Solutions for Preventing Trailer Theft

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SUBMITTED TO THE PROGRAM IN SUPPLY CHAIN MANAGEMENT

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF APPLIED SCIENCE IN SUPPLY CHAIN MANAGEMENT

AT THE

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

June 2023

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on May 12, 2023 in Partial Fulfillment of the
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ABSTRACT

Motor carriers with tight margins and cost constraints are under increasing pressure to improve utilization of their labor and assets. Many carriers face theft of their trailers that are exchanged between shippers, carriers, and contractors. Our project aims to answer the following question: How can trucking companies incorporate anti-theft measures to improve asset retention and therefore utilization of their trailer pools? Through our research and interviews with transportation professionals, we gained a better understanding of the complex industry relationships at play and identified potential areas of improvement to prevent trailer thefts. Our findings showed that there was no single solution that would be able to solve the trailer theft problem, and that cooperation between industry players would be difficult to achieve. However, carriers looking to reduce trailer thefts should implement a layered solution that encourages behavioral changes, expands physical deterrence, and improves process design.

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ACKNOWLEDGMENTS

We would like to thank our advisor Dr. David Correll for his guidance and patience through the past months on this project. His expertise in freight transportation has been invaluable to our research process. We would also like to thank our writing coach Toby Gooley for her insightful feedback helping us to iteratively improve our work. We are especially grateful to the Transportation & Logistics Council and all the industry professionals we interviewed who graciously allowed us to learn from their experiences. Lastly, we would like to thank our fellow classmates, friends and family for all their encouragement and support during our time here at MIT. This project would not have been possible without you.

Harry Hawkes & Lydia Lim

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1. INTRODUCTION

The motor carrier industry is the largest segment of logistics expenditure in the United States (CSCMP & Kearney, 2022). It is a highly competitive industry filled with a vast number of carriers due to the ease of owning and operating a motor carrier. The Covid-19 pandemic has made the environment even more difficult for carriers to thrive in by introducing volatile demand and shortages.

Demand for trucking is directly linked to consumer demand, which initially dropped in 2020 but has since spiked from a recent Covid-19 driven e-commerce boom (Taube & Campbell, 2022). The trucking industry has not been able to meet this high demand due to shortages in assets and labor. Some of the current causes of the driver shortage include decreases in driving-school applicants, a shift in interest to short-haul rather than long-haul driving, and increases in drug and alcohol testing (CSCMP & Kearney, 2022). Additionally, carrier assets, especially trailers, are in short supply due to Covid-19 supply chain disruptions, driving up the trailers' prices and lead-times.

1.1 Motivation

Trucking companies with their tight margins and cost constraints are inherently under pressure to increase utilization of their labor and assets. In an effort to improve utilization, motor carriers have been implementing a drop-and-hook model rather than a live-load model. With the evolving conditions from Covid-19, the push to drop-and-hook has become even stronger.

Traditionally, in a live-load model a trailer is unloaded at the customer's dock upon arrival and the same trailer leaves the site. The unloading process can take hours to

complete, and drivers are stuck at the loading dock not being paid for miles driven. This is incredibly inefficient and frustrates valuable drivers. Research shows that on average, the American truck driver is driving only 6.5 hours out of 11 legal hours a day (Correll, 2019). In the drop-and-hook model, when the driver arrives at the customer site, they leave the filled trailer at the dock and pick up a new trailer, either empty or full, from the customer. The drop-and-hook model offers many benefits, including significantly faster turnaround times for the driver and greater flexibility for the customer (Correll, 2022).

The downside to the drop-and-hook model is that it leaves trailers unsupervised and more susceptible to theft (Sponsor Company, personal communication, Fall 2022). Trailers are readily exchanged between shippers and drivers with no party having consistent obligation for the trailer. In a complex and large shipping network, tracking shared assets is increasingly difficult as the network scales. Trailers can be stolen not only with contract violations (i.e., drivers disregard their contracts with carriers and continue using trailers even after a job is completed), but also directly from parking bays with little physical deterrence. With an increase in stolen trailers, a common problem drivers face is not being able to pick up the trailer where they have been instructed to do so. When this happens, drivers go on a “trailer chase” to search other customer sites in the area where they hook-up a trailer and return to the original customer site. Additionally, the original trailer needs to be recovered, taking valuable time and resources. As a result, driver, employee and trailer utilization is reduced, partially undoing the very goals of the drop-and-hook model.

