A Human-Centered Approach to Modeling Security Information and its Impact on Cargo Operations for Guidance in the Design of Interventions in the Information Sharing Environment

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ABSTRACT

We demonstrate a model-based systems engineering (MBSE) approach to analyzing how information resources and the policies that govern their use impact security workflows. This approach establishes a crucial connection between workflow and the information sharing environment and enables the formative evaluation of candidate interventions designed to enhance security, such as new information systems and data standards. We (1) modeled the use and generation of security information in support of marine terminal operations and (2) analyzed security as a service in support of those operations. Our approach uses extensions of the Object Management Group's (OMG) Business Process Model and Notation (BPMN) standard and integrates workflow modeling with an information dictionary that records and automatically generates task-specific information requirements. The scope of the model we present is containerized cargo operations at a commercial marine terminal. The approach, which connects work activity to information flow, can be applied to analyze trade-offs between better information resources and more physical resources and to identify where and how future systems and programs will impact current operations. We discuss how the MBSE technique of generating the information dictionary aligns with important federal efforts to capture essential information exchange requirements.

ABOUT THE AUTHORS

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INTRODUCTION

Federal efforts to enhance maritime security via improved information systems or data sharing standards may miss the mark or introduce unintended consequences when the impact of information on workflow is not made an explicit part of their design. Introducing changes to the complex information sharing environment that ensures maritime security requires sensitivity to and an understanding of the dependencies among the constellations of people, technology, physical and information resources, that together, accomplish security work. Changes that are not designed with this sensitivity can interfere with operations and create security risks. A new approach is needed to design and validate information sharing requirements that will have a predictably beneficial impact on workflow.

In this paper we introduce a design methodology in which the impact on workflow is an integral component of, rather than an unpredictable response to, changes in the information sharing environment. The flow of work tasks and the flow of information that supports these tasks are co-evaluated in conjunction with potential interventions as equally important, integral parts of a system that must work together. This is accomplished by human-centered, participatory methods that put the owners of that workflow, the operational professionals, in a central role.

We developed a detailed process model of cargo operations, the corresponding security information flow, and how the use of current information resources constrains operations. The outcome is a graphical model developed using a model-based systems engineering (MBSE) [1] approach and implemented using an extension of the Business Process Model and Notation (BPMN) standard. [2] Models are iteratively co-developed with the operational professionals to produce a detailed, agreed upon representation of how work is conducted and how information is used in support of that work. The BPMN extension captures all information usage and change, including information that is shared or exchanged among systems and organizations, into an information dictionary of security information as it is used within the workflow of operations. The technique connects workflow to information flow and can be used to analyze trade-offs between better information resources and more physical resources and identify where/how future systems and programs will impact current operations.

OBJECTIVES

Our goals are to demonstrate a human-centered, MBSE approach for designing interventions to improve the delivery of maritime security services. This approach can reveal hidden constraints that can inform changes to the information sharing environment, improve relationships between software developers and the community, and ultimately result in a more effective intervention. We achieve our goal by implementing MBSE to understand and model the use and generation of security information in support of cargo unloading operations at a marine terminal.

METHOD

The focus of our model is cargo operations at a representative US maritime port of entry on the west coast. These operations are critical to our overall national security and a component of the DHS's strategic priority to "minimize the disruption to and facilitate the safe and secure inbound and outbound legal flows of people and goods." [3] A 2013 economic impact assessment of US west coast ports found that International Longshore and Warehouse Union (ILWU) terminals support 9.2 million workers who received $383.1 billion in wages and salaries in that year. [4] Cargo transiting west coast ILWU terminals generated $2.1 trillion, representing 12.5% of the U.S. GDP (2014). The role that seaports play in our economy makes them a target. A successful nuclear terrorist attack on a U.S. seaport has been estimated to result in "disruption of US trade valued at $100-200 billion, property damage of $50-500 billion, and 50,000-1,000,000 lives." [5]

The purpose of the seaport system is to transfer goods and passengers between maritime and inland modes of transportation quickly, safely, and cost-effectively. The physical elements of the system include container terminals, cranes, intermodal containers, vessels, trucks, railways, employees, etc. The informational resources of the system include people, electronic information systems, and paper documents. There are numerous stakeholders in the port system, including but not limited to, federal agencies, non-governmental organizations, state and local authorities, labor unions, port authorities, customers, and industrial partners.

