor operations during a major incident?</td>
<td>Subjective ratings on post-deployment surveys</td>
</tr>
<tr>
<td>17</td>
<td>Does the VCC improve mobility during major incidents in the Seattle/Central Puget Sound Area (see Figure 7)?</td>
<td>Maximum throughput speed threshold (85% of posted speed)&lt;br&gt;Percent of person-miles traveled on the Interstate system&lt;br&gt;On-time performance for transit providers</td>
</tr>
<tr>
<td>18</td>
<td>Is the rules engine making &quot;good&quot; decisions in terms of auto-generating incident models for VCC-level incidents?</td>
<td>Percentage of auto generated VCC Incident Models that are verified.&lt;br&gt;Percentage of launched Incident Models that were not auto generated.&lt;br&gt;Percentage of historical incidents that lasted over 90 minutes but would not have been identified by the rules engine.</td>
</tr>
<tr>
<td>19</td>
<td>What lessons were learned to reduce the demand on the I-5 corridor during major incidents that can benefit future VCC deployments in other regions?</td>
<td>Responses during post-deployment interviews</td>
</tr>
<tr>
<td>20</td>
<td>Do PIOs perceive that their messages to the public are getting out more quickly and are more actionable?</td>
<td>Approximate time between when an incident occurs and when the first message is delivered to the public&lt;br&gt;Subjective ratings by PIOs regarding message responsiveness and content</td>
</tr>
<tr>
<td>21</td>
<td>How does using the VCC use impact your development of public messages related to VCC-level incidents?</td>
<td>Responses collected during post-deployment interviews</td>
</tr>
<tr>
<td>Question #</td>
<td>Evaluation Question</td>
<td>Measures of Effectiveness</td>
</tr>
<tr>
<td>------------</td>
<td>--------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------</td>
</tr>
<tr>
<td>22</td>
<td>What lessons were learned to facilitate the creation of a unified, timely, and actionable message to members of the traveling public?</td>
<td>Responses collected during post-deployment interviews</td>
</tr>
<tr>
<td>23</td>
<td>What lessons were learned about how to engage major private employers in assisting with the distribution of messaging during a major incident response.</td>
<td>Responses collected during post-deployment interviews</td>
</tr>
<tr>
<td>24</td>
<td>Does deployment of the VCC reduce incident clearance times?</td>
<td>Incident clearance times</td>
</tr>
</tbody>
</table>

### 3.7.1 Institutional or administrative benefits

In this section we identify seven objectives that align with the FAST ACT institutional or administrative benefits goal and present the results to each of the evaluation research questions within the objective.

#### 3.7.1.1 Satisfaction with the VCC

Three questions were included on the evaluation plan to assess satisfaction with the VCC:

Question 1 How satisfied are you that the VCC has improved your ability to obtain accurate information from other agencies?

Question 2 How satisfied are you that the VCC has helped you to do your job better during a VCC-level incident?

Question 3 How satisfied are you that the VCC has increased collaboration across agencies or groups during a VCC-level incident?

For questions 1⁵ and 3, participants responding to the post-deployment surveys were asked to rate their satisfaction on a scale from Very Dissatisfied to Very Satisfied, where a score closer to 0 indicates very dissatisfied while a score closer to 100 indicates very satisfied. For questions about getting accurate information from other agencies, the average rating went up from the Phase 1 surveys to the Phase 3 surveys, indicating that VCC users were more satisfied over time. The improvement in getting accurate information from other agencies was more than just a random change as evidenced by results of the Mann Whitney U test, U=372, p=0.014. While the

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⁵ Question 1 was asked twice in error. Average ratings were calculated and reported on Figure 19.
average satisfaction rating for increased collaboration also increased from Phase 1 to Phase 3, this increase was not statistically significant (Figure 17).

![Figure 17. Mean satisfaction rating for Evaluation Questions 1 and 3. Error bars represent one standard error.](image)

In addition to specific questions about satisfaction with the VCC, we also asked users to report their overall satisfaction with communication and coordination with individuals within their agency and those outside of their agency. These questions were asked in the baseline survey and then again in the three post-deployment surveys (see Table 4 Questions 3 and 4 in section 3.6.2). As seen in Figure 18 mean satisfaction scores were significantly higher in the Phase 3 post-deployment survey than mean satisfaction scores in the baseline survey for both communication and coordination with individuals within (Mann Whitney U test, U=1694, p=0.003) and outside of their agency (Mann Whitney U test, U=1878.5, p=0.02), suggesting that the VCC was contributing to the satisfaction with internal and external communication and coordination of large, complex incidents.
To examine whether individuals with higher baseline satisfaction scores were more likely to be satisfied post-deployment, we conducted a correlational analysis. For this analysis we compared the baseline satisfaction of communication and coordination with those inside and outside their agency to scores from these measures on the Phase 3 survey including only those individuals who responded to both surveys. We found a weak positive correlation of 0.22 between pre-deployment and post-deployment satisfaction with communication and coordination with individuals inside the organization, suggesting satisfaction levels before deployment are only mildly indicative of the satisfaction levels after deployment. With regards to satisfaction with communication and coordination with individuals outside their agency we found a very weak positive correlation of 0.07, such that satisfaction levels before deployment are not a reliable predictor of satisfaction levels after deployment. In practical terms, these weak correlations imply that individuals with higher baseline scores are not substantially more likely to be satisfied post-deployment.

We did not specifically ask users question 2, rather we analyzed use of the VCC to assess satisfaction with the VCC. User Analytics were used to measure basic user engagement and interaction with the VCC. The data and insights help to identify areas for VCC improvement and help quantify the general success of the VCC.

Data was collected during Phases 2 and 3 of the evaluation periods. The user analytics dataset contains a variety of fields that indicate use of the VCC (e.g., open Incident Model details page, annotated Situation Map, open Mobility Strategies page, etc.). Additionally, all the Incident Model reports in the VCC were collected to retrieve relevant data to complete analysis. The Incident Model report data contains fields, such as Incident ID, Incident Type, Location, etc.

Figure 19 shows the daily number of unique users that logged into the VCC during Phase 2 and Phase 3 of the post-deployment period. There is an overall slight increasing trend with the
lowest number of users on the weekends and the busiest days on Tuesdays through Thursdays.

Figure 19. Unique number of users by day. Dotted vertical lines represent the end of Phases 2 and 3.

Access to all agency dispatches contributes to a common operating picture and shared situational awareness; therefore, it is not surprising that the Integrated Dispatch Feed was the most utilized area of the VCC. User analytics shows that there was a total of 6,539 interactions where the user opens a dispatch event from the Integrated Dispatch Feed of the VCC Dashboard, with a total of 25.13 events opened per user.

3.7.1.2 Provide a clear, accurate, and timely common picture of an incident.

The ability to provide a clear, accurate, and timely common picture of an incident is key to achieving shared situational awareness. While improved awareness is not sufficient for improved performance, it is a prerequisite. The Project Team considered two associated evaluation questions:

Question 4 How does performance in the corridor improve during incident conditions?

Question 5 Do the VCC user groups trust the Incident Model as represented in the VCC?

To assess evaluation question 4, the team collected baseline data from the SDOT TOC call logs and WSDOT’s Washington Incident Tracking System (WITS) data systems for the ten-year period prior to the deployment of the VCC. Within these data sets, the following performance measures were identified in the Evaluation Plan:

a. Approximate time difference between when an incident occurs and when intelligent transportation system devices (e.g., electronic message signs, traffic signals) are activated.

b. Time between incident notification and arrival of tow truck.
The initial plan was to compare this baseline data to the post-deployment measures available in the VCC. However, the team found that these performance measures, which were entered manually into the SDOT and WSDOT systems, were not available on a consistent basis, and as such were not an appropriate performance measure to answer question 4.

There was a third performance measure identified in the VCC data:

c. Approximately time difference between when an intelligent transportation system device is activated, and users are made aware that this has occurred because it appears in the VCC.

Of the 302 Closed Incident Models in the VCC, nine (2.9%) included one or more Mobility Strategies. In addition, four (1.3%) additional Incident Models included a mobility strategy in the Note field. Of the Mobility Strategies entered, eight involved activating an electronic message sign, four involved changing signal timings or closing ramps, and one involved diverting traffic (see Table 6).

It is not surprising that so few Incident Models included Mobility Strategies as it was expected that they would only be used for longer duration incidents. In fact, the average duration of all 302 incidents was five hours and 22 minutes, while the average duration for the nine incidents that included one or more Mobility Strategies was 19 hours and 11 minutes. The average time difference between when an Incident Model was created and a Mobility Strategy was entered into the VCC, was two hours and 34 minutes with a median time of 37 minutes. If the ramp closure (#10 in Table 6) is removed, which had a duration greater than six days, then the average time decreases to 32 minutes. While this is interesting, intelligent transportation system activations may not be an appropriate measure because it says more about the length and complexity of an incident than it does about the mobility in the corridor during an incident. It is only known when a VCC user is made aware that a mobility strategy was launched because it appeared in the VCC. The advantage of having these Mobility Strategies in the VCC is that they are viewable to all VCC users as soon as they appear in the VCC, providing a common operating picture for shared situational awareness, and as stated by one user on the Phase 3 survey:

“Using the mobility strategy tab, we could see what has been done by other agencies for us to act on it, especially for incidents that are on interstates and state routes.”

Combining separate data streams from separate agencies to evaluate improved corridor performance during incidents proved challenging. However, the team believes that the data in the VCC which is provided by all participating agencies will lead to better evaluation of performance.
Table 6. Mobility strategies included with Incident Models. MP is a milepost. DMS is a dynamic message signs, an electronic message sign. MVI is a motor vehicle incident, MVC is a motor vehicle collision, and COLUNK is collision injury unknown.

<table>
<thead>
<tr>
<th>#</th>
<th>Incident Type</th>
<th>Location</th>
<th>Mobility Strategy</th>
<th>Notes</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tunnel MVI</td>
<td>SB SR99 TUNNEL AT TUNNEL</td>
<td>Activated DMS at SB SR 99 at Ward.</td>
<td>n/a</td>
<td>1 hour 5 minutes</td>
</tr>
<tr>
<td>2</td>
<td>Wires Down</td>
<td>RAINIER AVE S S NORMAN ST</td>
<td>DMS at NB Rainier at S College St activated</td>
<td>n/a</td>
<td>1 hour 22 minutes</td>
</tr>
<tr>
<td>3</td>
<td>COLUNK</td>
<td>I-5 NB at SR 516</td>
<td>n/a</td>
<td>['SHOOTING // ALL LANES BLOCKED NB I-5 // SR 516 RAMPS TO NB I-5 CLOSED //', 'BLOCKING TWO RIGHT LANES AFTER SR 516 // SR 516 TO NB I5 OPENED //']</td>
<td>15 hours 25 minutes</td>
</tr>
<tr>
<td>4</td>
<td>COLLISION INJURY</td>
<td>I-5 Express Lanes</td>
<td>SDOT ACTIVATED DMS FOR EXPRESS LANES CLOSURE; SDOT SIGNAL OPERATIONS TEAM MADE SIGNAL TIMING CHANGES MADE ALONG EAST MARGINAL WAY TO ACCOUNT FOR INCREASING TRAFFIC VOLUMES</td>
<td>n/a</td>
<td>6 hours 9 minutes</td>
</tr>
<tr>
<td>5</td>
<td>COLLISION PERSONAL INJURY</td>
<td>1st Avenue South Bridge, Seattle, Washington 98108, United States</td>
<td>Received Call from WSDOT and retweeted post. Actively Monitoring incident.</td>
<td>n/a</td>
<td>1 hour 9 minutes</td>
</tr>
<tr>
<td>6</td>
<td>WIRES DOWN (PHONE, ELECTRICAL, ETC.)</td>
<td>East Marginal Way S at S Michigan St - 4th Ave S</td>
<td>DMS ACTIVATED</td>
<td>n/a</td>
<td>4 hours</td>
</tr>
<tr>
<td>7</td>
<td>Fire in Building</td>
<td>4331 5TH AVE NE</td>
<td>DMS POSTED ON NE 45 ST AT UNION BAY</td>
<td>n/a</td>
<td>3 hours 37 minutes</td>
</tr>
<tr>
<td>8</td>
<td>COLLISION PROPERTY DAMAGE</td>
<td>S405 (JS) COALCREEK MP10-2</td>
<td>n/a</td>
<td>No mobility strategies applied.</td>
<td>3 hours 42 minutes</td>
</tr>
</tbody>
</table>
To answer Question 5 VCC data was collected from VCC users at three separate times post-deployment. Users were asked to mark on a visual analog scale (VAS) their answer to the question, "How much do you trust the information that is available in an active VCC indent model?" The left endpoint on the VAS was No Trust and the right endpoint was Full Trust. These were then converted to scores out of 100 with zero indicating no trust and 100 indicating full trust. Table 7 shows the means and standard deviations of the trust ratings in all three post-deployment surveys. Trust was high in all three post-deployment surveys, and while there was a decrease in trust in Phase 2 compared with Phase 1, a Mann Whitney U test showed no statistically significant difference. Similarly, a Mann Whitney U test revealed no significant difference between mean trust in the Phase 1 and Phase 3 ratings, indicating that trust remained the same across the three phases of the post-deployment period.