1.2 Problem Statement and Research Question

Even with its frustrations, the drop-and-hook model outperforms the live-load model in time-efficiency, but it must be improved upon to prevent trailer thefts. There are two primary types of trailer theft that occur:

Type 1: A thief, most commonly a professional thief, enters a facility with a tractor and intentionally steals a trailer from a trailer pool typically with the intent of scraping, or selling.

Type 2: An inbound driver to a facility, most commonly an independent contractor, who is supposed to drop off a trailer continues holding the trailer for more days than authorized.

This second type of trailer theft, unauthorized use, constitutes the bulk of the trailer losses our sponsor company faces, perpetrated by independent contracted drivers who are attempting to reduce their own costs (Sponsor Company, personal communication, Fall 2022).

Our sponsor company hopes to retain the drop-and-hook model of freight appointments. They are seeking ways to better manage the possession and accountability of trailers to prevent the theft and misuse of trailers. Although measures such as GPS are currently in place, the cost of reacquisition is high and recovery is still required, unless thieves can be deterred proactively.

Overall, our sponsor company is open to implementing innovative methods to reduce the theft of trailers. Any proposed solution will have to minimize conflicts between drivers, shippers and third-party carriers. Our project aims to answer the following

question: *How can trucking companies incorporate anti-theft measures to improve asset retention and therefore utilization of their trailer pools?*

1.3 Project Goals and Expected Outcomes

The project's goal was to provide the sponsor company with a plan to decrease theft in order to help optimize the retention of trailers. We envisioned that a two-step strategy would be required to approach this issue. The first step was to focus on understanding the complex relationships between drivers, carriers, and shippers by utilizing system dynamics. By analyzing the interactions of the industry players and the subsequent consequences of their actions, we hoped to identify potential areas of improvement to prevent trailer thefts. In parallel, we completed interviews with industry professionals including drivers and shippers to help create potential solutions. We have two key hypotheses regarding our expected outcomes.

Hypothesis 1: A layered approach that utilizes multiple solutions from one or more of the three theft prevention measures listed here will be necessary:

1. Behavioral Design
2. Physical Infrastructure and Technology
3. Process Design

Hypothesis 2: As empty trailers are largely sitting idle in shippers' yards, we expect that shippers will need to play a key role in our solution. We hypothesize that shippers, both large and small, will be willing to cooperate in an anti-theft solution if the carriers are able to provide adequate incentives for them to do so.

The deliverables to the company include:

1. A summary detailing our system dynamics analysis. This summary shows the relationships between stakeholders in the truck transportation industry as well as positive and negative feedback loops that will influence the success of recommended solutions.
2. A summary detailing our process and the options explored. This report will summarize learnings from stakeholder interviews, site visits, and secondary research. Additionally, it will summarize evaluated options and a detailed explanation.

Our findings showed that there was no single solution that would be able to solve the trailer theft problem, and that cooperation between industry players would be difficult to achieve. However, carriers looking to reduce trailer thefts should implement a layered solution that encourages behavioral changes, expands physical deterrences, and improves process design.

After the implementation of an effective solution, we expect company profits and growth to increase for three reasons. First, decreased theft will improve trailer utilization and help negate increasing asset costs. Second, improved trailer retention at customer sites will increase driver retention and utilization, as this could increase work satisfaction and billable miles. Lastly, with these lifted constraints, the sponsor company will be able to take greater advantage of the growing e-commerce and potential increases in reshoring (the recent trend of U.S. manufacturing returning to the U.S.) that represent strong industry tailwinds (CSCMP & Kearney, 2022).

2. STATE OF THE ART

To ensure we thoroughly evaluated means to stop trailer theft in the motor carrier industry, we researched the underlying causes, current anti-theft designs that exist in other industries today, and fitting methodologies to develop and refine our own approach in preventing trailer theft.

2.1 Causes

The trucking industry is unique in that it is both asset-intensive and requires the sharing of those assets. Additionally, because it is largely fragmented, organizing this system is highly complex, especially as the transportation industry continues to scale. The drop-and-hook model has increased this complexity even further, making asset tracking and theft prevention challenging.