In the MBSE approach we report here,[1] the analyst uses interview and observational data to model the work process including the information that is required to perform each task. The model is then validated by a subject matter expert who works with the analyst to walkthrough the model and ensure that it accurately represents their work. Because these walkthroughs are led by the stakeholders who actually perform the work, the resulting model connects system requirements with user behavior, which in turn, supports the design of system interventions that align with the actual rather than hypothetical workflow. Our approach is iterative and comprises three stages:

1. Knowledge acquisition: in which we collected observational and interview data from subject matter experts, analyzed work artifacts and national data standards, and critically reviewed literature and government reports.
2. Modeling: in which we encoded this information into a graphical language that produces an interactive model of the workflow and information flow in support of cargo operations.
3. Analysis: in which we critically reviewed the model to identify information gaps and inconsistencies.

Knowledge Acquisition

The present study setting was a commercial terminal (henceforward referred to as "the terminal") that handles domestic and limited international cargo vessels. Using snowball sampling, we interviewed eleven individuals (N = 11) in job roles critical to the use case: terminal operations and security managers (n = 2); USCG inspectors (n = 2); a trucking company representative (n = 1); a US Army logistician specializing in offloading cargo (n = 1); ocean carrier operations, business process, IT, and customer service employees (n = 4); and a freight forwarder (n = 1).

The knowledge inputs into the model are interviews and observations with subject matter experts and source documents including work artifacts, literature, and government reports. We began with a semi-structured interview with a terminal security officer who also provided us with sample work artifacts, (e.g., computer print outs of planning documents, manifests, and email communication) and recruited additional interviewees as needed to complete our model. The focus of the interviews was on understanding the interviewee's work processes and associated information, where and how they get the information, and what they do with it.

Modeling

An essential element of MBSE is a common language that is clear and unambiguous for all participants and stakeholders. The modeling language for cargo operations study is an extension of the Business Process Model and Notation (BPMN). Using this language, knowledge elicited during the initial interview was encoded into an initial, high-level workflow model (Figure 1[2]), which we broadened and deepened with the addition of information gleaned in subsequent interviews. Using the initial model as a guide, we identified knowledge gaps, inconsistencies, and

[1] For additional information on this approach, see [6]

[2] The images in Figures 1, 2, and 3 are screenshots from MATH (Modeling and Analysis Toolsuite for Health IT)—a program that we used to capture the model. For additional information on this program, see [6]

individuals we needed to talk to for missing information, and what questions to ask next. Basing subsequent interviews on the draft model resulted in focused, detailed interviews that elicited insights critical to the workflow.

Following our MBSE methodology, the knowledge acquisition and modeling phases are iterative, and we completed several cycles before achieving a stable view of the tasks that comprise the scope of the selected workflow and the supporting flow of information. Supplementary information was gathered from publicly available sources such as the *United Nations' Rules for Electronic Data Interchange for Administration, Commerce, and Transport*[3].