Examining trust ratings on an individual level, we found that there were only nine participants who responded to all three post-deployment surveys with four individuals reporting greater trust over time and five individuals reporting lower trust over time. Examining the average change over time, of those reporting higher trust, ratings increase on average by 24 points, while those reporting lower trust decreased their rating by only 9 points on average. Given the importance of
trust in continued use and adoption of the VCC, we recommend a future assessment of trust in the incident model.

Table 7. Means and (Standard Deviations) of post-deployment surveys questions about trust in Incident Models and trust in dispatch data.

<table>
<thead>
<tr>
<th>Questions</th>
<th>Phase 1 (N=28)</th>
<th>Phase 2 (N=41)</th>
<th>Phase 3 (N=41)</th>
</tr>
</thead>
<tbody>
<tr>
<td>How much do you trust the information that is available in an active VCC Incident Model?</td>
<td>81.39 (18.96)</td>
<td>75.80 (27.11)</td>
<td>80.66 (21.37)</td>
</tr>
<tr>
<td>How much do you trust the information in the VCC agency dispatches?</td>
<td>81.56 (19.13)</td>
<td>75.07 (24.27)</td>
<td>83.15 (20.26)</td>
</tr>
</tbody>
</table>

The Project Team also asked users on the post-deployment survey how much they trust the information in the VCC dispatches. Ratings were like those for trust in the Incident Model. As with the trust in Incident Model question, trust decreased in Phase 2, however, again this difference was not statistically significant according to a Mann Whitney U test. Nor was the difference between trust ratings in Phase 2 and Phase 3.

In the Phase 1 survey participants were also asked to explain their reasoning behind their ratings of these trust measures. In general, users trusted the information because they trusted the information source (i.e., agency computer-aided dispatch). However, six of the 28 users (21%) said that while they trusted the information in the dispatches, it tends to improve over time as more information arrives from the scene. One participant credited the VCC with improving the speed at which the information is updated:

“Information coming in from various CAD systems is always the best information they have at the time, that tends to improve over time. The VCC allows for much quicker improvement on the information/data quality, but I know it is initially more relative as incidents develop.”

Similarly, when asked to provide an explanation for their rating of trust in the Incident Models, 12 of the 27 participants (44%) who answered this question said that they trusted the source of the data (i.e., the trained professionals entering the data into the VCC Incident Model). One participant commented that “as more agencies add to the incident, the information will be even more reliable.”

Considering that agency dispatches are generally considered a high-quality source of truth for working incidents, the comparable level of trust for VCC Incident Model information should indicate that the VCC’s Incident Models are considered quite trustworthy. The Project Team believes this is a marker of success in both creating the VCC Incident Model structure and the willingness of users to contribute broadly useful information to it. That trust in both agency dispatches and Incident Models did not significantly change over the course of the evaluation period may support a few possible conclusions, which are not necessarily mutually exclusive, and which bear further investigation in the future. Because each agency has unique expertise and access to information, and because incidents are extraordinarily complex and not fully
representable in any system, it is possible that there is a ceiling of trustworthiness for the VCC that has already been achieved. Another possibility is that more users from all agencies and workgroups are needed for the VCC to achieve its full potential in terms of information richness and trustworthiness – users might be too busy to fully verify, record, and update key information in the VCC due to the demands placed on them by their jobs. In addition, the user community is still developing shared work processes around the VCC that may gradually enable more trustworthy and complete information to be recorded in the VCC.

3.7.1.3 Leverage the resources of all agencies.

Knowing the location of agency resources contributes to shared situational awareness and allows agencies to leverage these resources in a major incident. In one-on-one online interviews conducted post-deployment from July 18 to August 11, 2023, VCC users were asked:

Question 6 Has the VCC helped you to leverage other agency resources (e.g., people, equipment) when needed?

Of the 18 users interviewed, 11 had sufficient experience with the VCC to be asked this question. Of those 11 who responded, five said that the VCC has helped them to leverage other agency resources. One participant suggested an improvement to the VCC that would allow users to leverage other agency resources, they said: "If [our SDOT Seattle Response Team] knew there was an [WSDOT Incident Response Team] nearby we could get them to help us. If the [WSDOT TMC] and [SDOT TOC] could see incident response team locations, then we could leverage them more."

Given that SDOT Seattle Response Team and WSDOT Incident Response Team units have automatic vehicle location systems, their locations could be displayed on the VCC Situation Map, thereby showing their proximity to an incident to all users of the VCC and allowing them to leverage these nearby assets when needed.

There is another way to view leveraging other agency resources. Because the VCC brings together data and people from multiple agencies, it offers new ways for a user from one agency to leverage a data resource from another agency. For example, an SDOT traffic manager at the Seattle TOC used a WSP dispatch to launch an Incident Model because it was a response to a fire that impacted city traffic. To date users are still discovering ways that the VCC can help them leverage other resources. The Project Team believes that supporting users to use the Mobility Strategies tab of the VCC more fully and effectively, easier user-to-user communication in the VCC, and the incorporation of additional data sources such as maintenance databases, can increase the VCC’s ability to support this goal.

3.7.1.4 Improve the ability to make informed decisions.

The value of after-action and management reports lies in their ability to capture a thorough analysis of an incident, promote continuous improvement, enhance preparedness, and
ultimately contribute to better decisions in future incidents. To measure the impact of the VCC on this objective, the following questions were included in the Evaluation Plan:

Question 7 Is there a reduction in the effort required to prepare management reports and after-action reports?

Question 8 Is the quality of management reports and after-action reports improved?

Data to answer these two questions were collected using post-deployment surveys and interviews. In the post-deployment surveys, participants were first asked if they were responsible for the creation of after-action or other management reports. Those who had report creation responsibilities were then asked to rate on a VAS with endpoints Strongly Disagree to Strongly Agree the statement, “The VCC reduced the effort required to complete my reports.”

In the Phase 1 post-deployment survey, 12 of the 28 respondents indicated that they were responsible for report creation, and on average, they somewhat agreed that it was less work to create these reports (Mean = 33.42, Standard Deviation=31.35). In Phase 2, 20 of the 41 respondents reported having responsibility for report creation, and they tended to have a higher agreement that it was less work to create reports (Mean = 39.50, Standard deviation = 31.50); however, this increase was not statistically significant. In Phase 3, the average agreement level increased to a mean rating of 76.60 (Standard Deviation=39.09), which was a statistically significant increase from the Phase 1 average rating, Mann Whitney U=40, p=0.002.

Report quality (Question 8) also was assessed during the Phase 2 interviews. While none of the eight interviewees responsible for creating reports had the opportunity to use the VCC to create an after-action report yet, these users did indicate that they were beginning to see the value of the Incident Model for report creation. According to one interviewee, many of their after-action reports have to do with creating a timeline, and understanding why and how decisions were made, “so having those inputs [in the Incident Model], I see the value in that.” Another interviewee commented on the value of the records management reports, which “wraps everything up into a tight little report and we can ship it off if needed.”

In conclusion, there has not yet been a representative opportunity to understand the value of the VCC for after-action and management reports, since there has not been a widely significant major incident since the VCC’s deployment. However, users are already identifying functional aspects of the VCC’s information that they can map to their known reporting needs and workflows, so the team expects that if the VCC remains in common use and those who prepare after-action and management reports are aware of the information that is recorded, success on these measures is very likely.

3.7.1.5 Changes in incident command behaviors and interactions with legacy systems
The Project Team expected that the VCC would result in some changes in incident command behaviors and changes to how the community interacted with their legacy systems. To assess these changes, data was collected to answer the following questions:

Question 9 For those events where there is an incident command post, was an incident commander or designee added to the Incident Model?

Question 10 How have interactions with legacy systems changed since we deployed VCC?

To answer 9, the team reviewed the 302 Incident Models that were created during the post-deployment period, only one included the name and agency of the incident commander. In addition to the Incident Commander field, there is a separate Incident Commander Agency field, where users can indicate which agency is currently in command of the incident, without being required to name an individual if this information is unavailable. In total 24 incidents included the agency of the incident commander. All 24 incidents were created by WSDOT personnel. Of these 24, 15 indicated WSDOT as the incident commander agency; six indicated WSP, and one each indicated SFD, and Whatcom Fire. As of the writing of this report, WSP, SPD, and SFD responders have not used the VCC during incident response, and Whatcom Fire is not a VCC member agency. However, it is expected that when more complex incidents occur that these agencies will have more need for the VCC and will either enter the incident commander and incident commander agency fields or provide the information to SDOT or WSDOT VCC users to enter the information.

Question 10 was asked during the Phase 2 Interviews. Of the 18 interviewees, eight shared how their interactions with legacy systems changed since the deployment of the VCC. The majority of interviewees had access to some dispatch data via other systems. For example, WSDOT TMC personnel have access to a WSP CAD client, while SDOT TOC has Viewpoint, which has dispatches from SPD and SFD. For WSDOT TMC personnel, the additional information that is available in their existing WSP CAD client results in their continued use of the CAD client as their primary source of information. WSDOT Incident Response Team, however, does not have access to the WSP CAD client and as a result have come to rely on the VCC and use it daily. According to one responder, “we’ve created an addiction to this [VCC].”

At the SDOT TOC, interaction with their legacy system, Viewpoint, has not changed. Again, this is primarily due to the additional information in Viewpoint that is not in the VCC. According to one interviewee, the Situation Map in the VCC is superior to the Viewpoint map because the map populates with dispatch events faster than they do in the Viewpoint map. Interviewees at KCM also said their interactions with legacy systems have not changed, primarily because they use those systems for major transit system disruption, which are not necessarily caused by traffic incidents.

For question 9, the team cannot draw any significant conclusions yet, as there is not enough information to reason about. The team believes further analysis will be possible when a more robust first responder user base is interacting with the VCC, since first responders tend to be
incident commanders most frequently. It is also likely that to learn more about the use of this information if a very large, serious incident occurs that implicates a multi-agency incident command structure. The team observed that having a separate incident commander agency field seems useful and might itself be actionable/helpful information, since this field was used significantly more often than the Incident Commander field. The team recommends learning more about the unique value of indicating an individual Incident Commander, or possible drawbacks if there are long incidents where who the acting Incident Commander is can change, and the information can get stale faster than some other fields.

Interactions with legacy systems have not changed for the most part; however, for an incident that involves agencies across jurisdictions there are tools, such as the Mobility Strategies, which would be utilized to notify all agencies of something like the activation of an electronic message sign or signal timing change. Changes in use to existing systems, where they do occur, seem to depend considerably on perceived information or functionality gaps in existing systems. These gaps are not the same agency to agency, so the unique value of the VCC for overall sensemaking and work are not the same. More can be learned about this by adding and incorporating a wider variety of users who have different relationships with their systems.

