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Resilient U.S. Land Ports of Entry

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EXECUTIVE SUMMARY

The continued operation of Land Ports of Entry (LPOE), managed by the Customs and Border Protection (CBP) and General Services Administration[1], is vital to the U.S. economy and security. Border faculties are included in the Department of Homeland Security (DHS) Government Facilities Sector[2], one of the 16 critical infrastructures "whose assets, systems, and networks, whether physical or virtual, are considered so vital to the United States that their incapacitation or destruction would have a debilitating effect on security, national economic security, national public health or safety, or any combination thereof.[3]" Specifically, disruptions to the flow of border crossing traffic, in the form of closures or increased border crossing wait times, impact the economy and security of all countries involved. This paper describes a process for analyzing and improving the resilience of U.S. Land Ports of Entry.

For LPOE, the team believes that energy resilience is the primary objective due to the complete reliance on the e-manifest system and the increasing use of Multi-Energy Portals (MEPs). E-manifests are part of CPB's Automated Commercial Environment (ACE). They document several key pieces of information about cargo vehicles wishing to cross the border into the United States and are submitted before arriving at the port. Vehicles can be flagged for more invasive inspection based on the content of the e-manifest. MEPs are a non-intrusive inspection (NII) technology used to scan the contents of the cargo. Together MEPs and ACE serve an important role in aiding CBP with their mission to protect "the public from dangerous people and materials", and "enabling legitimate trade and travel.[4]"

To analyze resilience of a port, the team would need to understand the port's current energy usage, which systems depend on energy and what backup systems exist, and any emergency operation plans that dictate how systems are operated in the event of a power outage. The team would also need to determine the design basis threats (DBTs) for the LPOE which could include natural disasters, man-made events, and accidents. The magnitudes of the DBTs are calculated and are then translated to expected impacts on the infrastructure and systems at the port.

With this information gathered, existing LPOE models developed here at Sandia National Laboratories could be extended to support decisions about resilience. Current models are implemented in FlexSim, a 3rd party discrete event simulator. FlexSim provides 3-D visuals of physical layout that can reveal valuable insights, allows input to be variable (e.g. time it takes to interact with the CBP officer at primary inspection can vary) so that a whole range of possibilities can be captured in the results, and can be used to collect user-defined output metrics.

Current LPOE models focus on cargo vehicle traffic, and process changes caused by the installation of new drive-through MEPs. Extending them to address resilience questions would require the addition of key pieces of information learned during the resilience analysis including critical systems, failure rates, and process changes for when failures occur. The primary output metric for current models is border crossing wait time. Additional metrics would also be added to the model to gain a more complete understanding of impacts related to resilience, for example, MEP scan rate. Once complete, the model could be used to analyze the effectiveness of mitigation strategies representing some future state.

ACRONYMS AND DEFINITIONS

Abbreviation	Definition
ACE	Automated Control Environment
CBP	Customs and Border Protection
CISA	Cybersecurity and Infrastructure Security Agency
DBT	Design Basis Threat
DHS	Department of Homeland Security
FEMA	Federal Emergency Management Agency
GSA	General Services Administration
LPOE	Land Ports of Entry
MEP	Multi-Energy Portal
NII	Non-intrusive Inspection
O&M	Operations and Maintenance

1. INTRODUCTION

Land Ports of Entry (LPOE) are essential to the all countries involved. Closures or additional delays at LPOE have the potential to significantly impact local and national economies, disrupt the delivery of critical supplies, and increase security concerns. For example, 11 million containers arrive at U.S. land borders by truck[5] using one of the 167 land border crossings owned, leased, or managed by the Customs and Border Protection (CBP) and General Services Administration (GSA)[1]. Strengthening the resilience of border facilities to various threats is an area of focus for the Department of Homeland Security (DHS), of which CBP is an operational component. As listed on the DHS Cybersecurity and Infrastructure Security Agency (CISA) website[3], critical infrastructures are "so vital to the United States that their incapacitation or destruction would have a debilitating effect on security, national economic security, national public health or safety, or any combination thereof". Government Facilities is one of the 16 critical infrastructures identified in Presidential Policy Directive 21 (Critical Infrastructure Security and Resilience). Border facilities are explicitly called out in the 2015 sector-specific plan[2]. This white paper outlines a process for assessing and improving the resilience of LPOE to various threats.