2.1.1 Challenges with the Current State of the Trucking Industry

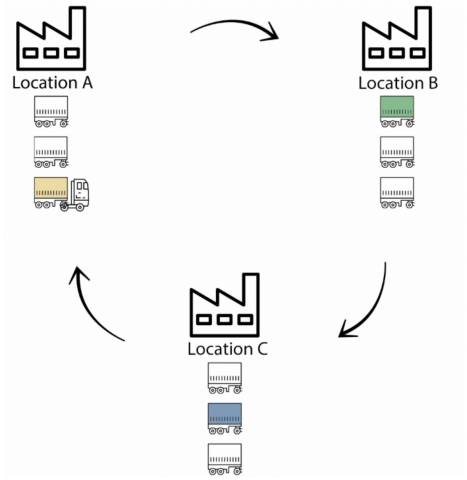
The American trucking industry is highly fragmented, with 91.5% of carrier fleets having less than 6 trucks and 97.4% of carrier fleets having less than 20 trucks (American Trucking Associations, 2021). This massive $831 billion trucking industry (CSCMP & Kearney, 2022) remains a small business industry, making it difficult to progress and implement standardized changes. Regardless of the carrier fleet size, trailer management has always been a consistent challenge for carriers as frequent monitoring and positioning of trailers is needed to run a successful trucking business.

2.1.2 Challenges with Drop-and-Hook Model

Figure 1 illustrates the drop-and-hook of a single truck traveling between three locations. Each location has a pool of empty trailers that is loaded with commodities before the truck's arrival. The truck begins its journey at Location A where it pulls the yellow load to its end destination at Location B.

Figure 1

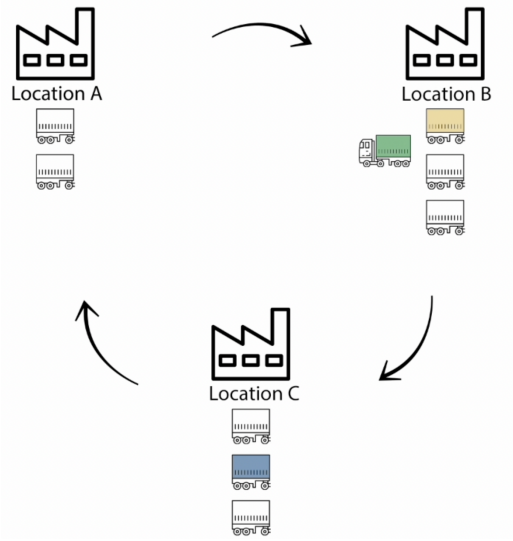
Illustration of Drop and Hook Model



Once arriving at Location B, the truck will drop off the yellow trailer and hook to the new green trailer, carrying on its journey towards Location C. In Figure 2, we observe that the yellow trailer that started off in Location A is now sitting idle at Location B. These exchanges of trailers take place over thousands of locations across the country daily, making trailer management a complicated task for carriers.

Figure 2

Illustration of Drop and Hook Model (Continued)



The drop-and-hook model is used by the majority of the US Fortune 500 companies (Convoy, 2020). There are many advantages to the drop-and-hook model, the biggest being the time savings that it brings about both to the shippers and drivers. On average, a drop-and-hook delivery can be three to four times faster than the traditional live-load model (Correll, 2022). However, the drop-and-hook model requires large trailer pools readily available for loading, and makes asset tracking more difficult, leaving trailers vulnerable to theft.

2.1.3 Challenges with Shippers and Drivers

In an asset sharing business where trailers are often unsupervised, many traditional theft prevention techniques have not been successful. Shippers require trailers to be easily accessible, therefore traditional locks and common physical theft deterrents will make it inconvenient for yard jockeys to reposition trailers within a warehouse yard

(Sponsor Company, personal communication, Fall 2022). Additionally, a carrier may have idle trailers in thousands of shippers' locations across the country, making it difficult to implement and standardize trailer outgate procedures. In a competitive industry saturated with carriers, theft prevention measures are rarely implemented by carriers in fear of jeopardizing their relationships with shippers and losing business. Carriers fear that if their customers are inconvenienced, shippers could easily switch to an alternate carrier that will keep their warehouse yard management efficient (Sponsor Company, personal communication, Fall 2022).

Similarly, drivers are in short supply, and carriers fear that inconveniencing drivers with troublesome theft prevention measures could encourage them to switch carriers. As it is, most long-haul truck drivers have been largely unsatisfied with their working conditions. Truck drivers commonly complain about long distances from home, and irregular schedules and pay (Randall Reilly, 2023). Carriers hoping to retain their drivers in a tight economy are worried about further straining their relationships with drivers by imposing restrictions.