3.7.1.6 Share project insights regarding shared situational awareness

To understand what project insights were learned regarding shared situational awareness during the evaluation, respondents were asked on surveys and during interviews the following two questions:

Question 11 What additional data sources should be added to the VCC to improve shared situational awareness?

Question 12 What additional groups could benefit from access to the VCC?

During observations and interviews throughout the evaluation several additional data sources were suggested that could improve the Situation Map, including tow truck locations, DOT maintenance vehicles, construction equipment, electronic message sign locations, and weather data. Knowing the location of these resources could allow for improved timing to arrive at the scene by deploying nearby resources, while weather information could be used to alert responders to poor driving conditions that could impact their estimates of arrival times to the incident scene. Additionally, if agencies know the location of their resources, they can request them specifically, if necessary. Congestion managers responsible for state roads also wanted milepost markers indicated on the Situation Map.

One city employee also requested that more accurate construction information be displayed on the Situation Map as some projects were missing entirely while others did not include important information such as estimated length of closure. Currently the VCC includes construction event data from INRIX, and while this is valuable, it is not always complete. SDOT also has construction data; however, it is not always up to date either as there are many challenges.
involved in maintaining current construction data. For example, sometimes construction is postponed, or it does not take up a whole lane, which is not always reflected even in the SDOT system. Knowing if an entire city street is closed due to construction or a long-term closure is essential for developing detour plans. In addition, interviewees also requested adding a layer on the Situation Map for flammable cargo restrictions and planned events (e.g., a Seattle Mariners home game today at 11am). Including icons on the Situation Map for the location of responders with a check in/checkout box that shows that if an agency is on the scene would also be useful congestion management information.

Transit partners suggested that having a map layer showing bus routes could help to quickly identify which transit routes could be impacted by an incident, allowing them to begin planning their reroutes earlier. In addition, they suggested that transit and Link light rail alerts could be included because an incident involving a bus that breaks down on I-5, even if it’s on the shoulder, could impact traffic because passengers must be transferred to another bus, which would require a trooper from WSP to block a lane to ensure the safety of the passengers.

When asked Question 12 on the post-deployment surveys, approximately half of participants suggested one or more groups who could benefit. VCC users suggested a wide range of federal, state, county, and city entities that could benefit from the VCC, including:

- Railroads, Airports
- United States Coast Guard
- Port of Seattle
- Washington State Department of Ecology Spill Response Team
- State Contractors
- WSDOT and SDOT Maintenance and Construction crews
- Transportation Management and Operations Centers across Washington State
- Pierce and Community Transit
- Elementary and secondary schools
- SDOT Commercial Vehicle Enforcement
- City of Seattle Office of Emergency Management
- Construction Crews
- Seattle City Lights
- Stadium and arena management offices
- King County Sheriff

With respect to questions 11 and 12, it was found that users are thinking broadly and proactively about how much more the VCC could benefit them and others. They can readily imagine how additional data sources, such as the locations of incident response teams, could be added to
the Situation Map, indicating that the system’s features are clear and useful to them in the development of shared situational awareness. However, this does also mean that there are some ways to go before it fully, robustly supports shared situational awareness. It is also evident from the extensive list of suggestions for new user groups that Seattle area users see the benefits of the VCC and want others in the area to receive those benefits as well. The team speculates that additional user groups’ participation would also contribute to the general perception of usefulness of the VCC, since users have indicated that the VCC will be more generally useful the more fully others are using it.

3.7.1.7 Improve intra-agency and inter-agency coordination

Below are the results for the three research questions included in the evaluation to assess the effect of the VCC on intra-agency and interagency communication and coordination:

Question 13 Has communication between the VCC user groups improved (e.g., is there less reliance on phone calls to verify incident details)?

Question 14 Do users feel sufficiently confident about the accuracy of the incident clearance times to include them in the VCC?

Question 15 Is the Congestion Management team able to leverage shared data to assess the effectiveness of response strategies and make future improvements?

VCC users were asked on the baseline and post-deployment surveys to mark on a visual analog scale from Never to Always how frequently they used cell phones and landlines to communicate with people in their agency and outside of their agency. The markings on the scale were converted to a number out of 100 and then the three post-deployment survey ratings were averaged across surveys for each respondent. While the team hypothesized that users may rely less on phone calls to coordinate their responses, it was also possible that given the additional information that users had access to via the VCC, they may have more questions and a need to communicate more. Indeed, in post-deployment interviews, respondents said that increased phone calls were not a negative outcome and that overall communication improved.
When comparing the average rating across the three post-deployment phases to the baseline rating, there was no statistically significant difference in the frequency of cell phone use (See Figures 20 and 21). However, one Phase 2 interviewee with a WSDOT incident response team member remarked that “People are starting to get information without making as many phone calls.” With respect to using landlines to communicate during incidents, there was a significant increase in the frequency of landline use both internally (Mann Whitney $U=3570, p<.001$) and externally (Mann Whitney $U=2688, p<.001$). This may be a result of traffic engineers in WSDOT TMC and SDOT TOC using landlines to communicate and coordinate now that they share a common operating picture.

On the Phase 3 post-deployment survey we also asked participants with a role in congestion management to rate their level of agreement with the statement, “Now that I have the VCC, I am coordinating with more people outside of my agency.” The average rating for the 11 participants who responded was 45.91 out of 100 and a median rating of 59 out 100.
We also asked participants in both the baseline and post-deployment surveys, “During a VCC-level incident, how often do you reach out to someone outside your agency to coordinate work?” (see Table 4, Question 5 in 3.6.2). As information was now available in the VCC via the incident model, we expected that the mean participant rating from the Phase 3 post-deployment survey would be less than the mean participant rating from the Baseline survey. Indeed, we found that the mean rating across all 41 responses in the Phase 3 survey (mean = 55.29, standard deviation = 33.68) was less than the mean responses of the 120 baseline respondents (mean = 58.40, standard deviation = 29.52); however, this difference was not statistically significant making it difficult to draw and clear conclusions. Furthermore, there was a large diversity of responses (high standard deviation) in both the pre- and post-deployment survey, which could be due to various factors such as role in incident response, personal preferences, or incident factors. An analysis of rating by role did not reveal any additional information, suggesting that the diversity of responses may be due to the incident itself, and therefore not a robust measure of communication and coordination.

To answer question 14, we examine the Incident Models in the VCC. Of the 302 VCC Closed Incident Models, only 18 (6%) included an estimated clearance time. This is not surprising, given that in the baseline interviews and surveys that VCC users preferred not to give estimates as they believed them to be unreliable. As seen in Table 8, three of the estimated clearance times were overestimated, while seven were underestimated, and only one included updated clearance times. Interestingly, Table 8 shows that the VCC was being used for more than traffic incidents. Eight (44%) of the incidents were special events, construction events, road closures or restrictions, and maintenance. In these VCC incidents clearance time estimates were provided, perhaps because they were easier to estimate.

Table 8. VCC Incident Models with Estimated Clearance Times.
### Incident Type | Location | Estimated Clearance Time | Duration in Hours and Minutes
--- | --- | --- | ---
Collision | I-5, Seattle, Washington 98108, United States | ['90 minutes to 2 hours'] | 1 hours 19 minutes
COLLISION INJURY UNKNOWN | N5 (JS)SR18 | ['2 to 4 hours'] | 4 hours 25 minutes
COLLISION FATAL | S405 (JN)SR167 | ['2 to 4 hours'] | 4 hours 52 minutes
COLLISION PERSONAL INJURY | S509 (TO)W Marginal Way | ['4 to 6 hours'] | 2 hours 48 minutes
Emergency Maintenance | Ship Canal Bridge, Seattle, Washington, United States | ['13:00 hours'] | 2 hours 33 minutes
Delayed opening of I-5 Express Lanes | I-5 Express Lanes | ['90 minutes to 2 hours'] | 4 hours 21 minutes
Closure | I 5 Express, Seattle, Washington 98102, United States | ['6 to 8 hours', 'More than 8 hours', '8pm', 'see notes'] | 20 hours 14 minutes
Construction closure | Northbound I 5 Mainline, Seattle, Washington 98102, United States | ['4 to 6 hours'] | 20 hours 33 minutes
FLAMMABLE CARGO RESTRICTION | I 90, Mercer Island, Washington 98040, United States | ['April 12th'] | 64 hours 7 minutes
INCIDENT | N5 (FM)DEARBORN MP164-6 | ['90 minutes to 2 hours'] | 1 hours 26 minutes
Special Event | Sr 99 Tunnel, Seattle, Washington 98109, United States | ['2 to 4 hours'] | 2 hours 54 minutes
Special Event | Washington Highway 99, Seattle, Washington 98109, United States | ['2 to 4 hours'] | 3 hours 9 minutes
Structure FIRE | SR539 E LAUREL RD | ['90 minutes to 2 hours'] | 7 hours 36 minutes
Roadway maintenance | Southbound I-5 just south of NE 45th St | ['90 minutes to 2 hours'] | 1 hours 9 minutes
MVC - UNK INJURIES | 3501 East Marginal Way South, Seattle, Washington 98134, United States | ['20:07'] | 1 hours 34 minutes
Ramp Closure | West Seattle Freeway Eastbound to SR 99 Northbound | ['Unknown'] | 152 hours 25 minutes
Collision | I 5 Express, Seattle, Washington 98102, United States | ['less than 30 minutes'] | 0 hours 9 minutes
COLLISION PROPERTY DAMAGE | N9 (JN)MP91 | ['90 minutes to 2 hours'] | 2 hours 55 minutes

To answer Question 15, VCC users with congestion management responsibilities were asked on the post-deployment surveys, how likely they were to make alterations to their congestion management strategies in future incidents after seeing the information from partner agencies in the VCC. Again, participants were asked to mark their rating on a visual analog scale with endpoints, Very Unlikely and Very Likely and then this was converted to a score out of 100.
Fourteen participants answered this question on Phases 1 and 2 surveys, while 11 responded to it on the Phase 3 survey. Ratings increased from a mean of 44.57 (Standard Deviation=31.72) in Phase 1 to 55.36 (Standard Deviation=32.69) in Phase 3 (Figure 22). While this difference is not statistically significant, this is likely due to the small number of participants responding to this question.

![Figure 22. Mean participant rating with error bars representing one standard error.](image)

In addition, participants were asked on the Phase 3 survey to explain their reasoning for their rating. Of the eleven participants who responded, six were from WSDOT, three from SDOT, and one each from KCM and SPD. Three of the participants responded that there was not yet enough experience with the VCC or data available in the VCC to make a substantial impact on their mobility strategies during a response to a major incident, and the respondent from KCM said that they did not utilize the VCC for congestion management. The remaining seven respondents, however, provided higher ratings (lowest rating was 58 out of 100 while the highest was 100 out of 100) and indicated that they were likely to make changes in mobility strategies in future incidents given the information in the VCC. Below are quotes from two participants:

“The information flow in VCC to other agencies is far faster than any other means we currently use. The more that operators become familiar with it, the more impactful it will become.”

“Can make faster decisions on the fly. Easier to pivot on the fly.”

It is particularly challenging to draw clear conclusions from the assessment of these evaluation questions given the small number of respondents and the lack of complex incidents during the post deployment period. However, at least some VCC users, particularly those at the DOTs with existing histories of interagency collaboration, find the VCC a way to enrich their interaction with
each other even if the mode of that interaction (i.e., telephone) does not entirely shift to the mode of the VCC.