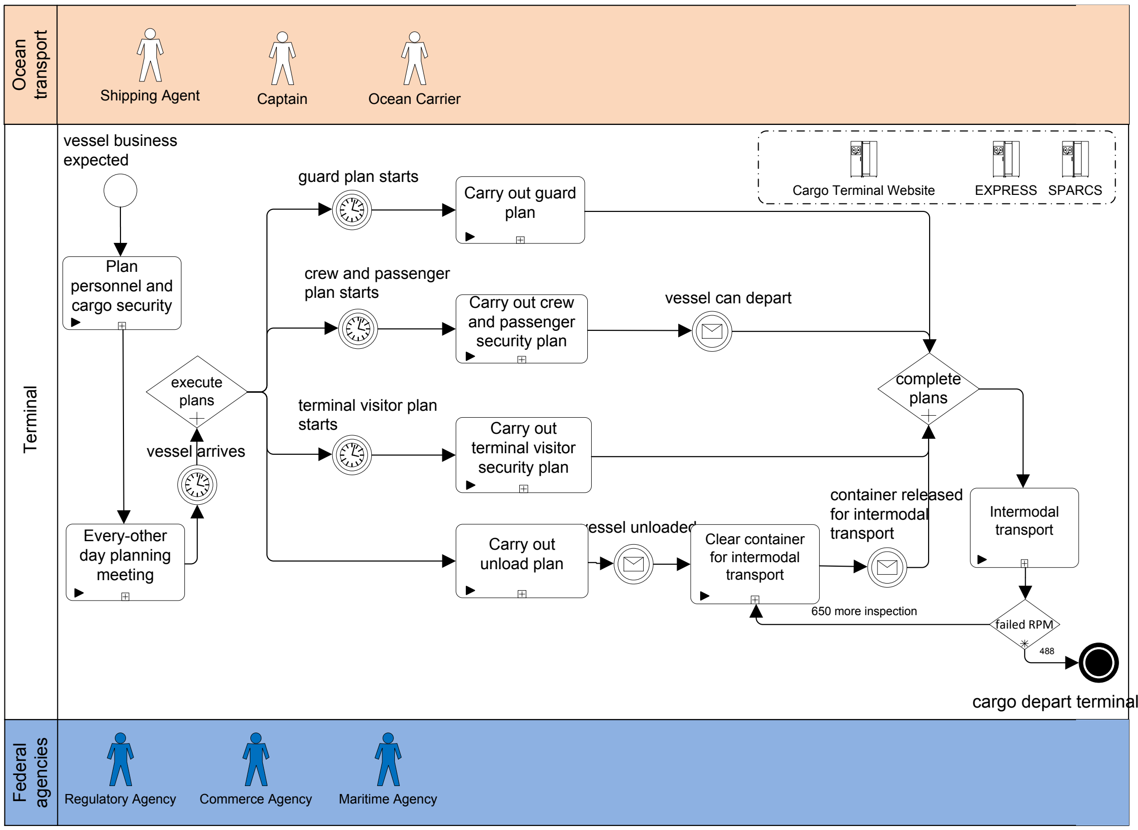

Figure 1. Graphical representation of top-level model of cargo operations security at the Terminal.

Analysis

Through a critical review of the as-is model of information flow that is currently used in the cargo movement workflow, we uncovered information dependencies among different operational divisions at the terminal (e.g., security and operations) as well as between the terminal and outside agencies such as the US Coast Guard (USCG), trucking companies, and ocean transport. We then researched policies and initiatives that constrain information sharing in the as-is workflow. In addition, we identified pending initiatives with the potential of impacting current operations and information sharing relationships.

RESULTS

In this section we describe the scope of the model, an example path through the model, and security measures taken regarding cargo operations and the information required to carry out those measures.

[3] http://www.unece.org/cefact/edifact/welcome.html

Model Scope

The terminal was the initial starting point from which the model was built. The terminal handles container and break-bulk cargo; only containerized cargo is considered in the model. As there is no on-dock rail, all intermodal transportation in and out of the terminal is via truck. The model aims to follow one container through the entire process of cargo operations.

The information used throughout the model is recorded as information inputs and outputs for each task. This information can then be exported as an information dictionary. This information dictionary itemizes all information that is essential to the terminal's workflow and records in which tasks it is used resulting in a record of information usage patterns needed by the workflow. Figure 2 shows a portion of the information dictionary listing tasks in the workflow and the information inputs to and outputs from these tasks indented below. To further illustrate information usage in the model, the next section will guide the reader through a representative path in the model and relevant portions of the information dictionary.

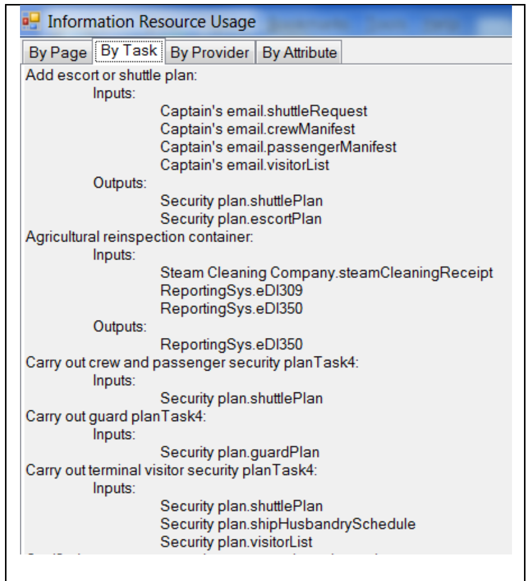

Figure 2. Portion of the information dictionary showing tasks (left justified) and their information inputs and outputs indented below