2. MOTIVATION FOR THE DEVELOPMENT OF EXISTING SANDIA LPOE MODELS

According to their website, "CBP's top priority is to keep terrorists and their weapons from entering the U.S. while welcoming all legitimate travelers and commerce." Part of their strategy to prevent contraband from entering through land ports of entry is the use of non-intrusive inspection (NII) technologies, one of which is the Multi-Energy Portal (MEP)[4]. The goal is that these drive-through x-ray imaging portals would scan 100% of the commercial vehicles waiting to cross the border; a large increase over current scan rates, which the FY19 CBP Trade and Travel Report[6] estimated to be 15%. The MEP images would be read and analyzed while the driver is still waiting to cross, and the results would be available to the officers for use as a tool in determining whether the vehicle should be flagged for further inspection.

Increased border crossing wait times can have significant impacts on the economy. For example, according to the 2007 Update: Economic Impacts of Wait Times in the San Diego-Baja California Border Region by the San Diego Association of Governments (SANDAG)[7], delays cost the U.S. and Mexican economies an estimated $7.2 billion in gross output and more than 62,000 jobs in 2007. Concerns that 100% scanning would negatively affect border crossing wait times led to several new projects at Sandia where models of this potential future state were developed and used to quantify impacts.

3. CHARACTERISTICS OF EXISTING MODELS

Each existing model focuses on a different land port of entry. The primary purpose of existing models is to assess the impacts to border crossing wait times and personnel needs resulting from 100% MEP scanning of commercial vehicles.

All existing models were developed using a commercial tool called FlexSim[8]. FlexSim is a 3D simulation, modeling, and analysis software tool well suited for developing representations of existing or proposed processes as well as physical layouts that include physical structures, equipment, and personnel.

At a high-level, the process for the border crossing of commercial vehicles includes:

1. An e-manifest for the truck is submitted to the CBP ACE before arriving at the port
2. Once the truck arrives at the port, while waiting to reach the primary inspection station, the vehicle is scanned by the drive-through MEP and its images are read and analyzed
3. The driver will then interact with the primary inspection officer. The officer will use ACE to look up the relevant truck information. The officer will also perform other security screenings such as verifying the driver's identity and asking questions about the contents of the container to determine if a driver is acting suspicious
4. After speaking with the primary inspection officer, the vehicle may be sent to secondary inspection. Further inspection may ultimately lead to devanning the cargo

More specifically, existing models were developed as follows:

1. Study and implementation of the physical layout of the port including:
    - The number of lanes leading to the commercial vehicle border crossing and what lanes can process what vehicles
    - How vehicles are routed (lane merges and splits), and the location of MEPs, inspection stations, and devanning area, all layered on top of a map (i.e. Google maps) as in Figure 1 below

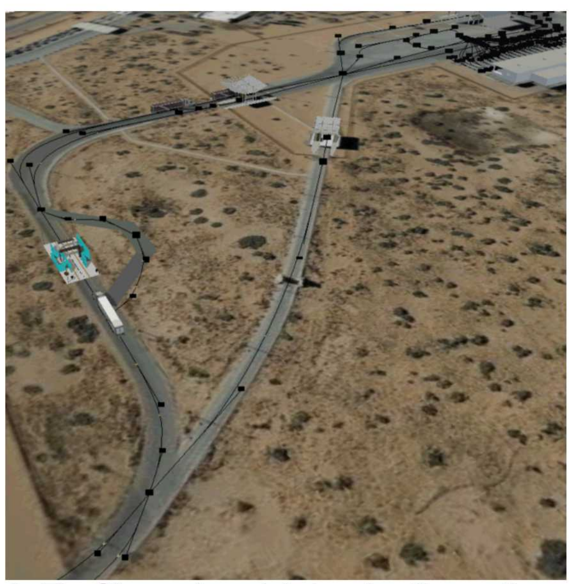

Figure 1: Example FlexSim port model showing the routing of trucks

2. Gathering of input data including:
    - The rate at which vehicles arrive at the port (by hour and day of week).
    - Hourly lane schedules determining how many are open
    - Vehicle characteristics such as whether they are full of cargo or empty, whether they are part of the Free and Secure Trade (FAST) commercial clearance program for low-risk shipments
    - Probability that a vehicle is flagged for secondary inspection. Various probabilities can be included. For example, a vehicle may be flagged by a MEP analyst who notices something on a MEP image, or by a primary inspection officer who sees a driver behaving suspiciously; each of those situations can have a probability assigned
    - The number of analysts available to read and analyze MEP images
    - The number of available devanning slots
    - The personnel available to do devanning
    - Various process times:
        - Time spent at the primary inspection booth
        - Time spent driving through a MEP
        - Time it takes to read and analyze a MEP image
        - Time spent at secondary inspection
        - Devanning delays