2.2 Design

In this section, we summarize the different levers that are currently used in preventing theft in other industries. We believe that we will be able to engage a combination of similar levers in our proposal using a multi-layered approach, sometimes referred to as a "swiss cheese model". The swiss cheese model, developed by James Reason (Reason, 1990), helps to explain accident causation with each slice of cheese representing a defense, while the holes represent situations where the defense fails. By

either reducing holes, or adding more slices, a model can become more effective and complete. We believe these slices will be derived from three key categories of solutions for trailer theft prevention.

1. **Behavioral Design**: Modifying the way people interact with their environments to prevent theft
2. **Physical Infrastructure and Technology**: Utilizing or creating both physical and digital technologies to prevent theft
3. **Process Design**: Modifying stakeholder interactions, the sequence of events, or adding additional processes to prevent theft

2.2.1 Behavioral Design

Over $44 billion worth of merchandise gets stolen each year, pressuring companies to grow their crime-prevention departments (Clark, 2016). Extensive research has gone into understanding how and where individuals choose to carry out thefts. In an interview regarding retail thefts, thieves stated that stores with disengaged employees and poor customer service made for easier environments to steal from (Clark, 2016). They were less likely to steal from happy engaged employees who would likely be able to identify them in a lineup. These experiences by retailers show that the conditions surrounding assets can have a large impact on preventing theft. A driver's experience at a shipper location could be crucial to determining the driver's behavior. This is reinforced by a commonly cited theory known as the "broken window" theory.

The broken window theory states that if the conditions of an environment degrade, they will continue to degrade and crime will increase (Wilson, 1982). It can be assumed

that the conditions of trailers, shipper yards and trucking environments are crucial to how truckers perceive the acceptability of crime. Simple changes at the sites of crime can have a large impact on stopping or displacing theft. An interesting study on bicycle theft was conducted to prove how the human mind operates on simple rules of thumb. At three locations with high rates of bicycle theft, signs stating “We’re watching you” with a photo of human eyes were placed. Thefts were measured for 12 months before the sign placement and 12 months after and bicycle thefts decreased by a remarkable 62%. In contrast, thefts increased by 65% at the control locations, indicating a displacement of theft (Nettle et al., 2012). If our sponsor company is able to utilize solutions such as signage on their trailers and work with shippers to improve site conditions, it can be expected that trailer theft will decrease.

2.2.2 Physical Infrastructure and Technology

The most common type of theft in the transportation industry is cargo theft. It is estimated that losses amount to a minimum of $15 billion per year in the United States (Mahoney, 2021). To reduce cargo theft, companies implement various forms of transport security such as GPS, geo-fencing and camera security. The presence of such countermeasures aims to influence a thief's decision-making process and potentially alter the outcome of the theft. This logic follows the theory of crime displacement, which in part states that criminals will choose the path of least resistance and proceed with crimes with lower chances of being caught (Leong, 2014). One study looked into the prevalence of cargo theft despite the multitude of countermeasures that had been implemented (Ekwall,

2009). The results showed that the presence of countermeasures does not lead to absolute elimination of theft but instead lead to changes in location and methods of thefts.

In comparison to cargo theft security, trailers have little to no theft countermeasures. There has been pushback against many theft prevention initiatives (e.g., wheel locks and anti-theft brake systems), as industry professionals believe that these countermeasures can be easily circumvented (Sponsor Company, personal communication, Fall 2022). It is simply more convenient for trailers to be unlocked and unmonitored to support the flexibility required in a drop-and-hook model. However, research suggests that thieves will choose the path of least resistance (Ekwall, 2009), and there is some merit in implementing theft countermeasures. The first mover in implementing successful trailer theft countermeasures would likely displace those thefts to less secured trailers.

2.2.3 Process Design

The Customs-Trade Partnership Against Terrorism (C-TPAT) is a program between the U.S. Customs and Border Protection (CBP) and businesses that encourage businesses to enhance the security of their supply chains in exchange for expedited clearance at ports of entry (Burges, 2012). The CBP's aim with this initiative is to strengthen supply chains so that they cannot be used by terrorist organizations for illegal activities. Businesses that cooperate with the security guidelines provided by the government are rewarded with quicker inspections and expedited processing. Even though the aim of this program is to prevent terrorist activity, reduced cargo theft is a positive by-product of the enhanced security throughout supply chains.

Currently, idle trailers are in the custody of shippers, but since shippers are not the owners of the trailers, they have little incentive to secure the asset from theft. Carriers do not impose rules on their shippers to enforce any security measures, as that would inconvenience the shipper and possibly motivate them to find an alternate carrier to work with. However, similar to the C-TPAT program, if carriers are able to find ways to align their goals and incentivize shippers to cooperate, there is potential to create a mutually beneficial solution for both parties.

