FEASIBILITY OF IMPLEMENTING AN EMERGENCY ROUTING WEB TOOL

Technical Memorandum

July 11, 2023

U.S. Department of Transportation
Federal Highway Administration

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16. Abstract This technical memorandum provides a high-level feasibility assessment for options to develop a web tool that could improve how information is shared to drivers of emergency response convoys through specific regions. The web tool would provide the information needed for drivers to travel to and from declared emergencies. This tool could also assist by providing access to current and consistent information that allows emergency convoys to better plan their trip and reroute if needed.			
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

API	application programming interface
AASHTO	American Association of State Highway And Transportation Officials
ERWG	Emergency Route Working Group
ETL	extract, transform, load
FAST	Fixing America's Surface Transportation Act
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
GIS	geographic information system
HTML	hypertext markup language
LAMP	Linux, Apache, MYSQL, PHP
MAP-21	Moving Ahead for Progress in the 21st Century Act
NBI	National Bridge Inventory
OS/OW	oversized and overweight
QA/QC	quality assurance/quality control
USDOT	United States Department of Transportation

CHAPTER 1. INTRODUCTION

PROGRAM BACKGROUND

In December 2015, Congress enacted the Fixing America's Surface Transportation (FAST) Act (Pub. L. No 114-94). Section 5502 of the FAST Act requires the Secretary of the United States Department of Transportation (USDOT) to create an Emergency Route Working Group (ERWG). As required, the ERWG provided the Secretary of Transportation advice and recommendations for implementation of practices for expeditious State approval of permits for vehicles involved in emergency response and recovery. In detail, the ERWG made seven recommendations, proposing the Secretary of Transportation should:

1. Incentivize States to modernize their permitting systems to provide for auto-issue permitting so that permits are available 24/7.

2. Fund a study that examines a multi-State emergency route scenario for vehicles involved in emergency response and recovery.

3. Encourage the development of a pre-clearance process that pre-identifies a set of vehicles that are part of response and recovery.

4. Study the feasibility of setting up a nationwide alert system (like an Amber Alert) to notify State and local authorities of emergency response convoy movements through their region.

5. Coordinate the development of an online resource with all relevant permitting and regulatory compliance information that can be accessed by those participating in emergency response and recovery operations (building on transportation.gov/emergency).

6. Collaborate with external stakeholders to identify opportunities to reduce impediments to utility service vehicle movements for emergency response and recovery efforts.

7. Inform Congress that expanding the coverage of the Moving Ahead for Progress in the 21st Century Act (MAP-21), Pub. L. No. 112-141, Section 1511 provision to emergencies declared by a Governor of a State would positively impact emergency response and recovery efforts. Currently, MAP-21 Section 1511 extends the States' authority to issue Special Permits to vehicles with divisible loads that are delivering relief supplies only during a presidentially declared major disaster under the Robert T. Stafford Disaster Relief and Emergency Assistance Act (42 U.S.C. 5121 et seq.).

The Federal Highway Administration (FHWA) will work with States and the Federal Motor Carrier Safety Administration (FMCSA) on studying the feasibility of the recommendations in the final report. The FHWA will also engage in external outreach to raise awareness of the ERWG report with the public, including targeting the affected stakeholders represented on the ERWG and identified in the FAST Act.

Currently, FHWA is pursuing research and feasibility studies to enhance permit automation and emergency routing, and considering necessary standardization and communication in the following areas:

- Auto-issue permit systems in the United States.
- Additional fields for the National Bridge Inventory (NBI) to facilitate emergency route mapping.
- Preclearance processes that could pre-identify a set of vehicles for emergency response and recovery operations to expedite movement through weigh stations and inspections.
- Multi-State emergency route scenario study to estimate delays and their impacts on relief and recovery efforts.
- Emergency response and recovery vehicle nationwide alert system study to develop a concept of operations for a technology solution.
- Emergency response guidebook on Federal regulations and requirements.
- Web tool for emergency routing.

OVERVIEW

This technical memorandum provides a high-level feasibility assessment for setting up a web tool in the form of a map that could improve how information is shared to drivers of emergency response convoys through specific regions. The web tool would provide the information needed for drivers to travel to and from areas with declared emergencies. This information would be provided during pre-deployment, deployment, redeployment, and return of responders to and from areas with declared emergencies. This tool could also assist by providing emergency convoys access to current and consistent information allowing them to better plan their trip and reroute if needed.

This technical memo provides insight into the different alternatives to achieve such a tool, the data requirements, and challenges that each alternative would present.

DOCUMENT STRUCTURE

The following is the organization of the document:

- Chapter 1 introduces the need for an emergency routing web tool.
- Chapter 2 presents four alternatives for the web tool.
- Chapter 3 summarizes the findings and provides a comparison of alternatives.

CHAPTER 2. WEB TOOL ALTERNATIVES

This chapter describes four alternatives for a web tool. The alternatives presented range from links to available information, to more advanced interactive maps and tools that would require substantial investment and partnership between States and the private sector to implement. Following an Agile process, each alternative builds upon the capabilities and requirements of the previous one, allowing this to be a phased project. The alternatives are as follow:

1. Alternative 1 – a database in table format from which drivers can query States and receive links that could provide useful information by State.
2. Alternative 2 – an interactive map, built from the static database from Alternative 1.
3. Alternative 3 – an interactive map that provides as much real time information as available and with routing capability.
4. Alternative 4 – a one-stop interactive web-based tool that handles all permitting from both the State and driver perspective, along with an interactive map and routing capabilities.

OPTIONS FOR IMPLEMENTATION

If an emergency routing web tool is to be implemented, an important first step would be to determine the lead agency and the key stakeholders to be involved in developing a concept of operations.

As an alternative to a national emergency routing web tool, there is the option for State agencies and AASHTO to take a lead in piloting a regional model with support from USDOT. Because Alternative 4 requires extensive data from and integration with State systems, this could be a candidate for a regional pilot run by a group of States that could eventually be scaled up to the national level.

ALTERNATIVE 1: DATABASE OF INFORMATION

Description

Alternative 1 will give emergency vehicle drivers the ability to query States that they might traverse through in route to areas affected by an emergency. After States have been queried, corresponding static emergency information will appear in the form of a dynamic table. This information could provide links to applicable State websites that provide emergency-related information. Figure 1 provides a mockup visualization of this alternative.