All model inputs mentioned above can be stochastic in nature, meaning they can be random values provided by a statistical distribution that fits subject matter expert estimates or real historical data. When input values are variable, multiple simulation runs result in a range of outputs that can provide insight into worst, most likely, and best-case outcomes.

FlexSim provides the ability to define many types of output metrics. The focus of the output metrics for existing models help answer questions about the effect of MEPs on wait times. The total time each vehicle spends crossing the border is available, but metrics at a finer level of detail are also included such as time spent waiting to reach a primary inspection booth, time spent waiting to drive through a MEP, time spent in secondary inspection, the number of secondary slots needed, the personnel needs in secondary inspection, and the number of open lanes required to keep border crossing wait times acceptable.

FlexSim can also be used to evaluate and compare various what-if scenarios. For example, existing models can be used to answer questions like, "what happens to the border crossing wait time if the MEP is moved to a different location or if the number of analysts available for reading and analyzing MEP images is decremented" or "how is border-crossing wait time impacted by increased traffic due to future growth? Figure 2 shows a FlexSim plot with a notional output metric where two what-if scenarios are defined.

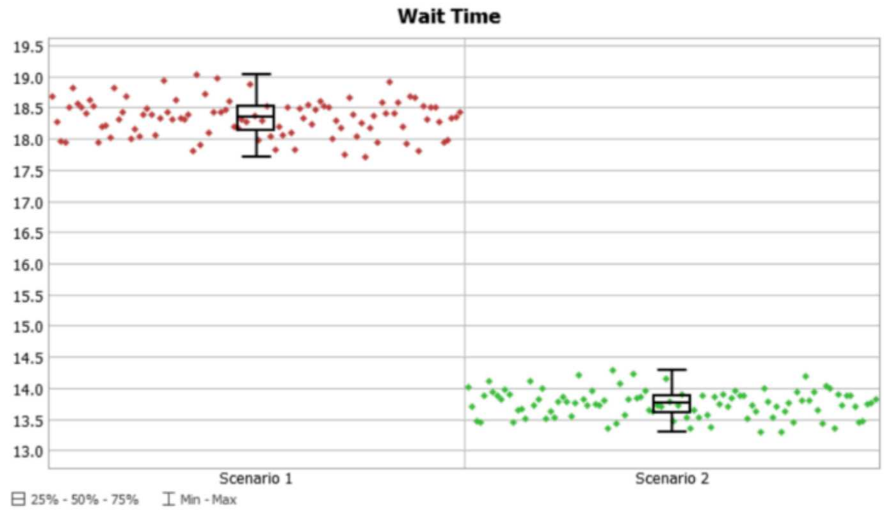

Figure 2: A notional FlexSim plot comparing the output metric of two what-if scenarios. Results for each what-if scenario are provided as a range of values displayed with a box plot.

At the time the existing models were created, no new installation of MEPs had occurred, in other words, although an "as-is" model was built to match the current performance of the port, other model variations represented a potential future state not an existing one. Being able to model potential future states in a decision support tool like FlexSim without having to make the changes in real life is a powerful capability that helps save time and money.

4. ANALYZING RESILIENCE FOR PORTS OF ENTRY

To address the impact of even slight delays in vehicle processing, resilience should be included as a key component of the port of entry models. Sandia has expertise in assessing resilience for multiple infrastructure sectors and has applied this expertise to help urban areas such as New Orleans and Puerto Rico, military installations, and even private companies[9,10,11]. Sandia's resilience framework[12] can roughly be broken down into the following broad steps:

- Define the scope and goals
- Identify performance- and consequence- based resilience metrics and consequence categories
- Conduct a baseline analysis of the current system
- Specify mitigations that can be used to improve resilience and calculate metrics
- Evaluate the effectiveness of mitigations that are implemented in the real-world

For ports of entry, the team believes that energy resilience is the primary objective due to the complete reliance on the e-manifest system and the increasing use of MEPs. To begin the analysis, researchers would need to work with the ports to understand their current energy usage, which systems depend on energy and what backup systems exist, and any existing emergency operations plans that dictate how systems are operated in the event of a power outage.