Example Path in Model

There are two aspects of security around cargo operations: (1) the local physical security of the terminal's perimeter and the people within it and (2) the terminal's role in external interactions with the larger supply chain security service system. The workflow depicted in the model begins when a vessel is expected to call at the terminal. This triggers the terminal's security manager to assess the perimeter and personnel security needs. Perimeter security involves manning the terminal gates and roving the premises. Personnel security pertains to authorizing[4] and enabling the crew, passengers, visitors, and vendors to enter and exit the terminal. The next activity is the terminal managers' every-other day planning meeting. In Figure 3, the sub-process for Every-other-day planning meeting has been opened to display the workflow in more detail. During this 30-40 minute meeting, the terminal managers hold a discussion in which each terminal manager[5] presents information they have received allowing the others present to confirm or correct their information. In Figure 3, the Task Properties editor tab is open to show the Input/output Information Resources for this task recorded in the model. The left panel shows the information needed for the security manager to update the security plan in terms of the information attribute and the resource from which it was accessed. Using this information, the security manager may update the perimeter and personnel security plan. The outgoing information resource (Security Plan) and attribute (plan change) are shown in the right panel.

The next activity is the physical arrival of the vessel. After vessel arrival, the unload plan is carried out. The security plans for manning gates and for escorting personnel are developed to support the unload plan. The unload plan details which containers are to be unloaded and where they are to be placed in the yard. The terminal knows which containers to unload via the COPRAR EDI message[6] and knows where those containers are located onboard the vessel via the BAPLIE EDI message.[7] [7]

The terminal sends the shipping line either a COARRI EDI or an EDI 322, depending on which standard[8] the company uses, to notify them that the container has been unloaded. The containers with no inspection holds are moved to their place of rest in the terminal yard. Containers requiring inspection will pass through a vehicle and

[4] All personnel wishing to access a marine transportation facility unescorted must possess a Transportation Worker Identification Credential (or TWIC). The terminal provides an escort to those needing transport between the gate and the vessel.
[5] The terminal has five managers: (1) safety and security, (2) operations, (3) facilities, (4) maintenance and repair, and (5) IT.
[6] The COPRAR is sent from the ocean carrier to the terminal authorizing them to discharge specific containers.
[7] The BAPLIE is prepared by the terminal operators at the vessel's last port of call in coordination with the ocean carrier and the vessel captain. It is passed on to the terminal operators at the next port of call by the ocean carrier.
[8] The COARRI comes from the EDIFACT standard, and the EDI 322 comes from the ANSI standard.

container inspection system, which produces an image of the contents of the container. This container image is compared to the container's cargo manifest, submitted by ocean carrier via EDI 309 and accessed by a regulatory agency via the agency's electronic system, to determine if further inspection is needed.