Overall, the evaluation demonstrated that the VCC provided many institutional and administrative benefits. The trusted data available in the VCC provided a common operating picture of an incident thereby increasing shared situational awareness and improving intra-agency and inter-agency coordination for users of the VCC. As discussed above, these VCC users are gradually learning to use the VCC and to incorporate it into their work, and protocols and processes are still being created and refined. Since no significant major incident occurred that required extensive, ongoing collaboration between agencies since the deployment of the VCC, it has not had the opportunity to be fully stress-tested with respect to institutional and administrative benefits. Therefore, the Project Team strongly recommends reassessing this suite of evaluation questions after a longer period of VCC adoption and learning curve.

3.7.2 Reduced congestion and/or improved mobility

We identified three objectives that align with the FAST ACT goal of reducing congestion and/or improving mobility, and present below the results of the evaluation questions for each objective.

3.7.2.1 Provide agencies with access to trusted, secure, and actionable data to quickly respond to congestion resulting from major roadway collisions.

To measure the VCC’s ability to improve mobility during a major incident the evaluation plan included one qualitative and one quantitative question:

Question 16 Does the Incident Model improve the Congestion Management team’s ability to monitor and manage I-5 corridor operations during a major incident?

Question 17 Does the VCC improve mobility during major incidents in the Seattle/Central Puget Sound Area?

On the post-deployment surveys, VCC users whose primary role was to manage the congestion resulting from major incidents were asked to use a visual analog scale with endpoints of Strongly Disagree on the left and Strongly Agree on the right to rate their level of agreement with the following statements.

- The VCC Incident Model has improved my ability to monitor and manage I-5 corridor operations during a major incident.

- I feel I have more information about an incident now that I have access to the VCC.

There were 14 VCC users who responded to this question on the Phase 1 and Phase 2 post-deployment survey and 11 on the Phase 3 survey. As seen in Figure 23, agreement with the
above two statements was approximately 50 out of 100 for both questions and increased to approximate 54 and 58; however, this increase was not statistically significant.

Figure 23. Post-deployment survey ratings by congestion managers of VCC’s impact on mobility.

To increase participation in the evaluation, those users who had activated their VCC login were asked to respond to a series of one-minute surveys during Phase 3 of the post-deployment period. These surveys included one question requiring a Yes or No response. Table 9 shows the questions asked, the percentage of respondents answering Yes, and the number of respondents who indicated that they had enough experience with the VCC to answer this question. While the response rate was like the above questions on the longer post-deployment surveys asked only of congestion managers, these respondents also included first responders and public information officers. This suggests that the VCC has valuable information, saves them time when working an incident or managing congestion, provides them with information that they cannot find elsewhere, and improves their ability to coordinate with other agencies across all incident management roles.

Table 9. Phase 3 one-minute survey questions.

<table>
<thead>
<tr>
<th>One-minute Survey Question</th>
<th>Percentage “Yes”</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Has the information in the VCC been useful to your work?</td>
<td>93%</td>
<td>14</td>
</tr>
<tr>
<td>Has the VCC saved you any time when working an incident or managing congestion?</td>
<td>56%</td>
<td>16</td>
</tr>
<tr>
<td>Has your ability to coordinate with other agencies improved since using the VCC?</td>
<td>69%</td>
<td>13</td>
</tr>
<tr>
<td>Has the VCC provided relevant information you could NOT have easily obtained elsewhere?</td>
<td>83%</td>
<td>18</td>
</tr>
</tbody>
</table>
Access to trusted, secure, and actional information is a key component of managing the congestion from a large, complex incident; therefore, we expected participants would find it easier to obtain information during a large, complex incident one they became familiar with using the VCC. On both the baseline and post-deployment surveys we asked participants to rate their level of difficulty in obtaining necessary information about an active VCC-level incident both from others internal to and external to their agency. As expected, we found that participants rated their ability to get information from those external to their agency as easier post-deployment than pre-deployment; however, this difference was only marginally significant, Mann Whitney U=2026.5, p=0.09 (see the two bars on the right on Figure 24). Somewhat surprisingly we found an even greater, and significant, improvement in the ability to get information from those within their own agency, Mann Whitney U=1532, p=0.0003. This improvement may be a result of individuals outside of the WSDOT Traffic Management Center and SDOT Traffic Operation Center, such as incident response team members and executives, getting access to incident data via the VCC rather than having to call into these centers to get information. A review of the individuals responding to the Phase 3 survey confirms this hypothesis. Approximately 60% of the respondents were from one of these two groups and they had a mean rating of 85.21 compared with a rating of 70.47 for those participants in roles within the centers.

![Figure 24. Comparison of mean ratings from the baseline and phase 3 post-deployment surveys about the difficulty of obtaining information regarding an active VCC-level incident both within and external to the agency](image)

Answering Question 17 using quantitative measures such as maximum throughput, percent of person-miles traveled on the interstate, and on-time performance for transit providers was much more difficult. For example, while on-time performance for transit providers is available from KCM, finding comparable incidents of similar complexity pre- and post-deployment was challenging as KCM does not include incident data along with their performance records. In
addition, assigning a causal relationship to any increase or decrease in on-time performance to the VCC was not possible, primarily because VCC use at KCM and Sound Transit was limited due to staffing shortages. Despite the slow adoption of the VCC, those VCC users in the KCM Transit Control Center who were using the VCC found certain capabilities to be very useful. For example, the Situation Map was frequently used to see which incidents could impact transit routes. They also made use of the camera layer on the Situation Map as they previously had only limited access to WSDOT cameras and found the cameras on the VCC easier to use than those on the public feeds. According to one VCC user from KCM: “It’s [the VCC] the best tool we’ve seen for traffic camera visuals. Seeing an event unfolding is very important for us. VCC is very intuitive for people who are visual – better than some list-based systems.”

The lack of very large major incidents may be affecting the strength of the survey responses as well as the ability to evaluate mobility using the above quantitative measures. As more users adopt the VCC, measuring mobility improvements during incidents will be better and easier. It may also be the case that the learning curve of the VCC is taking longer than we would have hoped for some users. To that end, the Project Team proposes some user experience enhancements and additional data sources in Appendix F. In the future these questions should be evaluated again to determine if additional users, improved familiarity with the VCC, or the planned improvements have had the desired effect on mobility.

From the one-minute survey results, the high percentage of respondents (83%) who said they did get information they could not have easily obtained elsewhere seems to contradict the more neutral responses on the evaluation survey. As previously indicated, this may be due to slightly different demographics; those who reply to the one-minute survey are likely those who are more active users, so they might be already aware of the benefits of the VCC to them. The Project Team wants to ensure that the VCC has value for as wide a range of users as possible, so we would ideally prefer to have similar ratings from both instruments. Further, almost all one-minute survey respondents said that the VCC has been useful, but only about half have said it saved them time. This echoes interview findings that time saved is sometimes less important than information density or quality of time spent.

3.7.2.2 System alerts of major incidents

Another way to reduce congestion is to provide users with system alerts that give them earlier awareness of evolving major incidents. This awareness enables them to get an earlier start on coordinated actions to ameliorate the situation. This was evaluated by focusing on the VCC rule-engine, and asked the following evaluation question:

Question 18 Is the rules engine making good decisions in terms of auto-generating Incident Models for VCC-level incidents?

As dispatches come into the Integrated Dispatch Feed, they are evaluated by transportation managers who can launch an Incident Model if they are seen as indicating a likely VCC-level
incident. In addition to this human review, the VCC applies these rules to identify possible VCC level incidents:

- Events from Seattle Fire Department that include “Tunnel MVI”, “Car Fire Freeway”, or “Fire Response Freeway” in event type.
- Events from Washington State Patrol in Area “I5” that include “Road Closure”, “Fatal Traffic Collision”, “Disabled Vehicle Fire”, or “Possible suicidal pedestrian on bridge or overpass” in event type.
- Events that include “bridge” in location and “blocking” in event type.

If a dispatch meets these criteria, the VCC auto-generates an Incident Model based on the dispatch, and an email alert of a system generated Incident Model goes out to users. All system-generated Incident Models must be verified by a human Incident Manager.

While the rules engine provides some early notification of potential major incidents, there are many cases where VCC-level incidents are not automatically classified as such in the VCC system. This is due both to limitations of the rules and to the nature of incidents, some of which appear to be relatively common occurrences but evolve into more complicated situations. The analysis of large amounts of data from dispatch events and incident logs, as well as other relevant data sources, can provide useful insight into the characteristics and patterns of events and responses, enabling both enhanced and improved rules for auto-detection that provide early awareness of evolving incidents. An analysis of the rules engine and Incident Models can be found in Appendix G.

The team found that the rules engine generates several false positives, which requires additional labor on the part of users because they must manually delete these misidentified incidents. However, these system-generated false positives have not been increasing in number over time as the number of total incidents has increased, indicating that the relative burden of managing them is decreasing. In addition, because of unexpectedly increase in complexity, a small number of false positives may not be entirely avoidable.

There are also quite a few false negatives in terms of human-generated incidents based on collision-focused dispatch events. The incident types of such human-generated incidents often include the term collision (such as COLLISION INJURY UNKNOWN), but since that is such a common dispatch event type indicating early uncertainty about a given situation, it on its own would not be significant enough to lead to a system-generated Incident Model. Further analysis of such incidents is needed to determine what additional characteristics of such dispatch events might be automatically detected and lead to a system-generated Incident Model. It is also possible that such additional characteristics tend to be added later in the life cycle of a dispatch event, or are correlated with non-dispatch information, and thus would not be recorded by the originating dispatch systems before a human VCC user would detect them anyway. It may well be that their curation and evaluation as VCC incidents by human users is already happening as quickly and efficiently as possible. Further research is needed to determine this, or if there are
methods of detecting relevant information beyond an individual dispatch event’s data (such as geographic proximity to other dispatch events recording similar information).

Closed incident models can provide us with a deeper understanding of how the rules engine performed in the automatic classification of dispatches as VCC-level incidents. Every incident model in the VCC can be either (1) closed when the situation is cleared or (2) deleted if it was created incorrectly, was a test, or was system generated and never verified. Table 10 shows the number of Incident Models that were both closed and deleted, how many of them were created by users versus the system, and how many had a duration greater than 90 minutes.

The closed system generated Incident Models represent 28.15% of all closed Incident Models, while the deleted system generated Incident Models are 44.23% of all deleted models. This higher likelihood of system-generated incident models being “incorrect” was expected, as the rules engine is still quite simple and may inaccurately classify some dispatches as Incident Models, which are later deleted as unverified. However, out of all the system-generated Incident Models (108), only 21.29% were deleted, suggesting that almost 80% of all these Incident Models were verified by a user or at least worthy of closing (which maintains a record). This suggests that the initial design of the rules engine was a promising start, as it was able to identify about four out of five real incidents.

User generated incident models can also be used to assess the rules engine. While 217 incident models were generated by a user, that is the rules engine failed to identify them first, we must also consider that 14% (30) of these were Flammable Cargo restricts (11) and Maintenance Closures (19) that were planned events which are not recorded by any of the agency dispatches. Taking this into consideration, we see that the rules engine failed to identify 62% of incident models. In addition, 27% of incident models were correctly identified by the system. In Appendix G, we present proposals to reduce these missed incident models based on user input and analysis of Incident Models to identify patterns that might lead to more specific and accurate rules.

Finally, we can look at duration of the incident models to assess the rules engine. From Table 10 we see that 50% of the incident models generated by users had durations greater than 90 minutes compared to 54% generated by to the rules engine. While the rules engine was slightly better at identifying longer duration incidents, we must keep in mind that incident models may not have been closed immediately upon the clearance of an incident as VCC users may have been occupied with other tasks (see Section 3.5 for additional details) so we should be careful to draw too many conclusions from this performance measure.