The team would then determine the design basis threats (DBTs) for the port which could include natural disasters, man-made events, and accidents. Specific threats could include things like hurricanes, wildfires, physical attacks, and cyber-attacks to name just a few. The map in Figure 3 shows historical occurrences of major natural disasters in the U.S. with some certainly occurring along the Mexican and Canadian borders[13]. Threats vary by geographic location, so threat selection should be specific to the port of entry being analyzed.

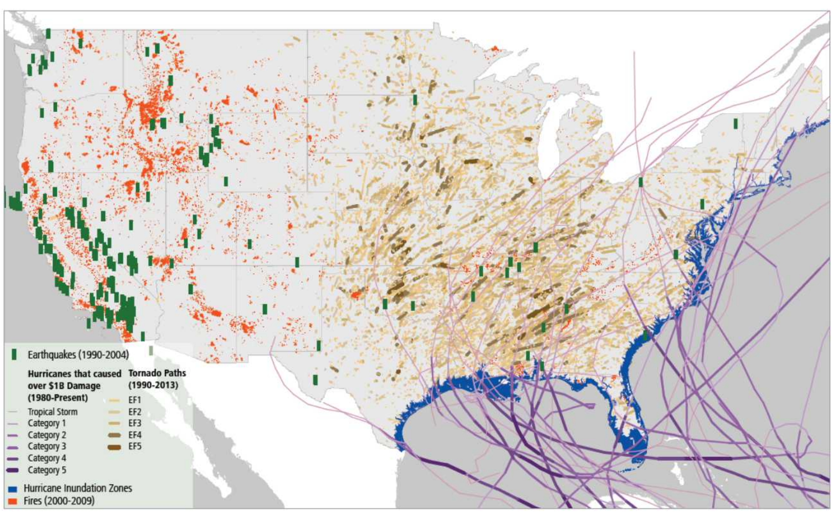

Figure 3. Map of historic U.S. major natural disasters

Once a list of the most likely DBTs is determined, the team will assess the expected magnitude of these threats. For natural disasters, tools like the Federal Emergency Management Agency's (FEMA's) Hazus models can be used[14]. These magnitudes are then translated to expected impacts on the infrastructure and systems at the port. This helps the analysts and stakeholders understand what levels of resilience are needed to be able to withstand low probability, high consequence events that may impact their location. For example, the requirement to withstand a week-long outage will necessitate different mitigation strategies than the need to withstand an hour-long outage.

After quantifying the anticipated effects of the DBTs and establishing resilience objectives/requirements, analysts will need to work with stakeholders to determine realistic mitigation strategies. These may include options such as localized microgrids, backup generators, or even non-technology options such as elevating systems above expected inundation levels. In extreme cases, disruptions may affect the surrounding area and require traffic to be routed through a different port—making the analysis a multi-port problem that would potentially need to consider road networks as well.

The goal with all resilience improvements is to enable systems used at the ports to operate with no or minimal interruption during loss of power from the grid. Solutions need to maintain both the throughput of traffic and also the scanning capacity. This prevents economic impacts caused by delayed goods and security threats caused by reduce scanning. Stakeholders and analysts should consider the tradeoff between cost (both initial and operations and maintenance (O&M)) and performance when determining which mitigation options to implement.

5. LEVERAGING EXISTING MODELS TO STUDY RESILIENCE

Although existing models focus primarily on the impacts of 100% MEP scanning, they could be extended to support decisions about resilience. What is added or changed in the model will depend on the scope of the resilience analysis. For example, what critical systems and assets were identified for the resilience analysis? Current models only include commercial vehicle traffic, but it's possible that the critical systems and assets identified require the addition of private passenger vehicle traffic. At the very least, the following would be added to the model:

- Critical systems and assets and any associated data, processes, and resources
- Failure rates to define downtime for critical systems and assets. What is the expected downtime/failure rates of assets based on impacts of the DBTs and also on normal failure rates
- Logic that defines how processes change when failures occur. For example, what occurs if a lane closes unexpectedly or MEP is down? This could be based on existing emergency operations plans.
- Definition of additional output metrics. For example, in the situation where a MEP is down, an important output metric to add may be the observed scan rate, since it's possible 100% scanning could not be realistically achieved with the remaining systems.