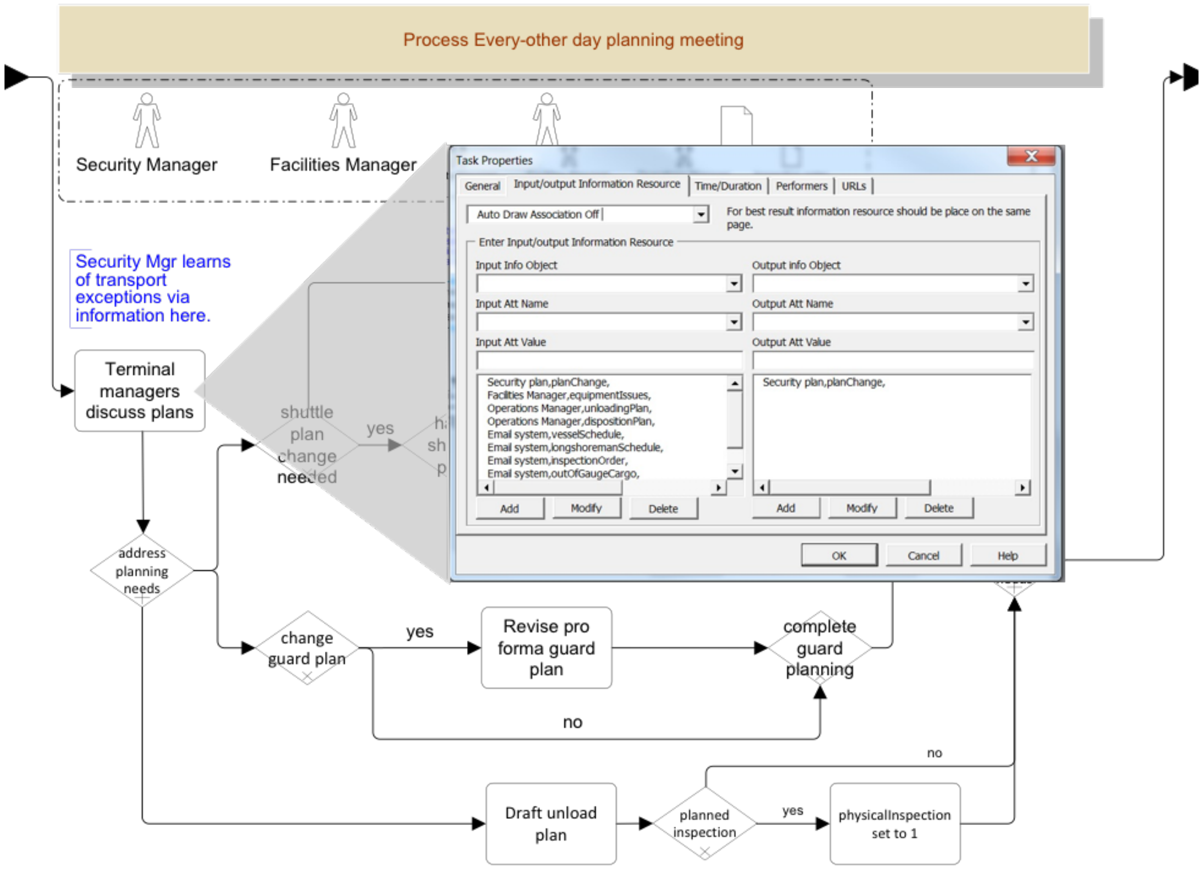

Figure 3. The Task Properties Editor showing information inputs essential to, and outputs from, the terminal managers' discussion during the every-other-day planning meeting

Once all holds are removed, the container is able to exit the terminal via intermodal transport. The intermodal transport activity is triggered by the arrival of a truck at the terminal security gate. The terminal gate guard will check whether the truck driver has a Transportation Worker Identification Credential (TWIC) and confirm he is a driver for an authorized trucking company.[9] The gate guard will conduct passive screening during this process and if anything is suspicious he will proceed to active screening. In active screening, the guard may search the vehicle.

Once the driver has passed through the security gate, he will proceed to the main gate. At the main gate, the truck driver interacts with the clerk, who will gather information (e.g., container number, booking number, Standard Carrier Alpha Code (SCAC)—a unique identifier of motor carriers) from the driver. The clerk will identify the containers available for pick-up that correspond to the booking number provided by the truck driver. Containers may be unavailable for a number of reasons including unpaid Customs duties and unresolved Customs holds. If a container is available, the trucker will obtain a ticket (a terminal interchange receipt, TIR) with the location in the yard where the container is to be dropped-off and the location of the container to be picked-up.

The truck driver will drop off and/or pick-up a container in the yard, and then drive through a regulatory agency's Radiation Portal Monitor (RPM) which passively detects radiation. The truck and equipment are checked for

[9] Ocean carriers that call at the Terminal must supply a list of authorized trucking companies. If a truck driver comes to pick-up a container for an ocean carrier that has not authorized that trucking co., the driver will not be allowed to pick-up the container.

roadability[10] before the transaction is verified by the clerk. The transaction is verified when the truck driver enters his TIR into the ticket kiosk at the out-gate; the information on the TIR is compared in Express to the container in the driver's possession either via OCR or camera. If the information matches, an equipment interchange receipt (EIR) is printed for the truck driver. The truck driver uses the EIR as verification that he delivered/picked-up a container in order to receive wages. The truck then exits the terminal and delivers the container to the prescribed destination. The terminal sends an EDI 322 at this point to notify the ocean carrier and customer that the container has exited the terminal. Selected tasks and information requirements for intermodal transport are shown below.