Table 10. Number of Incident Models with Final Status of Closed or Deleted and with durations longer than 90 minutes.
### Incident Model

<table>
<thead>
<tr>
<th>Final Status</th>
<th>Created by</th>
<th>Number of Incident Models</th>
<th>Number of Incident Models with a duration longer than 90 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed</td>
<td>User</td>
<td>217</td>
<td>109</td>
</tr>
<tr>
<td>Closed</td>
<td>System</td>
<td>85</td>
<td>46</td>
</tr>
<tr>
<td>Deleted</td>
<td>User</td>
<td>29</td>
<td>n/a</td>
</tr>
<tr>
<td>Deleted</td>
<td>System</td>
<td>23</td>
<td>n/a</td>
</tr>
<tr>
<td>TOTAL Incident Models</td>
<td>n/a</td>
<td>354</td>
<td>155</td>
</tr>
</tbody>
</table>

From this analysis, we can draw the conclusion that the identification of major incidents is a subtle and complex issue that will benefit from ongoing iteration: both in terms of updates to the rules engine, and thoughtful discussion with users as they learn to incorporate the VCC’s information into their workflows.

3.7.2.3 Lessons for demand reduction

To benefit future deployments of the VCC to other regions, participants were asked the following question:

**Question 19 What lessons were learned to reduce the demand on the I-5 corridor during major incidents that can benefit future VCC deployments in other regions?**

During the post-deployment interviews VCC users were given the opportunity to discuss what they learned when using the VCC for traffic and congestion management and how it might benefit future deployments. One interviewee suggested that having a common set of event types would make it easier for users from different agencies to quickly scan the Integrated Dispatch Feed to decide which events to monitor. For example, an event involving a motor vehicle sometimes uses the acronym MVC in the event type, while other agencies use COLUNK, which stands for “Collision, Injury Unknown.”

Another interviewee suggested using the VCC for planned events, such as the Taylor Swift concert and the Major League Baseball All-Star game in Seattle in July 2023, because they require extensive coordination between agencies prior to, during, and after the event. While the VCC’s Incident Model was designed using unplanned, traffic-related use cases, VCC users found ways to use it for planned events, such as closures and maintenance discussed in 3.7.1.7, demonstrating that its use could be expanded to planned events.

Additionally, beginning to plan for how to use the VCC to manage major, catastrophic events such as earthquakes was suggested by an interviewee. Knowing what’s still operational (rather than what is not) would help with the rerouting of commuter traffic as well as the routing of emergency responders to critical areas.
During the deployment period, VCC users demonstrated that the VCC provided value even in those less severe, less complex incidents. The above examples all speak to how the VCC can provide value across the severity spectrum for both planned and unplanned events and can have a positive impact on congestion and mobility. In addition, while there was insufficient time to make changes to the rules engine based on data analysis and user feedback, we believe that rules engine was a good first step towards a smarter approach to the early identification of large incidents that would severely impact mobility and we encourage future research in this area.

3.7.3 Effectiveness of providing integrated real-time transportation information to the public to make informed decisions

While the VCC does not include a public-facing portal, we believed that the Public Information Hub (see 2.1.5.1) would enhance messaging provided to the public allowing them to make informed decision. To measure the VCC’s impact on this goal, we present the results of the evaluation questions that align with the objectives below.

3.7.3.1 Improve timing, accuracy, and consistency of messaging to the public and major employers

Question 20 Do Public Information Officers perceive that their messages to the public are getting out more quickly and are more actionable?

Public information officers (PIOs) did not have many opportunities to engage with the Public Information Hub given the lack of large-scale, complex incidents during the post-deployment period. However, as one public information officer wrote on the Phase 3 post-deployment survey, “For high-level incidents requiring coordination, the POP-MO [population movement] group members would use this [Public Information Hub] to coordinate messaging or share what messaging we are issuing. Thankfully while we remain likely to engage, large scale incidents have not been prevalent.”

In the two Incident Models where PIOs did use the Public Information Hub, they shared links to Twitter posts and provided updates on closures. For example, for an Incident Model created for a maintenance closure on the Seattle Ship Canal Bridge, the public information officer wrote,

“SEATTLE From 9 a.m. to 1 p.m. Wednesday, March 8, two right lanes on the southbound Interstate 5 mainline will be closed at the Ship Canal Bridge (milepost 168) in Seattle. Washington State Department of Transportation bridge maintenance crews will be repairing potholes. To alleviate backups, the I-5 express lanes will remain southbound until work is completed before reversing to northbound for the afternoon commute. Commuters should anticipate significant delays on I-5 in Seattle.”

Despite the lack of opportunities, one VCC user during the Phase 2 interviews said that the VCC could help to get actionable messages out faster since they can see the initial scope of the
incident without having to call the WSDOT TMC, and that the initial alert helps them to understand how big the incident is going to be and how much they need to message it out.

In conclusion, the lack of existing engagement with PIOs, but their general interest in how the VCC might be useful to them during major incidents, highlights the need to continue proactively engage them. This way, when a large, complex incident requiring careful and deliberate public messaging does arise, PIOs who are VCC users feel ready to confidently take advantage of the VCC’s features for their work.

3.7.3.2 Impact on public messaging for improve decision making

Providing alternative travel options and encouraging travelers to use those options or delay their trips can reduce the congestion resulting from a major incident. The VCC, however, supports a trusted operational community and does not include a public-facing portal that directly provides travelers with congestion and alternative options. Rather, there is a Public Information Hub that is intended to enhance messaging and coordination among agency public information officers. Therefore, we focused our question on how the VCC impacted public information officers by asking:

Question 21 How does using the VCC impact your development of public messages related to VCC-level incidents?

Agency public information officers were interviewed and surveyed about their use of the VCC for developing public transportation messages. While there was no data to confirm direct VCC impact on the development of public messages related to major incidents, there was encouraging anecdotal information that indicated both general benefit and likely future use. The Public Information Hub was the last major feature developed for the VCC model deployment, and public information officers may still be figuring out how it best fits into their shared workflow. Despite this, public information officers described the VCC as “an aid in understanding the magnitude of incidents,” and indicated they continued to see the benefit of the Public Information Hub to make all VCC users aware of their communications.

3.7.3.3 Lessons for population movement

Question 22 What lessons were learned to facilitate the creation of a unified, timely, and actionable message to members of the traveling public?

Question 23 What lessons were learned about how to engage major private employers in assisting with the distribution of messaging during major incident response?

In the time spent with Public Information Officers in the design and development of the Public Information Hub and during post-deployment activities, a lesson learned that care must be taken to create messages that were accurate, and that the most trustworthy information comes from the incident scene. When VCC design first began, there was a belief that the VCC could be
used at the scene to record details such as key decisions, actions taken, and resource allocations. While there was not an opportunity to test this during the post-deployment period, there was some evidence of WSDOT IRT entering information directly into the VCC. However, for the VCC to be used by those with smaller displays such as laptops and tablets, the VCC must be enhanced to provide responsiveness and mobile compatibility. See 4.2.7, Ongoing Co-Evolution of Use and Technology.

Early work on the VCC was much more directly connected to the needs and constraints of major employers, both because of the partner participation of entities like Challenge Seattle, and the recognition that large employers’ presence in downtown Seattle can significantly impact traffic patterns, especially during morning and evening peak hours. Major employers such as Amazon and Microsoft take direct actions to manage their employees’ single occupancy vehicle traffic in Seattle, such as in the form of company shuttles and financial support of commuter-heavy Metro bus routes. The team initially planned to include major employers as possible read-only VCC users, so they could proactively use its information to send out messaging to employees requesting they delay heading home in the event of a major traffic incident and thus avoid contributing significantly to the incident’s congestion or any secondary incidents. Engagement with representatives of major employers had begun prior to VCC development. However, all of these plans were altered by the pandemic. The Project Team, as all others, saw the complex impacts of hybrid and remote work during the early months of the pandemic, largely negating major employers’ traffic impacts for some time. Most recently, many companies are attempting to bring workers back to their downtown offices. Thus, there is a lack data or an analytical through-line to assess this question. Now that commute and in person work patterns have begun to normalize, the team recommends re-establishing contact with major employers to learn more directly how information from the VCC could be of mutual benefit to them and to the VCC’s member agencies.

In conclusion, despite the lack of large-scale incidents that would have provided public information officers with opportunities to engage with the VCC, there was some evidence that the information available in the VCC combined with the incident notification email could help to get actional information out to the public faster to inform their travel decisions.

3.7.4 Improved safety

The VCC was designed to support the management of high-impact situations that put unusual stress on the Seattle-area transportation corridors. As such, we believed that one way to evaluate the goal of improved safety was to include Question 24 because the faster an incident is cleared, the sooner incident responders could remove themselves from the potential dangers experienced at the crash site.

Question 24 Does deployment of the VCC reduce incident clearance time?

To answer this research question, the team reviewed the Washington Incident Tracking System (WITS) and the SDOT TOC Call Logs for incident clearance times pre-deployment to compare
them to similar sized incidents among the 302 incidents in the VCC that occurred post-deployment. However, this research question turned out to be difficult to answer as the WITS data had only incident date and type to compare, but was lacking location, updates, units, or other information that could assess the size of the incident. The SDOT call log data has more data, but both datasets are very large (34,000 rows and 21,000 rows, respectively) indicating that each row would be a dispatch event and to be able to compare to the 302 VCC Incident Models, there would need to be an incident detection algorithm, which is being worked on in order to improve the rules engine, and given the limited data is not yet possible.

3.8 Benefit-Cost Analysis

A Benefit-Cost Analysis is an evaluation technique that systematically identifies and compares the benefits and costs of implementing a new project. Since the benefit-cost analysis incorporates all the benefits and costs arising from a project or program with a societal perspective, its result can guide transportation professionals to make the most economically advantageous decisions for society (i.e., choosing the alternative that maximizes the net societal benefits). There are multiple benefit-cost analysis guidelines and evaluation examples performed in the context of traffic incident and safety management systems (Guin et al., 2007). The Project Team’s analysis follows their approaches within the limitations of data availability.

3.8.1 Measuring Benefits

To calculate benefits, three types of savings were considered that the implementation of the VCC would bring into a society: 1) savings from additional time spent on the road due to delay, 2) savings from additional fuel consumption due to slowed traffic or waiting, and 3) savings from additional emissions of pollutants due to delay.

1) Savings from additional time spent on the road due to delay was calculated by first determining the total number of vehicle hours of delay (VHD) caused by the incidents. We employed the following formula to attain this objective.

\[ VHD = F \times R \times T \]

where \( F \) is normal traffic flow at the incident site and time, which implies the average hourly traffic volume. \( R \) is reduction capacity due to incident, and \( T \) is duration of incident (hours). The data pertaining to the average hourly traffic volume \( (F) \) was obtained from the WSDOT traffic count database system (TRACFLOW). We then matched it to each incident record based on the time of the incident and its proximity to the nearest mile post. Roadway reduction factors \( (R) \) for incidents on freeways, established by the US Federal Highway Administration, were incorporated into our analysis (Bertini et al., 2004).

Time costs reflect the value of labor loss due to incident delay, accounting for the largest portion of incident delay costs. The cost of delayed time was estimated using the following model.
Total cost_{delay\_time} = L_{hour} \times VO \times VHD

where \( L_{hour} \) is hourly labor cost, VO is vehicle occupancy, VHD is vehicle hours of delay adopted from the prior analysis.

Following the USDOT guidance, we used $17.90 (i.e., general travel time saving per person-hour) as a reference for the hourly labor cost. For the base case scenario of the BCA, we assumed a vehicle occupancy rate of 1.15.