State	Resource	Link
Alaska	State 511	http://511.alaska.gov/alaska511/mappingcomponent
Florida	IFTA	https://www.flhsmv.gov/driver-licenses-id-cards/commercial-motor-vehicledrivers/international-fuel-tax-agreement
Florida	IRP	https://www.flhsmv.gov/driver-licenses-id-cards/commercial-motor-vehicledrivers/international-registration-plan/
Nationwide	Permitting	https://ops.fhwa.dot.gov/freight/sw/permit_report/index.htm
Washington	State 511	https://www.wsdot.wa.gov/about/news/511/home

Source: Federal Highway Administration

Figure 1. Alternative 1 mockup.

Needs and Requirements

This section provides insight into what is needed to build this alternative, including data, software, and considerations for development and operation of the tool.

Data Needs

As a starting point, the tool should provide links from which drivers/dispatchers can obtain the following emergency information by State:

- State 511 Website, which provides road and traffic condition information on each State.
- State Permitting Website, which provides information on how to request the necessary permits to traverse through each State.
- State Emergency Declaration, which provides information of the declaration of emergency per State.
- FMCSA declaration, which provides freight specific information regarding active regulations.
- AASHTO emergency declarations website, which provides information on disaster declarations and changes to allowable vehicle weights and permit requirements.

Software Needs

Alternative 1 presents the information in a table format. The software used could include data visualization and business intelligence software that allow for interactive data visualizations. The developer of this project may also choose to use software with multiplatform charting libraries to produce mobile-optimized interactive tables.

Development Considerations

While Alternative 1 (i.e., a table that allows query) has an overall low complexity, the process to obtain the data needed can be complex. Development of this alternative will require the following:

- Collect data from the following:
    - State 511 website links
    - State Permitting website links
    - State Emergency Declaration links
    - FMCSA declaration links
    - Any other additional data element identified during the conceptualization phase
- Assurance/Quality Control (QA/QC) of State emergency resource forms/links to make sure they are correct and relevant
- Format links into a table that will reside in a database
- Connect to data visualization and business intelligence software
- Develop the Dashboard
- QA/QC of the Dashboard
- Deploy Dashboard and data source to host agency server

Limitations

Though the application developed under Alternative 1 will have the ability to provide users with a list of relevant links for emergency routing, the user will still have the following limitations:

- The software will not be able to show live updates of the information it provides. It is not envisioned to be updated with enough frequency to provide live/real-time data. During the systems engineering process, the developer will need to make a determination on how and when data will be updated.
- The user will not be provided a specific route. The user will have to rely upon outside routing software based on the vehicle weight (including cargo), dimensions, type of cargo, etc. This also includes the limitation of not providing network information such as road weather and traffic conditions, potential roadblocks, tolls, etc.
- This will not provide any information on bridge height or bridge weight restrictions. The user would need to obtain all permit and routing information from the State DOT.
- The user may encounter different formats of the same permit across differing States. If a user must attain multiple State permits and they are all different, this could add a level of confusion. There is not a common permit template.

Risks

Given the development process, how the information is expected to be provided, and the identified limitations of Alternative 1, the most significant risk is that the dashboard will provide inaccurate/outdated information to users. With links to multiple sites, there is a high probability of inconsistencies in how emergency declarations apply to carriers. There is a risk that the dashboard may not identify the most current information that applies to a carrier if different waivers are available from multiple sources. State emergency declarations may be posted to different State websites depending on the type of disaster and will vary by nature of the emergency. Clear disclaimers will need to be provided for information linked from other sources.

The database will need to be routinely updated to provide the correct permit links to the user. Similar action is necessary for State contacts and emergency resources. Updates, or validation of information, are important for accuracy during emergency events.

Estimation of Effort and Cost

Though Alternative 1 requires the least amount of development effort of the four options, it will still require the development team to conduct research, engage in dashboard development, and perform database development and maintenance. The following is a high-level estimation of the key categories of tasks and staff that are needed to successfully develop Alternative 1:

- Staff: Overall time of 900 hours (estimated):
  - 1-2 Researcher/Business Analyst(s)
  - 1-2 Extract, Transform, Load (ETL) Developer(s)
  - 1-2 Dashboard Developer(s)
  - Database Administrator
  - Project Manager
- Licensing costs: Alternative 1 will require 1-2 data analytics software licenses with at least one of these licenses being a Creator level.

Overall cost range for development: $120k to $160k (estimated)

This is a high-level estimate for development alone and does not include on-going maintenance and operation cost. This development cost may change as the concept and design details of the tool are more clearly defined.

Operations and Maintenance (O&M) ***is not*** included in the cost range provided above. O&M costs of this alternative will depend on two main factors: the software used and the required frequency for updating the database. Though the application will require few aesthetic changes after development, the database behind the application will require regular data refreshes to provide relevant and up to date data for users. Assuming that the database is updated two to three times per year, this cost could range from $30-60k annually.

Resources

The following are examples of emergency resources that could be linked from the site:

- State 511 website examples (for the State routes it goes through):
  - Washington State 511 travel information[1]
    Alaska traveler 511 Information[2]

[1] "511 Travel information," Washington State Department of Transportation, accessed April 21, 2023, https://wsdot.wa.gov/travel/511-travel-information.
[2] "Traveler 511 Info AK," Alaska Department of Transportation and Public Facilities, accessed April 21, 2023, http://511.alaska.gov/alaska511/mappingcomponent.

- State permitting websites:
  - Oversize/overweight load permits nationwide link list[3]
  - IRP[4] and IFTA[5] permits for Florida
- State emergency declarations:
  - FMCSA, State emergency declarations by State[6]
  - USDOT, emergency preparedness, response, and recovery information[7]
- Commercial Vehicle Safety Alliance (CVSA) and AASHTO website:
  - Emergency Declarations Portal[8]
  - FMCSA declarations[9]
- Emergency operation centers (EOC):
  - FHWA, National Traffic and Road Closure Information[10]
  - FEMA, The EOC's Role in Community Preparedness, Response and Recovery Activities[11]
  - US Department of Homeland Security, National Incident Management System[12]

ALTERNATIVE 2: INTERACTIVE MAP BASED STATIC INFORMATION

Description

Alternative 2 couples the static information generated in Alternative 1 with Geographic Information System (GIS) software to allow users the ability to utilize a dynamic web map containing data relevant to emergency information and vehicle permits. Similar to the previous alternative, users will query specific States that an emergency vehicle might need to traverse through on its route. However, Alternative 2 is more visual and users can click on an individual State and receive the corresponding State emergency information. Figure 2 presents a mockup of how the tool could look under Alternative 2.