Although the list of additions is short, it does not imply that the process of modifying the model or creating a new one would be simple or quick. There are many details that would need to be studied and implemented. Once the model is developed, results could be used to quantify how output metrics change when accounting for specific threat scenarios and various outage lengths. By defining what-if scenarios, the model could also be used to assess the effectiveness of any proposed mitigations.

6. CONCLUSIONS

This paper has described a process for assessing and improving the resilience of LPOE, bringing together Sandia National Laboratories' expertise in resilience and LPOE modeling. LPOE are part of the U.S. critical infrastructure and CPB plays a critical role in their operation. Closures or increased border crossing wait times can have significant impact on the economy and security of all countries involved. Planning for potential disruptions can help mitigate impacts. This paper describes a process for identifying potential mitigations by first analyzing port resilience, then using the information learned to extend existing LPOE models, and then lastly using the models to determine the effectiveness of any potential mitigation strategies. Using existing LPOE models represents a first step to incorporating resilience into models that are already used by CPB, but later phases of resilience analysis could utilize Sandia's other resilience software capabilities and expand into other infrastructure areas through employing cyber, road network, and supply chain models.

REFERENCES

[1] Land Ports of Entry Overview, U.S. General Services Administration, 23 May 2018, https://www.gsa.gov/real-estate/gsa-properties/land-ports-of-entry-overview

[2] Government Facilities Sector-Specific Plan, U.S. Department of Homeland Security and GSA, 2015, https://www.cisa.gov/sites/default/files/publications/nipp-ssp-government-facilities-2015-508.pdf

[3] Critical Infrastructure Sectors, Cybersecurity & Infrastructure Security Agency, 24 March 2020, https://www.cisa.gov/critical-infrastructure-sectors

[4] About CBP, U.S. Customs and Border Protection, 18 September 2019, https://www.cbp.gov/about

[5] Cargo Security and Examinations, U.S. Customs and Border Protection, 25 October 2019, https://www.cbp.gov/border-security/ports-entry/cargo-security

[6] CBP Trade and Travel Report Fiscal Year 2019, U.S. Customs and Border Protection, January 2020, https://www.cbp.gov/sites/default/files/assets/documents/2020-Jan/CBP%20FY2019%20Trade%20and%20Travel%20Report.pdf

[7] 2007 Update: Economic Impacts of Wait Times in the San Diego – Baja California Border Region Fact Sheet, San Diego Association of Governments (SANDAG), September 2007, https://www.sandag.org/uploads/publicationid/publicationid_1181_5101.pdf

[8] 3D Simulation Modeling and Analysis Software, FlexSim Software Products, https://www.flexsim.com/

[9] A Grid Modernization Approach for Community Resilience: Application to New Orleans, LA, U.S. Department of Energy Office of Scientific and Technical Information, 01 October 2017, https://www.osti.gov/biblio/1510648

[10] Analysis of Microgrid Locations Benefitting Community Resilience for Puerto Rico, U.S. Department of Energy Office of Scientific and Technical Information, 30 September 2018, https://www.osti.gov/biblio/1530167

[11] John Eddy, Ph.D., Application of the Microgrid Design Toolkit to Military Installations and Remote Communities in Alaska, MORS 87th Symposium, 20 June 2019

[12] Sandia's Integrated Methodology for Energy Resilience Analysis, SAND2019-14340 O

[13] Preston, B.J., S.N. Backhaus, M. Ewers, J.A. Phillips, C.A. Silva-Monroy, J.E. Dagle, A.G. Tarditi, J. Looney, and T.J. King. 2016. Resilience of the U.S. Electricity System: A Multi-Hazard Perspective. U.S. Department of Energy Office of Policy. Washington, D.C.

[14] FEMA Flood Map Service Center: Hazus, Federal Emergency Management Agency, https://msc.fema.gov/portal/resources/hazus