2) Savings from additional fuel consumption due to slowed traffic or waiting was calculated by first converting the measure of VHD into vehicle miles of delay (VMD) using the formula below. We assumed an average speed of 20 miles per hour during the incident.

\[
VMD = VHD \times \text{Average Speed during the Incident}
\]

Then, we calculate the amount of extra fuel consumption (gallon) as follows. We obtained the information regarding average fuel consumption per mile from all vehicle types in the US\(^6\).

\[
\text{Additional consumption (gallon)} = VMD \times 0.04016 \text{ gallons per mile}
\]

Lastly, we estimated the associated costs by multiplying the additional fuel consumption with the average gas price per gallon in Washington\(^7\).

\[
\text{Total cost}_{\text{fuel}} = \text{Avg.} P_{\text{fuel}} \times \text{Total gallon}
\]

3) Savings from additional emissions of pollutants due to delay was calculated by adopting the method used by Guin et al. (2007) to estimate the costs associated with extra emissions of pollutants due to incident delay. Three different types of pollutants, i.e., HC (hydrocarbons), CO (carbon monoxide), and NO (nitrogen oxides), were considered for estimation of the costs. The hourly emissions of these air pollutants were calculated to be 25.676/10^6 tons for HC, 338.69/10^6 tons for CO, and 36.064/10^6 tons for NO. Reducing 1 ton of emissions would result in cost savings of $6,700 for HC, $6,360 for CO, and $12,875 for NO. We applied the following model to each pollutant separately to obtain total cost savings associated with extra emissions.

\[
\text{Total cost}_{\text{emission}} = VHD \times Emission_{\text{hour}} \times Price_{\text{gas/ton}}
\]

3.8.2 Measuring Costs

---

\(^6\)Source: US Environmental Protection Agency [https://www.epa.gov/automotive-trends/explore-automotive-trends-data#DetailedData]

\(^7\)Average gas price per gallon in WA by years: 2017- $2.91; 2018 - $3.27; 2019 - $3.18
The costs of the VCC are based on the Federal Highway Administration award of $3,424,361 for the development of VCC in 2020, the cash match of $1,410,000 from WSDOT, the in-kind match of $3,769,000 from the private and public sectors, and the $1,600,000 estimated yearly operating expenses of the VCC, which includes staff, ongoing software licenses, and maintenance costs. A 5% discount rate was applied for both benefit and cost outcomes over the period of 10 years.

Below is a summary of the results of the benefit-cost analysis and offer conclusions based on the team’s analysis. Details concerning the literature review conducted prior to performing the benefit-cost analysis, the data sources used, and the methodology can be found in Appendix H Benefit-Cost Analysis.

3.8.1 Benefits and Costs

Total benefit includes both current and future benefits, with the latter calculated as the sum of present values of expected benefits over a 15-year period. Reducing incident duration by 30 seconds and one minute for all incidents covered by VCC would yield a benefit of approximately $9-17 million, depending on the amount of time the incident was reduced. The total cost of VCC comprises the initial investment and yearly operating expenses. The total costs are estimated to be approximately $27 million for 15 years.

3.8.2 Benefit-Cost Ratio

The benefit-cost ratio is calculated by dividing the total benefits expected from a project/program by its total costs. A ratio greater than one indicates that the expected benefits of the project/program exceed the costs, implying that the project is likely to generate a positive return on investment. The results of the benefit-cost-ratio for the VCC across the different levels of incremental delay savings are presented in Table 11 below. The analysis demonstrates that a three-minute decrease in incident delay would result in a benefit-cost ratio of 1.07.

Table 11. Results of the benefit-cost ratio (unit: US dollar). A severe incident is defined as an occurrence requiring more than 20 minutes for the clearance of affected lane(s).

<table>
<thead>
<tr>
<th>Delay time savings</th>
<th>Total benefit</th>
<th>Total cost</th>
<th>Benefit-cost ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 seconds</td>
<td>4,736,677</td>
<td>26,554,492</td>
<td>0.18</td>
</tr>
<tr>
<td>1 minute</td>
<td>9,487,199</td>
<td>26,554,492</td>
<td>0.36</td>
</tr>
<tr>
<td>2 minutes</td>
<td>18,923,943</td>
<td>26,554,492</td>
<td>0.71</td>
</tr>
<tr>
<td>3 minutes</td>
<td>28,391,762</td>
<td>26,554,492</td>
<td>1.07</td>
</tr>
<tr>
<td>4 minutes</td>
<td>37,843,047</td>
<td>26,554,492</td>
<td>1.43</td>
</tr>
<tr>
<td>5 minutes</td>
<td>47,269,955</td>
<td>26,554,492</td>
<td>1.78</td>
</tr>
<tr>
<td>6 minutes</td>
<td>56,769,410</td>
<td>26,554,492</td>
<td>2.14</td>
</tr>
<tr>
<td>Delay time savings</td>
<td>Total benefit</td>
<td>Total cost</td>
<td>Benefit-cost ratio</td>
</tr>
<tr>
<td>-------------------</td>
<td>----------------</td>
<td>--------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>7 minutes</td>
<td>66,261,545</td>
<td>26,554,492</td>
<td>2.5</td>
</tr>
<tr>
<td>8 minutes</td>
<td>75,714,945</td>
<td>26,554,492</td>
<td>2.85</td>
</tr>
<tr>
<td>9 minutes</td>
<td>85,201,483</td>
<td>26,554,492</td>
<td>3.21</td>
</tr>
<tr>
<td>10 minutes</td>
<td>94,683,061</td>
<td>26,554,492</td>
<td>3.57</td>
</tr>
</tbody>
</table>

The findings suggest if the time to clear lanes is reduced by approximately three minutes on average after the introduction of the VCC, the benefits would exceed the costs (see Table 11). Analysis did not account for incidents that occurred in the major arterials of the region, as sufficient data was unavailable. Consequently, one can expect that extending the geographical coverage of the VCC is likely to result in an increase in the benefits.

3.9 Overarching Conclusions from Evaluation

There are two major overarching conclusions from the VCC evaluation effort. Together, these conclusions are potential future game changers for the understanding and assessment of integrated corridor management.

1. An evaluation plan for a community-centered, agilely designed operational environment must itself be agile even into the post-deployment period if it is going to evaluate the innovative activity that this new environment engenders.

2. The data available in the VCC (and other future VCC-like operational environments) provide a major opportunity to analyze and evaluate multi-agency integrated corridor management in new and far more effective ways.

The Project Team learned that the evaluation plan needs to be agile beyond the launch of model deployment if it is going to adequately assess the innovative collaborations evolved in this new virtual environment. Not only are the community’s use of new features and capabilities still being evolved by the partner agencies, but also the data being generated is still being determined. Key VCC milestones in the processes of integrated corridor management, such as the launch and closure of an Incident Model, were still only general ideas when the evaluation plan was already completed and approved. By employing an agile evaluation plan, new and critical measures of impact and effectiveness can be evolved in parallel with the evolution of innovative operational processes and new interagency data.

This leads to the second point. The VCC brings together existing agency data such as dispatch records and new multi-agency data such as the information entered into an Incident Model, all organized around the management of incidents. This combination and organization of existing agency data and new VCC data provides an intriguing opportunity for new measures and analyses of regional incidents and how they are managed. It is as yet unclear what the agencies
are doing with the new multi-agency data beyond retaining for compliance with public records laws.

The team recommends thoughtful consideration of how the new combination of data in the VCC can be used to analyze and evaluate multi-agency integrated corridor management in new and far more effective ways, while still meeting the records retention and management needs of the individual partner agencies.
4. Lessons Learned and Recommendations

The final chapter of this report is not the final chapter of the VCC. The model deployment of the VCC, developed with significant support from FHWA, is now a state-funded program managed by WSDOT. The program is funded to maintain the existing system and also to expand it. There is much the Project Team learned and is still learning that will help to manage the future of the VCC program.

In addition, the VCC in its current form is a model for other VCC-like efforts that could help other regions and cities, especially about the creation, nature, management, governance, and evaluation of a virtual collaborative environment for integrated corridor management.

Following are these lessons and recommendations from the VCC model deployment, organized by: (1) Community-Centered Design and Development, (2) Features and Capabilities, (3) Policy and Governance, (4) User Management, (5) Future Enhancements, and (6) Moving Forward.

4.1 Community-Centered Design and Development

Over six years of co-creation with a diverse community of agencies, three under FHWA funding, the VCC team has learned a number of lessons associated with the management of a community-centered design, development, and implementation project. The goal was to develop and evaluate a collaborative operational environment that was designed by the transportation management community, for the transportation management community. Partner stakeholders were diverse agencies with different but overlapping missions, policies, jurisdictions, standard procedures, systems, data, and cultures. There were city, county, and State agencies with law enforcement, freeway, arterial, and transit focuses.

Given these goals and the diversity of partner agencies, the most critical management activity was community building. Expanding and reinforcing the operational community was the secret ingredient for everything from data integration and feature design to incident detection and operational updates. A shared operational environment is built upon existing relationships and grows by expanding those relationships.

Some key community building and community-centered design takeaways were:

- Sharing a new operational environment will impact how people work together, but you cannot jump right to a new collaborative vision; you must start by recognizing and building on the different ways that agencies and operational roles currently interact.

- Many new features seemed to call for new shared standard operating procedures, but this is an extremely sensitive issue that must be community owned and addressed over time. The project team was very sensitive about not telling agencies how to do their jobs.
● The community adopted change more through collaborative use, feedback, and refinement, than through formal agreement.

● VCC had to be an environment that produced value when needed and didn’t add work when it wasn’t. The community would not accept another system or tool that required additional care and feeding that distracted from their already demanding work.

● The community did not want a specialized application that they would only use during rare, high-impact, complex incidents. They wanted an environment that provided value on a daily basis yet enabled them to adjust and expand their activities as required by the complexity of the situation.

● Multi-jurisdictional areas were a sweet spot for VCC use that led to community building. For example, SR 99 is both a state highway and a city street. Incidents involving SR 99 called for shared community awareness of evolving situations and associated multi-agency dispatches and actions. These natural interagency incidents were a driving force behind VCC adoption and use.

● The project team presented options, but the community set priorities. This could require the project team to reduce its ambitions and scope. For example, the project team initially prioritized efforts to meet Section 508 accessibility guidelines and to develop a mobile version of VCC, but the operational community was focused on core CAD and Incident Model features. As always, the community ruled.

● The cost of community buy-in and time was more significant than dollars. Any direction that lost engagement and buy-in of the operational community was too costly, no matter how seemingly beneficial or economical the effort.

4.2 Features and Capabilities

There have been numerous lessons associated with the current VCC features and capabilities. This is not surprising as these have been co-created over time with the operational community. Continued and expanded use of these features and capabilities will continue to generate new lessons, leading to ongoing enhancement and improvement.

4.2.1 Interface and Display of Incident Data

As a model deployment, the current display of data from dispatches and within Incident Models has been extremely successful. However, the lack of uniformity in content and format of dispatches from different agencies was challenging, and often was handled by allowing the differences within the display. Unique formats, like that of the TMC Log, were presented as is and appended to associated WSP dispatches. While this was a vast improvement for agencies who, before the VCC, did not already have ready access to this useful information, it was not optimal for future possible interface options such as supporting user searches or integrating
displays. As VCC expands geographically, these issues are likely to become even more important. New partners will mean new and more types of data to be understood and integrated; additional focus on incidents outside the immediate Seattle area will mean more regions to be represented and accessible in support of new collaborations.

Appendix F presents an extensive review of possible VCC interface and display enhancements that could improve user ability to identify and manage data of interest for future interagency management of incidents and mobility.

4.2.2 System-generated Incident Models and Alerts

The VCC provides an environment for supporting agency operators by learning from the vast amount of data on events that impact the transportation system. During model deployment, the Project Team explored using available data to determine if an event, such as a traffic accident, is likely to develop into a major incident – a VCC-level incident. Early detection and prompt notification of such incidents can facilitate collaboration among the community of agencies, both to respond to the incident and manage the resulting congestion.

As an initial effort, the Project Team collaborated with the community to develop a set of rules that would enable the VCC to automatically generate an Incident Model. Every dispatch event received by the VCC is evaluated against these rules. If the rules are satisfied, the system generates an Incident Model and sends out an alert to all users. If the incident is worthy of people’s attention, then this automatic detection and alert enables users to collaborate as quickly as possible. If it is not worthy of their attention, it is an unwanted distraction.

See Appendix G for a quantitative analysis of Incident Models and a plan moving forward for improving the rules that produce system-generated Incident Models, based on this data analysis and interviews with users.