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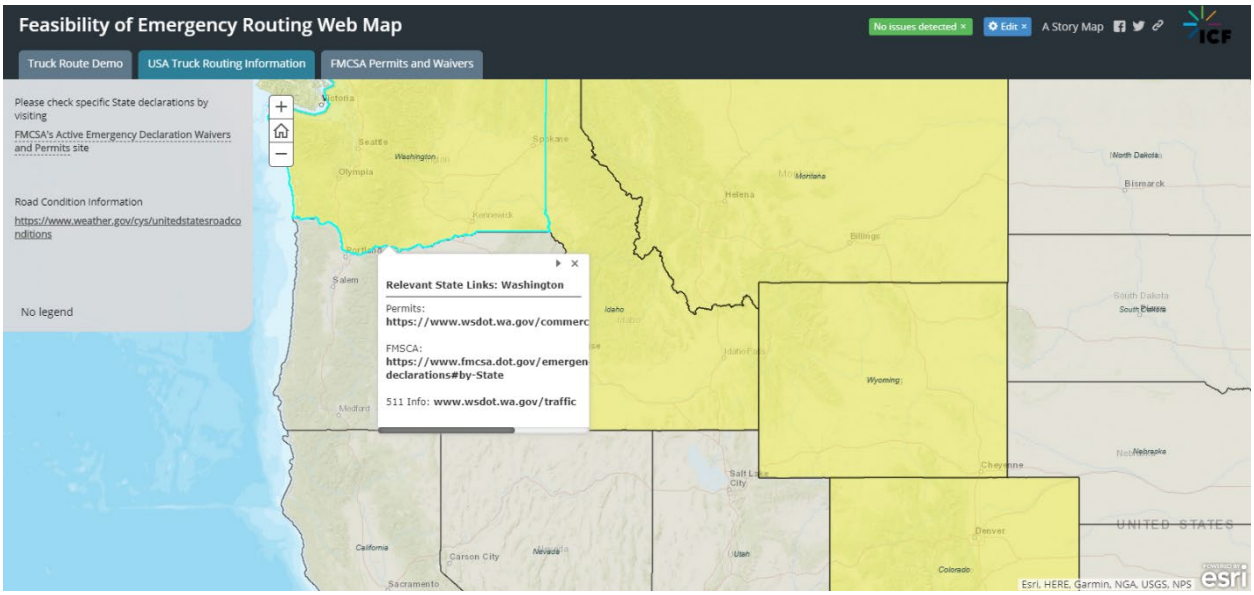
[3] "Oversize/Overweight Load Permits," FHWA Office of Freight Management and Operations, accessed April 21, 2023, https://ops.fhwa.dot.gov/freight/sw/permit_report/index.htm.
[4] "Commercial Motor Vehicle Drivers International Registration Plan," Florida Department of Highway Safety and Motor Vehicles, accessed April 21, 2023, https://www.flhsmv.gov/driver-licenses-id-cards/commercial-motor-vehicle-drivers/international-registration-plan/.
[5] "Commercial Motor Vehicle Drivers International Fuel Tax Agreement," Florida Department of Highway Safety and Motor Vehicles, accessed April 21, 2023, https://www.flhsmv.gov/driver-licenses-id-cards/commercial-motor-vehicle-drivers/international-fuel-tax-agreement/.
[6] "State Emergency Declarations by State," Emergency Declarations, Waivers, Exemptions and Permits, FMCSA, accessed April 21, 2023, https://www.fmcsa.dot.gov/emergency-declarations#by-State.
[7] "DOT Emergency Preparedness, Response, and Recovery Information," USDOT, accessed April 21, 2023, https://www.transportation.gov/emergency.
[8] Emergency Declarations Portal, CVSA and AASHTO, accessed May 11, 2023, https://www.cvsaemergencydeclarations.org/map.
[9] "Federal Emergency Declarations by FMCSA," Emergency Declarations, Waivers, Exemptions and Permits, FMCSA, accessed April 21, 2023, https://www.fmcsa.dot.gov/emergency-declarations#FMCSA.
[10] "National Traffic and Road Closure Information," FHWA, accessed April 21, 2023, https://www.fhwa.dot.gov/trafficinfo/index.htm.
[11] FEMA, *The EOC's Role in Community Preparedness, Response and Recovery Activities* (independent study course), accessed April 21, 2023, https://training.fema.gov/emiweb/downloads/is275.pdf.
[12] FEMA, *National Incident Management System*, FEMA publication P-501 (Washington, DC: U.S. Department of Homeland Security, December 2008), https://www.fema.gov/pdf/emergency/nims/NIMS_core.pdf.



Source: Federal Highway Administration.

Figure 2. Alternative 2 mockup.

Needs and Requirements

This section provides insight into what is needed to build Alternative 2, including data, software, and considerations for development of the tool.

Data Needs

Alternative 2 builds on the data collection effort from Alternative 1. The information needed to develop the tool is the same as Alternative 1. This data will, however, need to be associated with a specific State in GIS format.

Software Needs

Alternative 2 presents the information in a map format. For this, GIS is recommended as the primary software that should be considered. A brief description is provided below.

Alternative 2 could use a GIS Cloud-based Mapping and Analysis Tool. Data, maps, and applications are stored in a secure and private infrastructure. There are GIS tools that provide different web mapping application templates that allow users to create dynamic dashboards and applications.

There are several GIS software features that could be relevant to Alternative 2:

- *GIS StoryMaps*: Helps outline stories with custom online maps.
- *GIS Dashboards*: Uses charts, gauges, maps, and other visual elements to reflect the status and performance of people, services, assets, and events in a dynamic dashboard application.
- Software to help build 2D and 3D web apps, including HTML apps.

Other software with more limited mapping capabilities that could be considered include business analytics and dashboard software. Software with multiplatform charting libraries to produce mobile optimized interactive tables is another option that could be employed to provide some of the GIS features.