Security Information Captured in the Model

One objective of the model was to provide a through account of the security information used and generated in order for the terminal to complete its cargo operations. Modeling the system with this purpose in mind exposes information dependencies in key security measures and how they may be impacted by changes in the information sharing environment (e.g., new IT, policy, or the use of new data standards).

- The ocean carrier must submit the cargo manifest 24 hours before containers are loaded onto the vessel at a foreign port. The information used is the cargo manifest (EDI 309) submitted to the regulatory system.
- The regulatory agency must notify the terminal that it intends to perform non-intrusive inspection (NII) and itemize which containers to set aside for NII purposes. The information used is the inspection NII system list that the regulatory agency emails to the terminal.
- The terminal can only unload containers that they are authorized to by the ocean carrier. The information used is the COPRAR EDI message visible to the terminal in Express.
- The ocean carrier is notified of any movement of its containers at the terminal. The information used is the EDI 322 sent by the terminal in Express.
- High risk containers are immediately inspected upon unloading at the terminal. The information used is the container image produced by the NII system.
- Sensitive radiation detection equipment and physical inspection are used to identify misdeclared, illegal and/or dangerous cargo. The information used is the radiation measurements and visual inspection results.
- Biological hazards are identified and eliminated before the container may leave the terminal. The information used is the status of agricultural hold (EDI 350) visible in Express and the regulatory system.
- Only TWIC holders and authorized truck drivers are allowed to access the terminal to transport containers. The information used is the truck drivers TWIC and the terminal's list of authorized drivers. The TWIC is visually checked by the terminal guard. Trucking companies transmit information on authorized drivers to the terminal through EDI messages, phone, email, or fax.
- The safety of the truck and equipment is checked before the truck is allowed on public roads. The information used is the roadability check results. The check is carried out by contracted mechanics.
- All containers pass through passive radiation detectors before exiting the terminal. The information used is the alarm, or its absence, from the RPM.
- No container with a hold on it may leave the terminal (unless it is being transported by a bonded carrier to an off-site Customs examination station). The information used is the EDI 350 Customs Status message visible in the regulatory system and Express.

DISCUSSION

The purposes of the initial workflow model are to capture how work is actually performed and to understand how that work is constrained or enabled by information. Our extension of BPMN emphasizes information as a resource and integrates information modeling as part of the workflow model. The workflow of cargo operations is constrained by *physical resources*, such as a terminal shuttle vehicle, and *information resourc*es, such as email or paper documents. Our study revealed that information resources included physical and electronic media. Important reasons for capturing all types of information resources in a workflow, whether digital or not, include the fact that there may be overlapping records in different media that need better configuration management, and the integration of physical and digital resources can be a source of inefficiencies to correct in a new system.

[10] Roadability is the qualities (as steadiness and balance) desirable in an automobile on the road. In 2009, the Federal Motor Carrier Safety Alliance (FMCSA) issued the Requirements for Intermodal Equipment Providers and Motor Carriers and Drivers Operating Intermodal Requirement as mandated by \textsection4118 of the SAFETEA-LU.

In addition to physical and digital information resources, a number of conditions determine why information moves through the cargo operations workflow in the way that it does. For example, regulations, organizational culture and policy, technological constraints, and performers' personal preferences for ways of operating may all impact information flow, and these conditions are implicit constraints in our model. Subject matter experts sometimes explain these conditions during interviews with analysts, and we documented such explanations in field notes. However, a thorough understanding of the constraints that shape the business process under study requires additional interviews and background research. Were we using a directed rather than a pure discovery approach to our analysis, a thorough understanding of these conditions would be critical to designing an intervention that explores all possible avenues for process improvement—whether it be a policy, technology, or personnel training. As the purpose of the present model was exploratory, a complete inventory of all of the constraints is outside the scope of this report, however, we have identified a subset of the constraints in the course of our modeling activity. Any proposed intervention would need to perform within these constraints:

- The division of responsibilities between the Port and the terminal operator is established in the port governance and financing structure. Many ports act as "landlord", and the terminal operator performs the activities. Some ports, including the Port at which the Terminal is located, have preferential berths, which can be used by the Port in exchange for favorable tax rates for the terminal.
- Cargo manifests (EDI 309) must be submitted by the ocean carrier 24 hours before a vessel is loaded due to the Trade Act of 2002. [8]
- The requirement that all personnel wishing to access a marine transportation facility unescorted must possess a Transportation Worker Identification Credential (TWIC) is mandated by the Maritime Transportation Security Act of 2002. [9]
- The roadability check on all trucks leaving the container terminal is required by the Federal Motor Carrier Safety Alliance (FMCSA) Requirements for Intermodal Equipment Providers and Motor Carriers and Drivers Operating Intermodal Requirement as mandated by 4118 of the SAFETEA-LU (Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users). [10]
- The type of work, hours, wages, etc. of ILWU longshoremen and clerks are fixed in contracts that are negotiated at regular intervals (National Labor Relations Act).

Potential Applications

Our exploratory analysis has implications on current and federal information sharing initiatives that could be investigated further in future work—specifically, electronic data interchange (EDI) and data standardization efforts. EDI is pervasive in the trade industry and can inform the current development and industry integration of the National Information Exchange Model (NIEM). Finally, we will comment on the value of using the MBSE approach to (a) articulate workflow and uncover hidden work; (b) automatically generate an information dictionary in a format that can be used by software developers, and (c) validate technology's positive impact on mission accomplishment with precision through model checking.

Electronic Data Interchange: An electronic data interchange (EDI) is the "transmission, in a standard syntax, of unambiguous information of business or strategic significance between computers of independent organizations." [11] EDI software is required to transform information stored on a company's internal systems to EDI standard format. A company can choose to send some or all of their documents via EDI; similarly they can communicate with some trading partners via EDI and other partners via other methods. The degree to which a company uses EDI varies across the maritime industry. In our model, six EDI messages appear:

1. The BAPLIE communicates the position of containers aboard the vessel. [7] The BAPLIE is transferred between the ocean carrier, the vessel's captain, and terminal operators at ports at which the vessel intends to call and contains information about container weight and whether the cargo is hazardous. The position of hazardous cargo is a safety issue—incorrectly stowed hazardous cargo has led to maritime casualties. [12]
2. The COPRAR is sent from the ocean carrier to the terminal operator and authorizes the terminal to discharge containers. [7] The COPRAR is important in security and economic resilience—it ensures that the correct cargo is unloaded in the correct place. Containers holding hazardous goods, arms, or ammunition, for example, could cause security issues if they are unloaded at the incorrect port, and delays in delivering goods to their intended destination will increase costs and could delay the larger supply chain.

3. The COARRI message is sent from the terminal operator to notify the ocean carrier that the authorized containers have been unloaded. [7] This message allows the ocean carrier to confirm the location of its containers and the shipper to track their shipment.
4. The EDI 322 is sent from the terminal operator to the ocean carrier to notify the carrier of container activity (i.e., discharge of the container). [13] This message keeps the ocean carrier aware of what is happening to their container and increases transparency of container activity.
5. The EDI 309 Customs Manifest is sent from the ocean carrier to the regulatory agency to satisfy the 24-hour advance vessel manifest rule. [13] The transaction set can also be used by carriers to provide terminal operators, port authorities, or service centers with manifest data on cargo arriving at their facilities. The ocean carrier submits one EDI 309, which contains individual bills of lading from separate shippers, before the vessel leaves the first foreign port at which it loads cargo, (i.e., the first export port). As the vessel loads additional cargo at following port calls, additional EDI 309s are sent for each cargoes' bill of lading.
6. EDI 350 is sent from the regulatory agency to other interested parties to notify them of various agency actions (e.g., container hold). [13] Prior to receiving this EDI, the container may not leave the terminal unless it is going to an external examination station. The hold status is visible on the terminal's website for external parties to check. This EDI has economic implications; if a truck driver arrives at the terminal to pick-up a container that has not been cleared, the customer will need to pay for two trips to the terminal.

Not all companies choose to use EDI, due to its cost, so alternate methods of computer-to-computer data transmission (fax, email, and web) must be supported. The current version of the regulatory agency's system accommodates companies that do not use EDI. The system allows users to interact with it through either EDI or the regulatory agency's system Portal. The Portal requires users to manually input data. One trucking company interviewed uses EDI to communicate between the main office and on-board truck computers, but their EDI software cannot communicating with this system, so they use the Portal to communicate with the regulatory agency.