4.2.3 Records Management

The Records Management feature described in 2.1.7 is working well but is still part of a learning process. The general approach sends the same information to each agency, leaving them to store and manage this information according to their own policies. Since each agency employs different data and records management systems, this approach seems efficient and equitable.

The records management reports and the Records Management feature generated value beyond meeting the formal records requirement for which they were created. The reports neatly encapsulate a wide variety of incident data, which can be used for analysis and to prepare reports for management. Moreover, the table of closed incidents reflected in the Records Management feature makes it easy to refer back to recently closed incidents for those with access. This raises the question of appropriate usage since the Records Management feature and functionality were originally viewed as being restricted. The Project Team recommends exploring the usefulness of this functionality beyond this original intention, including ways users
can access this information for their management reports without requiring them to download records management reports.

Finalization of records within the VCC prior to their being sent to agency records managers proved to be more onerous for users than expected. Expectations had to shift for how much human-in-the-loop was required to adequately monitor the VCC's data. Initially, the plan called for each closed Incident Model to be reviewed by a VCC Records Manager within 72 hours of incident closure to ensure that it did not contain any errors. The person who closed the incident was considered the ideal person to review and finalize it, but this was not enforced by the system. Any user with the VCC Records Manager role could finalize an incident. This was to increase the likelihood that someone would be available to confirm data quality and accuracy before moving the records on to individual agency systems.

In practice, this workflow did not work well. The assignment of a Record Manager to a given incident record was not straightforward. Since the system does not require any one person to finalize the report or send any individual reminders, report finalization often became out of sight, out of mind. Many incident records remained in the system for far longer than desired: months, in some cases. The Project Team adjusted by creating a script that automatically finalized incident records 96 hours after incident closure. Users were still encouraged to manually finalize reports, but if they did not, the system would do this task for them.

Many different solutions to distribute finalized incident records were examined, including the possibility of creating a secure link between the VCC and agency records retention systems. While this would be a more robust solution, only WSDOT had the existing capability, and each agency wanted to host and maintain records on their own agency's system. As such, it would have required considerable resources and time to vet, build out, and fully test this approach with all stakeholders. However, further VCC development efforts may wish to investigate this more robust option.

### 4.2.4 Pre-Planned Actions

One early project goal was for the VCC to support some form of pre-planned actions, perhaps through flexible templates of incident and/or congestion responses that could be used during common kinds of scenarios. One motivation for this was the success of pre-planned detours in the area south of Seattle around Joint Base Lewis-McChord. In early 2022, members of the project team and VCC users attempted to work toward design concepts for these pre-planned actions. Users were particularly interested in the possibility of establishing alternate routes/detours, along with associated interagency lane management and messaging strategies, which could be readily reused under well-understood incident conditions. For more about the role of the Concept of Operations in community-centered, agile development process, see Appendix E.

To support these activities, the Design and Development team worked with the Concept of Operations team to create operational scenarios that were used during design activities to
identify (1) responses that could be planned in particular types of complex incidents, (2) information that would typically be shared among agencies, and, if possible, (3) design features in the VCC that would best support these planned actions. This work was supplemented with one-on-one and small group interviews with a subset of users, to better understand the details and nuances of their strategic responses to complex incidents.

The Project Team found that people in different roles and at different agencies had very different perspectives on the feasibility of creating planned actions. Some, particularly those working at transit agencies, actively created and maintained internal planned actions and had extensive procedures for enacting and monitoring them, both from control centers and on scene. This may relate to the more fixed nature of transit operations. Others, typically those who managed congestion on a more macro level, thought major incidents were too nuanced, with too many inputs and moving parts, to create truly effective and applicable planned responses. These users also pointed out that Seattle’s unique and challenging geography make it hard to identify specific tactics or detour routes that can be meaningfully repeated between incidents. For this reason, the team decided to pivot away from planned responses for the time being and adjusted the project deliverables accordingly.

While the team did not directly develop pre-planned actions during the course of designing and developing the VCC model deployment, the time spent working on this proposed capability was still well spent and had unanticipated benefits. Several design insights from user engagements fed into other aspects of the VCC (particularly the Mobility Strategies tab of the Incident Model page). Additionally, the operational scenarios created were used in developing the Concept of Operations and were much richer and more detailed since they’d been tested out with a variety of real users.

Interestingly, in the time since this exploration of pre-planned actions was wrapped up, users have employed the VCC for uses that resemble pre-planned actions. These uses go beyond managing unanticipated traffic incidents. Users sometimes create VCC Incidents when they are planning to restrict the passage of flammable cargo in a tunnel or are planning to close off major roads for an extended construction period. These non-incident uses approach some of the goals of planned responses but arose naturally. This was an instance where the community-centered development approach allowed users to gain unexpected benefit and for the design team to continue learning about use cases for parts of the system that were not able to be developed during the original development period.

In general, the team still believes that planned responses are a worthy area of inquiry and development, and as VCC expands may be more easily applied to areas where the geography is more favorable or where the possibilities for ingress and egress near an area are more like the Joint Base Lewis-McChord case. The team expects that as VCC users in the Seattle area gradually develop their own shared processes and preferences, there may come a time when creating true pre-planned actions makes more sense.
4.2.5 Features with Location

There were useful lessons associated with features that included the description of location. For example, one value of the Integrated Dispatch Feed is related to its ability to give rich information about what is going on in specific locations. Of four dispatch feeds, not including the TMC Log, two provide less location information, partly due to variations in data creation/representation, and partly due to agency constraints based on their perceived need for information security. The challenge of providing useful location information is emblematic of many other complexities in creating a system for shared use that draws upon a variety of agency systems that were originally developed for other purposes.

Another example of a location challenge arose from pulling in the King County Metro's bus management and communication system. This system contains records created when KCM bus drivers contact the coordinators at KCM's Transportation Control Center. These records encompass a wide variety of issues drivers face, some of which involve reporting on traffic-impacting incidents in progress. However, because of the way the buses' vehicle location technologies report location back to the system, and the very nature of a bus as a moving object, the VCC was unable to pull in meaningful latitude/longitude data from these records. Records usually do include a street address, which appears in the Location column, but not a latitude/longitude, so there are no map pins for KCM events. This can make it more challenging for a user to associate a KCM dispatch event with a VCC event than it is for agency dispatches with latitude and longitude.

A third location challenge pertains to data security. While SPD's CAD system does produce both latitude/longitude and street address information, SPD chose not to include street address information in the records they push to the VCC for internal operational security reasons. While SPD dispatches can still be associated with Incident Models, it makes the glanceability of these records within the Integrated Dispatch Feed table more difficult. At present, the Location field for SPD records always shows "NA." Hopefully over time, the trust in the security of the VCC community will grow and encourage agencies to be more open in their information sharing.

4.2.6 User Interactions with VCC Features

Lessons could be drawn from user interactions with VCC features. For example, information fields in the Incident Model were not used uniformly. The Incident Commander field was only used once, while the Incident Commander Agency field was used in 29 Incident Models. There are several possible reasons why this may have occurred, including:

- Commanding Agency is more generally known than individual Commander
- Commanding Agency is more useful than individual Commander
- Users are unsure about or reluctant to name an individual
- It is not clear which users have the authority to announce the Incident Commander
Depending on the motivations behind this uneven use of information fields, it may be useful in the future to adjust the composition of Incident Model fields.

The Notes tab on the Incident Model was extremely popular. In many cases, information was shared in notes even when there was a field that was specifically included for that information. For example, users tended to indicate closures, detours, changes in signal timing, and variable sign messages under the Notes tab, even though there was a Mobility Strategies tab designed specifically for this information. The likely lesson is that users prefer a more conversational exchange of information rather than a more formatted constrained list of items.

Another lesson from the use of the Incident Model was a change in the concept of when an incident ended. As a shared collaborative space, it was originally thought that the Incident Model would be closed when the last active agency closed the Incident Model. The team learned that users view a VCC-level incident as less about specific agency participation and more about traffic management. This means that the Incident Model is closed when the incident is cleared and the traffic is flowing. This perspective is reinforced by the primary users who are at the WSDOT Traffic Management Center and the SDOT Transportation Operations Center. These users usually drive the evolution of Incident Models and close them when they are no longer engaged, even if, for example, the law enforcement agencies still have open active dispatches associated with the incident.

A related lesson was that agencies with missions that extend beyond transportation were less likely to use the VCC than agencies whose primary mission is to operate and manage the transportation system. SFD, SPD, and WSP were extremely cooperative in sharing their data for the benefit of the transportation community, but far less likely to fit VCC use into their existing workflows. This may be because transportation management is only a part of their law enforcement and emergency response mission.

Finally, transit agencies are still exploring their usage of VCC. Sound Transit is even considering what a VCC-like environment designed specifically for their needs would look like. What benefits and drawbacks would an agency-specific VCC provide? Could a VCC focused on transit enable transit agencies to better serve the traveling public? The Project Team looks forward to exploring these and related questions.

4.2.7 Ongoing Co-Evolution of Use and Technology

It is important to remember that current patterns of VCC use are not permanent. In its early stages, VCC use has continually evolved and for many new users is still an act of discovery. For example, law enforcement and fire agencies are currently infrequent users, but WSDOT Incident Response Team members with laptops in their vehicles and managers have recently been adopting the VCC, and SDOT Response Team dispatchers are beginning to incorporate VCC into their workflows. How this use plays out among the response community, including the evolution of technology access and possible mobile versions of the VCC, should be closely monitored and facilitated in the future.
Along these lines, SDOT and WSDOT are currently working to create a shared standard operating procedure for VCC usage. This is an extremely important initiative and likely to have considerable impact on patterns of VCC use. This impact should be investigated once the new procedures have had a chance to be completed and instituted. This information should also be shared with other DOTs who may use the VCC in the future.

There is a close connection between the evolution of VCC use and the evolution of the VCC itself. Every new incident managed with the VCC is a potential learning experience, and while clear and impactful lessons are not common, they should not be lost when they are available. For example, recently an SDOT TOC user launched the following Incident Model:

- **VCC Incident (8ab-b2)** was created by Jane Doe (alert 13:48) using WSP dispatch (type: fire, start 13:10, close 14:14). SFD dispatch added (type: encampment fire, start 13:10, close 14:06). Location: NE 50th St at 5th Ave NE (WSP dispatch location: S5 50TH Milepost 169-6). Contributing Factors: Fire

- **Notes:** (1) Signals were in flash. Signals are now dark. Fire has departed. SPD UPOs are no longer directing traffic. SDOT Signal Shop has been notified. (14:03) Posted by XXXX. (2) Traffic signals are back operational. (15:04) Posted by John Doe.

There are a number of potential lessons to consider in this incident. First, the SDOT user launched the Incident Model using a WSP dispatch, and then later added the SFD dispatch. This was unusual and cool to see a city user use a state dispatch to launch an Incident Model. What was their thought process? Did they consciously appropriate the WSP dispatch for city purposes, or has the VCC successfully built an operational community that transcends the particular jurisdiction and mission of a specific agency?

Second are potential lessons associated with the signal repair process. A note that the signal shop had been notified of the dark signals was posted at 14:03, and by 14:14 both relevant dispatches had been closed. However, the Incident Model was still open until a second city user associated with the signal repair team posted a note at 15:04 that the signals were operational. After John Doe posted this note, he closed the Incident Model. For an hour or so, the status of the Incident Model hinged on the status of the repair process, and this was unclear.

Should VCC incorporate a mechanism, perhaps an interim note, to facilitate reporting on the progress of signal repair? Should the evolution of the Incident Model leader from Jane Doe to John Doe be more explicit and clarify for the community the shift from an incident about fire to an incident about signal repair? These and other questions, stimulated by the operational community’s use of VCC to manage incidents, are central to the future of VCC.