Development Considerations

Alternative 2 is feasible under current conditions. Development of this alternative will require the following:

- Collect data from the following:
    - State 511 website links
    - State Permitting website links
    - State Emergency Declaration links
    - FMCSA declaration links
    - Any other additional data element identified during the conceptualization phase.
- QA/QC of State emergency resource forms/links to make sure they are correct and relevant.
- Format links into a csv table format
- Convert csv table to GIS format (i.e., shapefile, feature class)
- Upload GIS file to GIS database
- Create custom web map that will feature the GIS layer
- Create custom dashboard using web map
- QA/QC of GIS Dashboard
- Embed GIS Dashboard into a host agency website

Limitations

Alternative 2 has the same capabilities of Alternative 1, with the addition of an interactive map. It has similar limitations, detailed below:

- Alternative 2 will not show live updates of the information it provides. It is not envisioned to be updated with enough frequency to provide live/real-time data.
- Despite having a map interface, Alternative 2 does not provide route information. Users will have to rely upon outside routing software based on their weight, dimensions, cargo, etc. This also includes the limitation of not providing network information such as road weather and traffic conditions, potential roadblocks, tolls, etc.
- This will not provide any information on bridge height or bridge weight restrictions. The user would need to obtain all permit and routing information from the State DOT.

- The user may encounter different formats of the same permit across differing States. If a user must attain multiple State permits that are different, this could add a level of confusion. There is not a common permit template between States.

Risks

Alternative 2 also shares the same risks as in Alternative 1. The most significant risk is providing inaccurate/outdated information. With links to multiple sites, there is a high probability of inconsistencies in the effect of emergency declarations. Clear disclaimers will need to be provided for information linked from other sources.

It will be necessary for the database to be routinely updated to provide the correct permit links to the user. Similar action is necessary for State contacts and emergency resources.

Estimation of Effort and Cost

Alternative 2 will require a significant amount of time for initial research, extract, transform, load (ETL), dashboard development, and database development/maintenance. The following is a high-level estimation of the key categories of tasks and staff that may be needed to successfully develop Alternative 2:

- Staff: 1,100 hours (estimated):
    - 1-2 Researcher/Business Analyst(s)
    - 1-2 ETL Developer(s)
    - 1-2 GIS Developer(s)
    - Database Administrator
    - Project Manager
- Licensing costs:
    - Alternative 2 will require at least two subscriptions. If the organization does not have access to a GIS desktop software, it may be necessary to get a least one GIS Professional subscription to perform GIS conversion processes.

Overall cost range for development: $180k to $240k (estimated)

This is a high-level estimate for development alone and does not include on-going maintenance and operation cost. It is equally important to note that this development cost may change as the concept and design details of the tool are more clearly defined.

O&M cost **is not** included in the cost rage provided above. Similar to Alternative 1, O&M costs of this alternative will depend on two main factors: the software used, and the required frequency for updating the database. Updates in the database and user interface are more complicated than Alternative 1. The range of this cost is much higher, potentially from $60-100k annually.

Resources

In addition to the resources listed in Alternative 1, the following are good examples of applications with GIS:

- ArcGIS StoryMaps (Michigan DOT)[13]
- Operations Dashboard for ArcGIS (Maryland Water Quality Status)[14]
- Web AppBuilder for ArcGIS (City of Sioux Falls)[15]
- The Commercial Routing Assistance[16]

ALTERNATIVE 3: INTERACTIVE MAP BASED ON DYNAMIC INFORMATION

Description

In contrast to the previous alternatives, Alternative 3 would include a truck-routing element in addition to a database of various State emergency resource links. A truck routing Application Programming Interface (API) would need to be custom developed with the parameters necessary to guide truck drivers through legally permissible routes.

Detailed information on route, load posting, bridge and tunnel clearance, and other hazard elements, would be considered by the software in identifying potential routes. Within the proposed custom truck-routing API, truckers would be able to define truck characteristics such as dimensions, weight, hazardous materials, and any special needs.

If a specific State is found to be included within a projected route, the corresponding State on the route will be highlighted within the tool. Once a route has been successfully queried, corresponding links to State emergency information will appear in the web application. Figure 3 presents a mockup of the tool under Alternative 3.

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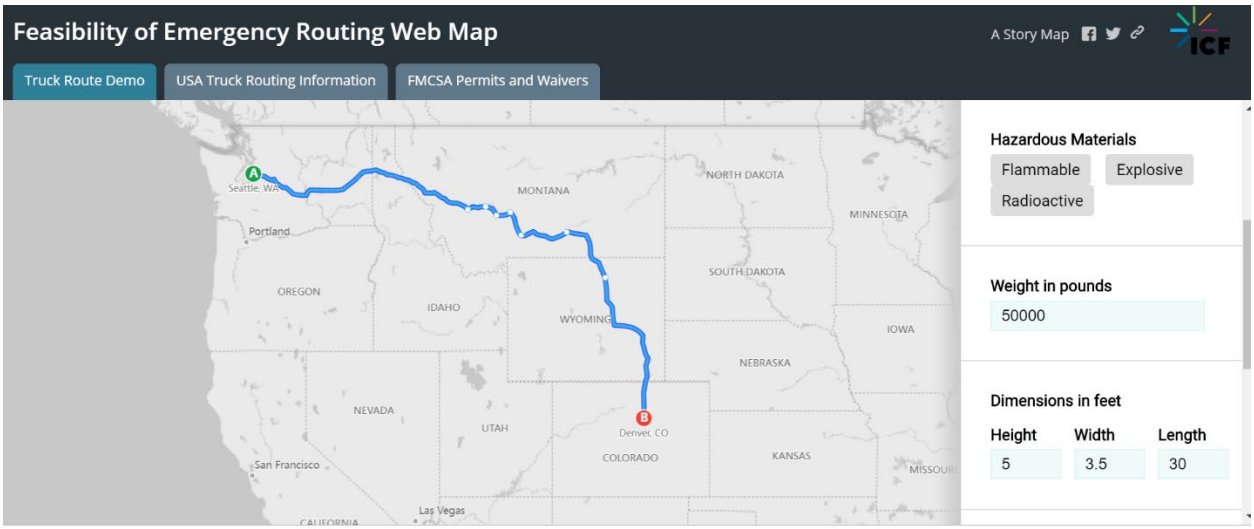
[13] "Michigan Bridge Conditions," National Bridge Inventory (NBI) and Pedestrian Bridges, Michigan Department of Transportation, accessed April 21, 2023, https://mdot.maps.arcgis.com/apps/MapSeries/index.html?appid=fb70725b2be04dc7b01703d0b6c91bb6.
[14] "Water Quality Status," accessed April 21, 2023, https://www.arcgis.com/apps/opsdashboard/index.html#/37d0e7637f98479e83f5cdcf51038c3e.
[15] "Parcel Finder," DataWorks, City of Sioux Falls, accessed April 21, 2023, https://cityofsfgis.maps.arcgis.com/apps/webappviewer/index.html?id=f6cf6b9dd71246f5aaa0b5e9fc94e82b.
[16] "Commercial Routing Assistance," Idaho National Laboratory, accessed April 21, 2023, https://cra.inl.gov/.