The cargo operations model exposes the varying use of EDI and reinforces the need for federal systems to support non-EDI methods of information sharing. Entities that do not use EDI messages are still influenced, however, by the standards; the EDI standards define common data elements and ensure the community has a common vocabulary.

A current federal initiative to standardize the format of information exchange is the development of NIEM, which serves as a data model and reference vocabulary. [14] Data models describe the data needed and created by business processes. [15] Our cargo operations model can inform the development of NIEM standards by making explicit the information needed to complete the business process of facilitating trade.

Methodology Discussion

The main methodological conclusion from this work is that the MBSE approach achieved our goal of user-driven understanding of the use-case and that this understanding provides insights that can guide the design of interventions into this information sharing environment. In the cargo operations use-case this manifested in the discovery and documentation of the usage of security information in container terminal cargo operations. Now that we have created this model, we can export an information dictionary that provides precision requirements for data interoperability. In the following section we further discuss three ways in which this methodology adds value:

(1) Discovery

Workflow modeling delivers accurate design requirements by identifying the information that is actually used in mission accomplishment—it also adds important context that aids recollection of information use, as compared to conventional methods, such as focus groups. A criticism of workflow models is that they can be too complex and are thus prohibitively difficult to create or understand, yet we can ameliorate this difficulty by treating information as a resource instead of a task, so that the resulting workflow models are tractable in size and complexity.

Workflow modeling also reveals inconsistencies or gaps in our and community members' understanding of work processes, which can be addressed in follow-up interviews or observations. Our methodical technique of stepping through the workflow to identify needed information provides a means of working with operators to cross-check tasks and the information by which they are enabled, and in turn, validate the model. This iterative aspect of our method allows us to develop only the necessary components of the model in increments and thereby reduce the possibility of wasted or duplicative effort.

(2) Automation
Automated generation of an information dictionary (Table 1) is another cost-effective feature of our modeling approach. The dictionary indexes information attributes to each of the tasks where they are used, giving some indication of the value of that specific information. It also indexes the information to the immediate information resource, which reflects the value of the resource. Redundant information resources often add overhead cost to manage and keep synchronized.

The information dictionary has important implications for standardizing information types and usage (e.g., NIEM and EDI). Our findings in previous work [17] show uneven and limited adoption of relevant information standards. Analyzing new information standards in the context of the operations they must support can provide direction on where to focus standardization endeavors in order to reduce wasted effort and maximize benefit.

(3) Verification
We have recently demonstrated how these models can be checked to verify the capability of a complex, interactive system of people and computing devices to accomplish mission goals. [18] Two innovations in MBSE allow this: The first innovation described above is the technique for capturing the use and change of information as an integrated part of a workflow model. Information usage is treated as a property of tasks, which can be performed by people or machines, and an information dictionary records the association of information and tasks.

The second innovation involves specifying the conceptual product that the workflow must transform from its starting state to its goal state. This specification is independent of any technology or process and can thus serve as a new form of evaluation criterion for model checking. In [18] we show how ontology modeling has been extended for these specifications, and how these two innovations complement each other to work with the well-established SPIN model checker. [19]

CONCLUSION

In this paper, we demonstrated a human-centered approach to designing IT and informing data standards for one specific use-case. The outcome of the approach is a strong understanding of the work and the information that the use-case requires. The methodology presented here can be used to integrate both user and software developer viewpoints to achieve solutions that satisfy all stakeholders and allow the community to mature its understanding of its work processes and information needs, communicate and build upon that understanding with external designers, and drive the design of interventions that measurably improve operations. The outcome of the model is the identification of who exchanges what information, with whom, how the information is used to help achieve the mission, and how the information exchange must occur.[11] This information is necessary to align investment in IT systems and programs designed to meet the maritime community's information sharing needs.

ACKNOWLEDGEMENTS

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[11] "Information exchanges express the relationship across the three basic architecture data elements of an operational architecture (operational activities, operational nodes, and information flow) with a focus on the specific aspects of the information flow and the information content." [1]

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