The Project Team is still learning about the evolving perception and use of the VCC. Possible future enhancements in both use and system capabilities are likely to focus on improved understanding of the status of incident clearance, improved user identification of useful information, and improved usability of the Mobility Strategies feature to encourage wider use.
4.3 Policy and Governance

The governance of VCC has been an ongoing balance of WSDOT leadership and individual agency autonomy and collaboration. WSDOT leadership stems largely from its role as a state transportation agency and the recipient of funding that has been essential for making the vision of VCC a reality. However, respecting and supporting individual agency autonomy is equally essential since without the engagement and contributions of partner agencies the VCC collaborative vision is unattainable.

Interagency agreements and charter work have together established the foundation for the collaborative VCC effort. The VCC charter established the Steering Committee that helped govern the project during design, development, and operational testing. Operational agreements allowed partner agencies to use the VCC to manage congestion for real life incidents. Data sharing agreements formalized details about the sharing of agency data feeds with the VCC community, including clarification of retention and rules for data use. While many interagency VCC practices evolved within less formal operational relationships, these more formal agreements were the foundation that empowered operators and emergency responders to explore innovative collaborations.

Funding of VCC design, development, and implementation has been through WSDOT, either with State funds or Federal funding awarded by FHWA. Now funding for maintenance and expansion of VCC is coming to WSDOT from the State Legislature. Throughout the six-year VCC journey, WSDOT has exercised its fiscal and policy authority with an eye towards respecting the various missions, jurisdictions, policies, processes, and cultures of the partner agencies. This benevolent leadership, predicated on the value of self-motivated collaboration, has been essential to the success of VCC.

The VCC interagency Steering Committee, established by WSDOT, has been a critical component of shared governance and policy making. It has not, however, been the apex of a top-down organizational structure. Rather than govern VCC development and use, the Steering Committee has primarily been a forum for information sharing and a sounding board for ideas and strategies. Nevertheless, the Steering Committee assures that partner agencies have a forum where they can make their needs known and negotiate priorities.

4.4 User Management

From the project team’s perspective, user management encompassed three interdependent activities: (1) fostering operator engagement in the design and development process, (2) encouraging and facilitating user adoption of the VCC system, and (3) supporting active users. For details on these activities, see Appendix C. VCC User Adoption, Training, and Support.

While operators engaging in the design and development of VCC were not yet technically system users, they were taking the first step on the road to active VCC use. The busy transportation management community did not want yet another system dropped into their laps.
By taking a community-centered, agile approach to VCC design and development, the virtual collaborative environment evolved under the guidance of the operational community. As the product evolved, so did the operators’ shared sense of ownership and trust that their perspectives would be represented and respected. Operators began to look forward to the next iteration of their system so they could see how their input impacted the design of the VCC, and eventually so they could begin using it in their work.

Fostering operator engagement in this design and development process was key. Agencies needed to be engaged at the management level so that operators would be encouraged to participate. Once operators took part, it was critical to design user engagements to make maximum use of their time and revolve design around real-world cases that would be of interest to the transportation management community. Most importantly, the community had to be the driving force behind design and development decision making, not the project team.

User adoption evolved from this design and development process. Operators who had been most active in guiding the design decisions became the first and most active users. These tended to be WSDOT and SDOT congestion managers working at transportation centers as the VCC was most aligned with their existing workflows.

Thus, success was not a simple matter of numbers; rather it was a matter of identifying and supporting those users who were driving the development of VCC strategies that would be incorporated into regional transportation management. Eventually, 302 potential users received invitations to create a VCC account. Of those, 160 users created and confirmed their accounts. In actual use, however, about 30 users on a daily basis became the core group who employed the model deployment of VCC as a new and uniquely useful component of regional transportation management (Figure 19 in 3.7.1 shows daily usage during the evaluation period). This usefulness was focused on sharing information on incidents and management activities that crossed jurisdictional and mission boundaries.

Once active, users needed support to handle various types of problems that they encountered in navigating a new operational environment with multiple capabilities. As anticipated, there were unintended outcomes. Issues uncovered during operational use were recorded by users in a log that was immediately available to the project team. Some issues were classified as bugs and moved to a bug log where they were prioritized and addressed. Some issues were classified as ideas that would enable the VCC to better serve the needs of its users. These were maintained in an ideation log.

Items in the ideation log did not only come from operational use. Throughout the VCC’s design, development, and evaluation, additional features and capabilities were identified that could bring value to users. Much of this took the form of user stories created by the design and development team through the course of development; others arose from documenting user input across a variety of user engagements. The Project Team was not able to address all of these ideation user stories during the period of the demonstration project funding, but carefully documented and prioritized them so that when future capacity and funding are available, work
can begin efficiently and in a principled fashion. The number and variety of these ideation items are an indication of the potential depth and value of the VCC.

Following are categories that can be used to prioritize the ideation log and advance the goals of the VCC:

- **Going from Model Deployment to Product**: Ideas that contribute to the process of turning the VCC model deployment into a production version that can be put to widespread use. This would encompass additional work to assure that the VCC rests on a firm foundation for future expansion of scope and functionality.

- **User Administration and Communication**: Ideas that reduce the manual effort on the part of system and agency administrators to manage and support users. The current level of effort has been acceptable during the period of high-effort development and assessment of the VCC, and where the total number of users is relatively low. However, both of these conditions are likely to change, and there are a number of additional features that would facilitate how users are added, managed, and supported in a consistent and maintainable way. Foremost of these would be an improved administrative interface for filtering and bulk actions. While the current administrative interface contains several filters that can be used to produce a subset of users (e.g., based on status, name, agency), this should be expanded to become a full-featured administrative tool that supports more sophisticated filtering, sorting, and administrative actions, such as: (1) granting or revoking user permissions to multiple users at once, (2) looking up and confirming user roles (currently roles do not save until the user has confirmed their account, causing difficulty when looking up and verifying user roles), (3) establishing a common tool for system administrators to communicate with users and user groups.

- **Responsiveness and Mobile Compatibility**: Ideas that would benefit users, especially those not in operations centers with the benefit of large desktop displays to interact with the VCC's content. These users must use smaller displays such as laptops or mobile devices that are currently less satisfactory for showing the VCC's content. Some response vehicles have laptops that exhibit occasional performance issues, such as flickering, when displaying content. In addition, many users rely on mobile devices and tablets in their daily work, and the VCC is currently not mobile friendly. As a first step, the design team has drafted several mobile and responsiveness-related user stories that build on community input.

- **Accessibility**: Ideas that would make the VCC fully accessible to all its potential users, both to meet regulatory requirements and to realize core design values. This will be increasingly salient as the user base grows and changes, and the range of abilities that needs to be supported grows along with it.
● **Data Integrations and Reliability:** Ideas that contain technical, process, and partnership aspects, such as the maintenance and expansion of the key data streams that feed the Integrated Dispatch Feed. Future expansions or scaling of the VCC will require modifications to existing data integrations and would benefit by a thoughtful onboarding process for incorporating new data integrations. This could include procedures for ensuring that the data source owners are active participants in not only setting up integrations but maintaining their value and reliability.

● **General Requests for Improvements:** Some of the more frequently requested user-driven improvements include:

  ○ Customization of the Dashboard – Users want to have custom settings for how their Dashboard displays. This could include choosing which columns in the Integrated Dispatch Feed are visible by default, saving filters as individual defaults, and changing the placement and size of elements. Options for customization could enable users to adjust the display to meet the constraints of their screen size and type.

  ○ Updates to the Situation Map – (1) Content. Users requested additional information be added to the map, such as an overlay of transit routes, state road mileposts, and impactful weather conditions. (2) Interaction. Users requested an always-accessible full-page map and a user-set default zoom level.

  ○ Support for enhanced user interaction – Users wanted more effective ways to interact with other users and user groups, such as an in-system user directory page, indicators of who is currently online/using the VCC, and a direct inter-user messaging system.

● **Other Usability Improvements:** In addition to the discussion and examples in Appendix F, the ideation log recorded some additional features and adjustments that could improve the VCC user experience. These included:

  ○ Adjust the default zoom on the Incident Model Situation Map to always show all related dispatches (rather than using a fixed radius around the incident location)

  ○ Enable agency and/or distance filters to the lookup modal used to add related dispatch events to an Incident Model

  ○ Add a visual indicator on the Integrated Dispatch Feed to show which WSP events have attached TMC Log comments.
4.5 Future Enhancements

As shown in Chapter 4.4, lessons learned from this model deployment and operational evaluation naturally lead to recommendations for future improvements and enhancements. Beyond user issues, there are lessons learned associated with design and development processes, such as how best to align the different perspectives of users in different roles and at different agencies.

The expansion of the VCC into new geographical areas and operational environments will also drive future enhancements of the VCC. New agency partners will bring new data sources that need to be adopted within the VCC and may require innovative ways to present that information and integrate it with current information. Additional geographical areas may require an enhanced map interface and new collaborative combinations to be supported. The future addition of agencies in rural areas will also drive new use cases to be addressed within the VCC environment.

Another motivator for enhancement may be the opportunity to apply VCC to the operation of a bi-state corridor, such as between Vancouver, Washington and Portland, Oregon. The additional issues introduced by interstate travel could drive future enhancements of the VCC environment.

Another possible area for future enhancement might be the creation of a public facing VCC portal that does not affect the security of the trusted operational VCC environment. Given the participation of law enforcement agencies, this topic would have to be approached with extreme caution. Nevertheless, the benefits to the public of direct access to relevant VCC information, coupled with increased trust in the secure environment, might make this effort worthwhile.

Finally, the future may bring the possibility of new partners who are not government agencies, such as large employers and institutions. Here again, the VCC may need to support a separate version that keeps secure information from non-governmental partners.

4.6 Moving Forward

The VCC project was an operational evaluation of an innovative model deployment of a virtual collaborative environment for integrated corridor management. Now with the success of the VCC and adoption by the State of Washington, the state is prepared to work with Federal partners to enhance and expand VCC both regionally and for national use. The management of an interstate corridor with VCC is a logical next step. An excellent candidate would be the Vancouver, Washington to Portland Oregon Corridor. In addition, VCC-like projects have already begun in other city corridors across the nation, and the Project Team would look forward to helping these projects learn from what was accomplished in the Seattle area. It is the team’s hope that VCC will enable other regions to be more resilient in the face of major disruption such as the collapse of the I-95 interstate freeway in Pennsylvania in June 2023. Breaking down
operational silos and building operational collaborations are critical components of a resilient regional mobility system.

May this report serve as a valuable resource for future projects that build on what has been accomplished here.

As the Project Team was completing this final report, the new WSDOT VCC Program Manager sent the team an email from a Research Scientist at a major Transportation Institute.

*I'm working on similar technology… but it's not exactly at the same level yet as your system. I'm assuming we're all working under the same approaches – unless you're blessed with everyone using the exact same CAD system (I'm dealing with 15 different ones).

I would appreciate the opportunity to chat with you about the system. While I'm curious about the technology, I'm actually more curious about the recruitment effort for the system. I've found that the technology component was relatively simple compared to dealing with the various agencies to play along (I was read the Riot Act for even asking one agency what CAD system they used).

Yes, the agency “recruitment” component is more difficult than the technology component, but No, we're not “all working under the same approaches.” The difference in approaches, however, has nothing to do with the number and diversity of CAD systems. It has to do with whose system this is and how it comes into being.

In the VCC, agencies do not get recruited and play along – they partner and are empowered to drive the creation of the system. Long before instituting a technical solution for integrating multiple agency CAD systems, agencies came together as an operational community to decide what they wanted the VCC to be and how they would achieve it. Community building and participatory design before technology integration—that is the difference in approach. There is no “Riot Act” to read because agencies know that if something is not to their liking, they can collaborate with their partners to change it. It is theirs.

The foundational lessons of VCC are community-centered design coupled with agile, iterative development that is driven by the feedback of the operational community. Without this community, as our fellow Research Scientist is learning, there are no technology solutions. With this community in the driver’s seat, the VCC is an operational program even before the funded research is completed.