Source: Federal Highway Administration.

Figure 3. Alternative 3 mockup.

Needs and Requirements

This section provides insight into what is needed to build Alternative 3, including data, software, and considerations for development of the tool.

Data Needs

In addition to the data needs from Alternative 1 and 2, this alternative will also require vehicle and trip information. The truck-related information needs to include:

- Dimensions
- Weight
- Cargo
- Special requirements
- Origin address
- Destination address
- Route specific information (load posting, bridge and tunnel clearance amongst other hazard elements)
- Private sector map data and routing systems

Software Needs

Alternative 3 presents the State emergency resource information with a mapping interface, building on the work previously described in Alternative 2. However, to provide truck routing suggestions to users, a custom truck routing API would have to be developed as there is not a single comprehensive and accurate map of the National Network. The cost and time to develop an API from scratch could be minimized by developing the mapping interface on top of an existing private sector or third-party truck routing engine, or alternatively, modifying an existing private sector or third-party truck routing engine by adding additional parameter options.

The development of the custom API may need to be done in close coordination with States and the private sector, since the API would also need to integrate the routing used by all States and may require State-by-State confirmation of the National Network. States would need to identify the routes and update routes regularly as conditions change—particularly information related to bridges and infrastructure affected during disruptive events.

A brief description of various private sector or third-party truck routing vendors is provided below. It is possible that multiple vendor software services could be combined to generate a final software solution that fits the needs of the user.

Alternative 3 would require more time and effort to build and maintain because many aspects of the API would need to be custom developed. Using an Agile development process could help to focus work on completing the most valuable product features first with an iterative approach. The API would also need to integrate the routing software and policies developed by all States across the country. This research could possibly require significant time and effort.

Oversized and overweight (OS/OW) loads would not be able to use Alternative 3 and would be required to go through individual State permitting offices to obtain permits and assigned routes. This truck routing API will likely not have complete information that States use for routing oversized and overweight loads, including the following attributes:

- Current bridge weight and height information for oversized and overweight loads
- Tunnel restrictions
- Other roads that are designated truck routes by State DOTs and local road agencies
- Hazardous material restrictions
- Workzone restrictions
- Weather restrictions
- Emergency road closure restrictions

Leveraging Commercial Products

As previously mentioned, this alternative envisions the use of a custom API for truck routing information. However, the development process could leverage the efforts and information already collected and developed by existing vendors. While acknowledging the lack of accuracy needed to route trucks in real time, particularly OS/OW, the following types of products could be considered as starting point:

Currently available commercial products can offer route calculation between two or more locations. These products can extend roadway routing with truck-specific options. Below is a list of factors that these products consider when generating optimal truck routes:

- **Legal Restrictions:** Contains detailed information on exact areas and roads where certain legal restrictions apply, from material limits to areas where specific trucks or trailers are forbidden.
- **Environmental Zones**: Includes information on areas where access restrictions apply to certain vehicles or trucks due to environmental reasons, plus provides route data to

support audits if traveling through zones that require information to be stored and provided to local governments.
- **Hazardous Materials:** Includes information on areas or roads where transport of hazardous materials is prohibited.
- **Warnings:** Includes detailed information on the exact location of signs warning of certain road conditions that apply to trucks (e.g. lateral wind, risk of grounding), sortable based on truck type within the truck routing software.
- **Physical Restrictions:** Includes information on areas where access restrictions apply to certain vehicles or trucks due to physical dimensions (e.g. height, weight), sorting carrier routes by ZIP codes and other details.
- **Trucks POIs:** Contains information about fuel stations for trucks, including lower-emission fuels and additives as well as valuable and practical information about special truck facilities. Carrier route maps can be adjusted to include access to these facilities.
- **Distance Markers:** Includes detailed information on the exact location and number of signs indicating road distance along carrier route maps.
- **Loading Dock Locations:** Contains the location of loading and unloading docks at buildings, truck entrance locations and associated geometry.
- **Traffic Conditions**: Speed limit, construction, lane closures.

Web Application Hosting Options

Once the web application behind Alternative 3 has been developed, it will be necessary to host the web application and corresponding database(s) for eventual public consumption. It may be helpful to identify early on the agency/entity that will host the tool.

There are several options for hosting. Below is a summary of types of web application deployment and hosting options:

Commercial Cloud Computing Services

Commercial cloud computing services for building, testing, deploying, and managing applications and services are available from several vendors. Developers can use key tools to deploy and host web applications, including application services and static web applications. Commercial services include a secure cloud services platform, offering compute power, database storage, content delivery and other functionality. These services often include open source standards and software.

Development Considerations

Alternative 3 has a mid to high level of complexity, with the biggest efforts being the data collection, the custom API truck routing configuration, and the development of the interface(s) for the application. The development of this alternative will require the following:

- Collect data from the following:
    - State 511 Website links
    - State Permitting Website links
    - State Emergency Declaration links

    - FMCSA declaration links
    - Transportation network/infrastructure data
    - Any other additional data element identified during the conceptualization phase.
- The development of a truck routing API that integrates various State routing systems into a single, combined national truck routing API.
- QA/QC of State emergency resource forms/links to make sure they are correct and relevant.
- Format links into a national emergency resource database that will feed data to the application.
- Custom web development of application – build interactive application that houses two containers: the mapping portion that displays the route and the dynamic html table that changes based on routing query.
- QA/QC of web application.
- Embed web application into a host agency website.
- Create a detailed and robust O&M plan that includes continuous updates to account for changes in infrastructure conditions and truck routes.

Limitations

While Alternative 3 has more advanced capabilities than Alternative 2, it still has limitations, including:

- While Alternative 3 would provide routing suggestions, it is limited by the use of static information (i.e. snapshot of data) and not real time data, including delays due to congestion, bridge clearance information, weight restrictions, or long waiting on permits at a specific State border(s).
- Oversized and overweight loads would not be able to use this truck routing API and would be required to go through individual State permitting offices to obtain permits and assigned routes.
- The user would still be required to obtain permits from each State they travel through. These State permits will have different formats, which could add a level of confusion.
- State contacts will need to be updated for emergency resources.

Risks

Alternative 3 introduces new risks that are associated with its new capabilities. Because of these risks, this alternative may not be a viable option. The risks include:

- There could be issues with providing routing suggestions (e.g., there might be errors in the route). The route provided may place trucks onto roads where the type of vehicle is not allowed. The route may also lack accurate information on bridge weight limitations and structure clearances. Improper routing may result in damage to infrastructure. Commercial motor vehicle crashes from improper routing may also result in injuries or fatalities.
- There is a risk of not providing the most up-to-date information if the database is not routinely updated to provide the correct permit links to the user.

- If the custom API is developed as a silo, without leveraging existing APIs, there is a probability that the custom API will be limited in capabilities in early stages as it gains maturity. For instance, it may limit the user in the route selection by providing only one route and may not provide other viable routes. It could take significant effort and various iterations (versions) of the custom API to address this limitation.
- Several States vary in how frequently they update their 511 data. For instance, some State DOT 511 road restrictions are updated every 15 minutes. If there is an emergency where a bridge is damaged, lowering weight allowed across a bridge, the truck driver would be required to rely on the updated 511 map and not the route provided by the API.

Estimation of Effort and Cost

Alternative 3 will require a large amount of time for initial planning research, ETL, web application development, database development/maintenance, testing/piloting and production deployment. This alternative may require multiple web developers and researchers/analysts. The following are high level estimation of the key categories of tasks and staff that are needed to successfully develop Alternative 3:

- Staff: 7,000 hours (estimated):
  - 3-4 Researcher/Business Analyst(s)
  - 2-3 ETL Developer(s)
  - 2-3 Web Developer(s)
  - 2-3 Software Developer(s)
  - Database Administrator(s)
  - Project Manager
- Licensing costs: see Alternative 3 "Software Needs":
  - Routing Solutions
  - Web Application Hosting

Overall cost range for planning and development: $800k to $1.5M (estimated). This does not include the cost of testing, piloting, implementation, and operation.

Compared to Alternatives 1 and 2, Alternative 3 has a higher level of complexity and would need a more robust stakeholder involvement (including state permitting offices) at all stages of the System Engineering development process. The cost for the entire process of deploying this alternative can be separated in four phases:

1. *Phase 1: Planning* – identifying user needs, system requirements, outreach, data and security management, as well as all planning documents necessary for the successful completion of the project.
2. *Phase 2: Design and Development* – defining the architectural and system design and development of the proposed alternative.
3. *Phase 3: Testing/Piloting* – real-world demonstration of the tool.
4. *Phase 4: Production/Transition* – transitioning from a pilot tool to deployment. Depending on the procurement/business model selected, this phase could also include the cost of O&M for a defined number of years during or post transition.

The overall cost presented here is limited to the Phases 1 and 2. For complex systems such as this, the cost for Phases 3 and 4 are better determined throughout the planning and design phases. Estimation of Phases 3 and 4 this early in the conceptualization process would be unpredictable and susceptible to change as requirements for testing a deployment are more clearly defined.

Based on the above, the high-level overall estimated range of cost for Phases 1 and 2 is $800k-$1.5M. This is an estimate for initial research, outreach to all States, planning, and Agile development alone and **does not** include implementation and O&M cost. This estimate assumes 100k transactions per month through the Custom API. It is important to know that this estimate is not ensured, as cost will increase as the software cost increases, especially if more than one existing truck API are used. It is equally important to note that this planning and development cost may change as the concept and design details of the tool are more clearly defined.

O&M costs are estimated to range from $100-150k annually; however, this cost will depend on the frequency of refreshes required to provide relevant and up to date data for users, as well as the level of troubleshooting provided to States and users.

Resources

In addition to all the resources listed in the previous alternatives, the following are resources that apply specifically to this alternative:

- Example of truck routing API
  - The routing API[17] is an HTTP JSON REST API that offers route calculation between two or more locations.
  - Microsoft® Bing™ Maps Truck Routing Demo[18]
- Data Tables
  - Further explanation of Data Tables JavaScript based library[19]
- Systems Engineering
  - The system engineering development process is explained through the "V" diagram, as described in *Systems Engineering for Intelligent Transportation Systems*.[20]

ALTERNATIVE 4: ONE-STOP INTERACTIVE WEB TOOL

Description

Alternative 4 would be an interactive web tool that serves as a one-stop shop, including routing, requesting and processing permits. This alternative is currently not feasible, as States use a range

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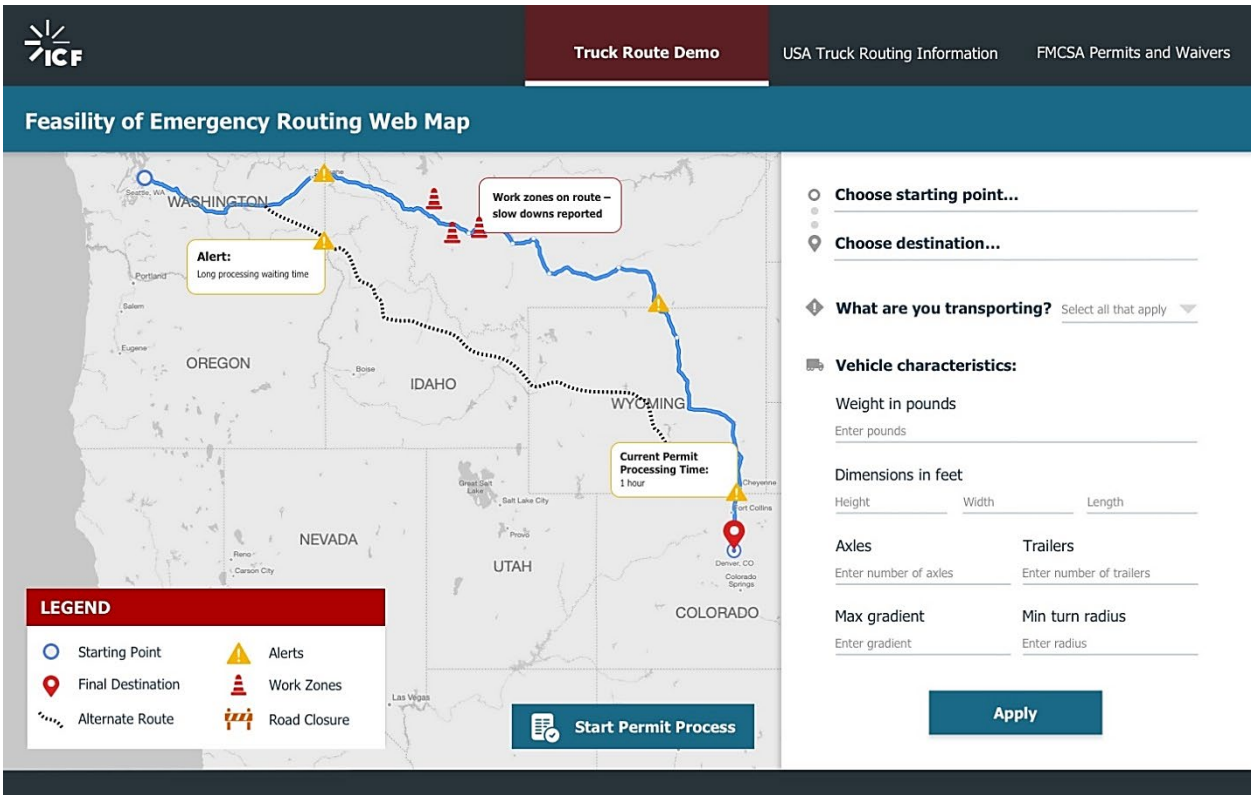
[17] "HERE Routing API v8 Developer Guide," HERE Technologies, accessed April 21, 2023, https://developer.here.com/documentation/routing-api/8.20.0/dev_guide/index.html.
[18] "Bing Maps Truck Routing Demo," Microsoft® Bing™, accessed April 21, 2023, https://www.microsoft.com/en-us/maps/truck-routing/truck-routing-api-demo/.
[19] "Data Tables," CloudTables, accessed April 21, 2023, https://datatables.net/.
[20] National ITS Architecture Team, *System Engineering for Intelligent Transportation Systems*, publication number FHWA-HOP-07-069 (Washington, DC: FHWA, Office of Operations, 2007), https://ops.fhwa.dot.gov/publications/seitsguide/index.htm.

of proprietary systems, and a national system would need to be able to interface with all State systems. Several States currently do not have automated permitting systems and there would need to be a process for automating all the data, information, and procedures the States currently use. This would require States to agree on a standard national permit application form. This would also require States to continuously provide updated network data, specifically bridge information and any infrastructure impacted by disrupting events within the State.

Instead of filling out a permit application form for each State that a truck driver will need to traverse through, the user would fill out one form that applies to all States on the route. Having a one-stop-shop would help expedite the permitting process for emergency response vehicles. By utilizing a web mapping and permit application, users could query their route based on the truck API, as well as fill out any required emergency routing forms. Figure 4 illustrates a mockup of this alternative.

Using a customized Truck Routing API solution previously mentioned in Alternative 3, the truck driver or dispatcher will be able to identify potential routes based on the provided information (e.g., dimensions, weight, cargo, origin, destination, and any other special needs associated with the vehicle). Once a route has been queried, all corresponding forms relating to State emergency information will be provided for the user.



Source: Federal Highway Administration.

Figure 4. Alternative 4 mockup.

Needs and Requirements

This section provides insight into what is needed to build Alternative 4, including data, software, and considerations for development of the tool.

Data Needs

In addition to all the data detailed in the previous alternatives, Alternative 4 requires detailed information on the permitting processes for each State. All forms will need to be standardized nationally so that a user does not have to fill out different individual forms when traversing through multiple States.

Software Needs

Alternative 4 builds heavily on the capabilities and needs of Alternative 3. The software needs are similar to the previous alternatives. However, there are new software needs that are associated with the added capabilities of Alternative 4.

Alternative 4 will rely more heavily on web development efforts than Alternative 3. In addition to utilizing the truck API to identify potential routes based on user-provided truck information, the user will also be able to view and fill out corresponding forms relating to State permits. An HTML-based form will be developed for users to enter their information in the online form. Accordingly, there will need to be a backend database that will store all form information that users enter. Through utilizing PHP web programming, an html form can be directly connected to an SQL database. This information will be made readily available to State DOTs, so they are aware of every driver with emergency materials on the road.

Truck Routing API – Alternative 4 would utilize the same Truck Routing API as Alternative 3 - see description in Alternative 3 "Software Needs" where this technology is outlined. This system would need to be built using routing data and integrated with systems used by all States.

General-purpose Web Scripting Language – A web scripting language can be utilized to handle, validate, and submit form data that a user will enter. These scripting languages are often open-sourced.

Open-sourced Relational Database Management System – A system that is compatible with PHP form handling methods. It is designed to handle a range of workloads, including Web services with many concurrent users. Multiple options are available.

Web Application Hosting Options

Once the web application behind Alternative 4 has been developed, it will be necessary to host the web application and corresponding database(s) for eventual public consumption. There are several options for how this can be accomplished. See Alternative 3 for a list of cloud vendors and their corresponding web application deployment and hosting options.

Development Considerations

Development of Alternative 4 will require the development team do the following:

1. Compile a list of relevant State contacts for:
    a. State 511 resources
    b. State Permitting resources
    c. State Emergency Declaration resources
    d. FMCSA declaration resources
    e. Transportation network/infrastructure data
    f. Any other additional data element identified during the conceptualization phase
2. Develop a truck routing API that integrates various State routing systems into a single, combined national truck routing API
3. Coordinate with States to gather ideas on developing standard formatting for resources listed above
4. Develop custom forms
5. Get State feedback on forms
6. Publish forms
7. Develop a custom interactive web application that houses two containers: the mapping portion that displays the route, and the dynamic html form portion that will display corresponding emergency resource forms
8. QA/QC of web application
9. Embed web application into a new website

Limitations

All of the limitations discussed in previous alternatives would also apply to Alternative 4. Alternative 4 will also require the most time for research and coordination, potentially taking more than 5 years to complete all the tasks necessary to develop the tool. This may require extensive involvement by States to coordinate and gather ideas on developing standard formatting for emergency resources, finalizing and publishing the forms, custom developing a web application, system testing, and publishing the full production to a new website.

This new website may need to be coordinated with States and AASHTO. States use a range of proprietary systems, and any national system would need to be able to interface with all State systems. Almost one third of States also currently do not have auto issue permitting systems and there would need to be a process for automating all the data, information, and procedures the States currently use. The scale of effort and coordination required for this option will serve as a significant barrier to it adoption.

Risks

Being the most advanced of all the alternatives, Alternative 4 provides the most risks. In addition to all the risks listed for the previous alternatives, this alternative also has the following risks:

- There could be issues with using a third-party Truck Routing API, or with providing routing suggestions (e.g., there might be errors in the route, and it may not be the most efficient or even a viable option).
- States generally have their own preferences and methodology when it comes to emergency resource policy. For instance, States often route OS/OW permit applications through their bridge office for review, so the system would need to allow the State to process the applications through their own procedure.

- States may be reluctant to rely on a national OS/OW permitting system. The amount of time and effort required to standardize national permitting forms may make this option impractical.
- Making future changes to the application will include collaboration with every State involved in the permitting forms and reviews.

Estimation of Effort and Cost

Of all alternatives, Alternative 4 will require the most time for completion. This alternative would require all States to agree on and develop standard formatting for permitting, routing, and emergency resources. This will require significant efforts by researchers with knowledge of State transportation policy, ETL developers, web application developers, and database development and maintenance. A high-level estimate of cost if provided below:

- Staff: a minimum of 10,000 hours (estimated for planning alone; the total effort could be over 30,000 hours over multiple years):
    - 1-4 Researcher/Business Analyst(s)
    - 1-2 ETL Developer(s)
    - 1-3 Web Developer(s)
    - 1-2 Software Developer(s)
    - Database Administrator
    - Project Manager
- Licensing costs: see Alternative 3 "Software Needs":
    - Routing API
    - Web Application Hosting

Overall cost range for planning (Phase 1 only) is $2M to $2.5M (estimated).

The cost range provided here is limited to Phase 1 (Planning) of the system and **does not** include O&M cost. At this early stage of conceptualizing the system, accurately estimating the cost of this alternative is extremely difficult because of the many questions surrounding its development. Specifically, the tasks (capabilities) that would be included in development for this alternative need to be further defined. Development of Alternative 4 would follow the System Engineering development process outlined in Alternative 3:

1. Phase 1: Planning – identifying user needs, system requirements, outreach, data and security management, as well as all planning documents necessary for the successful completion of the project
2. Phase 2: Design and Development – defining the architectural and system design and development of the proposed alternative
3. Phase 3: Testing/Piloting – real-world demonstration of the tool
4. Phase 4: Production/Transition – transitioning from a pilot tool to deployment. Depending on the procurement/business model selected, this phase could also include the cost of O&M for a defined number of years during/post transition

The above process for Alternative 4 would be more extensive than Alternative 3 and involve collaboration with the States and AASHTO to develop a new national system that would interface with States for permitting and routing. Because of the variables in the process, an

estimate is only for Phase 1 in the development process—the planning of the tool. Upon completion of Phase 1, a cost estimate can be provided for development of the system.

If this type of system was pursued, it could be developed through an Agile approach, providing insight into the tool development status through showcasing interim versions of the most valuable program (MVP). With this approach, simplified versions of the tool could be showcased so that FHWA (and other stakeholders) can assess the "look, feel and functionality" of the tool. Another option would be for a group of States and AASHTO to take a lead in piloting a regional model with support from USDOT.

For Alternative 4, O&M costs could range upward of $250k annually. The web application may require aesthetic and functionality updates after development, the database behind the application could require constant data refreshes to provide relevant and up to date data for users. Staff would need to be designated to provide support and troubleshooting 24/7.

CHAPTER 3. CONCLUSION

The following are a set of recommendations for consideration when deciding next steps for the development of this Web tool. Depending on the alternative that is pursued, there may need to be extensive collaboration between USDOT, States, and AASHTO:

- Alternative 1 would be the least time consuming and would require the least cost to develop of the four alternatives. While it doesn't provide mapping capabilities, this alternative would still be useful to truck drivers in identifying emergency resources across their intended route.
- Alternative 2 would be a slightly more complex than Alternative 1 but would have similar functionality. The output for Alternative 2 would include a corresponding interactive map that could be useful for truck drivers. By selecting States on the map, users will be able to identify emergency resources across their intended route.
- Alternative 3 would include the development of a new Truck API and corresponding dynamic html tables containing links to emergency resources across their intended route. This alternative would include more development time and cost than Alternatives 1 and 2 as it includes a large web development effort.
- Alternative 4 would create a national permitting and routing system that could help expedite the permitting process for emergency response vehicles. However, this option could not be implemented under the current permitting and routing process. There is no way of accurately estimating how long it would take to coordinate with States to develop a standard formatting for emergency resources, finalize and publish the forms, custom develop a web application, and publish to a new standardization website. There are many unknowns in this alternative, but it would be significantly more expensive and time consuming than the other alternatives.

Alternatives 1 and 2 are realistic options, with reasonable development time. Table 1 provides a brief description of all the alternatives and their associated level of development complexity, cost, research, and State coordination requirements. Table 2 provides a summary of the high-level estimate of cost and time needed for the development of each alternative, excluding maintenance and operation cost.

Table 1. Summary of Alternatives.

Dev. Option	App. Dev. Complexity	Dev. Cost	Research and State Coordination	Highlights and Key Characteristics
Alt 1	Low	Low	Med	Dynamic table using data visualization software. Users can query specific State emergency form information.
Alt 2	Med	Med	Med	Web mapping application containing specific State emergency form information. GIS mapping software is utilized.
Alt 3	High	High	Med	Custom web application using a Custom Truck Routing API and dynamic html tables.
Alt 4	Very High	Very High	Very High	One-stop shop for permitting and routing emergency response vehicle. With this option, users are provided routing options as well as request and process corresponding permits.

Alt = alternative; app. = Application; Dev. = development; GIS = geographic information system; Med = medium.
Source: FHWA

Table 2. Cost and Time Summary of Alternatives.

Development Option	Estimated Dev. Cost	Estimated Time Required
Alt 1	$120k to $160k	900 hours
Alt 2	$180k to $240k	1,100 hours
Alt 3	$800k to $1.5M	7,000 hours
Alt 4	$2M to $2.5M	10,000 (planning alone)

Alt = alternative; Dev. = development.
Source: FHWA

Each alternative builds upon the capabilities and requirements of the previous one, which would allow for phased development of the web tool following an Agile process.

Next steps in developing an emergency routing web tool would be to determine the lead agency and the key stakeholders (e.g., USDOT modal administrations, other Federal agencies, State agencies, AASHTO, and the private sector) to be involved in developing a concept of operations. There is also the option for State agencies and AASHTO to take a lead in piloting a regional model with support from USDOT.

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