2.2.4 Conclusion

It is unfortunate but also unsurprising that theft is prevalent in an industry where high-value assets are easily accessible. Empty trailers are particularly difficult to safeguard as they are shared-assets in a drop-and-hook trucking model. Furthermore, shippers and drivers hold bargaining power over the carrier, making it difficult for the carrier to implement any additional security measures. Security measures by nature make assets more difficult to access, and can be a major inconvenience to those who require daily access to them.

Our literature review has shown that the three pillars of theft prevention are: (1) Behavioral Design; (2) Physical Infrastructure & Technology; and (3) Process Design. We will use this three-layered framework to categorize our findings and potential solutions in Chapter 3.

3. METHODOLOGY

Our research is focused on a problem that is widely recognized and documented, yet there is little data to utilize. Thefts occur across a wide range of suppliers, the causes vary, and organized data would be taxing for our sponsoring company to collect. To work within this reality, there are two unique phases to our methodology: (1) idea generation and refinement; and (2) pilot testing. Within the scope of this project, we have completed Phase 1, while our sponsoring company will complete Phase 2 at their discretion. In conducting idea generation and refinement, we followed a two-step process:

1. **Research**: Industry and sponsor company research to understand the current state, while utilizing system dynamics to illustrate the relationships between stakeholders.
2. **Interview**: Semi-structured interviews (SSIs) with shippers, drivers and industry professionals to verify research results, gather new perspectives and collect opinions on incentivizing shippers to participate in anti-theft measures.

In parallel with completing these two steps, we held ideation sessions with our sponsoring company, as we continued to learn more about stakeholders and their needs. Upon potential solutions being recommended at the completion of Phase 1, a review can be completed by our sponsoring company and a pilot project can be completed at one or more locations. Two studies previously discussed in this paper, “The Displacement Effect in Cargo Theft” (Ekwall, 2009) and “‘Cycle Thieves, We Are Watching You’: Impact of a Simple Signage Intervention against Bicycle Theft” (Nettle et al., 2012), help to reinforce our choice of methodology.

In “The Displacement Effect in Cargo Theft”, the team focused on validating their hypothesis by triangulating the results of research, interviews and surveys (Ekwall, 2009). The first step was understanding the landscape and current state. The second step included “a macro-level, qualitative, open and descriptive expert interview, and as a last verification, a micro-level quantitative-closed survey” (Ekwall, 2009). In total six interviews were conducted with industry experts. Anonymity was guaranteed and the same two open-ended questions were asked to all participants (Ekwall, 2009). Utilizing research and interviews would be key to our development of a solution for trailer theft. We chose to not include a survey as there are many stakeholders involved in the trailer exchange process and surveying statistically significant numbers of each stakeholder exceeded our capacity. To verify the effectiveness of this solution, the pilot methodology used by Nettle, et al. (2012) can be referenced.

Nettle et al.’s methodology regarding cycle thieves utilized pilot locations for testing the effectiveness of their custom signage. The study was completed at three locations with thefts measured 12 months before and 12 months after implementation. Control locations were also measured to detect displacement and account for any macro trends. A pilot is necessary to verify our research and recommendation as it will allow for greater control and minimized costs compared to large-scale implementation.

Further details regarding our methodology for Phase 1: idea generation and refinement, are detailed in sections 3.1 to 3.2.

3.1 Step 1: Research

The first step of our methodology was conducting research to understand the current state, while utilizing system dynamics to illustrate the relationships between stakeholders. System dynamics was originally developed by MIT Professor Jay Forrester in the 1950s to model complex relationships within a system. Systems are commonly represented by causal loop diagrams or stock and flow diagrams that map out the interactions between various components of a system (Forrester, 1994). By illustrating the various relationships in a system, we are able to identify feedback loops and potentially explain a system's behavior over time. System dynamics recognizes that a system's behavior is not just determined by the individual behaviors of its components but also by the complex relationships that are formed between its components.

The issue of trailer theft has emerged from the complicated relationships and conflicting goals between carriers, shippers and drivers. To gain clarity on these issues, we set up meetings with our sponsor company and conducted initial research on trailer management in the trucking industry. With the information gathered, we illustrated the complex relationships that contribute to trailer theft through system dynamic models. These models helped us visualize and identify areas of concern that we can focus our solutions on.

3.2 Step 2: Interview

The second step of our methodology was to complete semi-structured interviews (SSIs) with shippers, drivers and industry professionals. From the *Handbook of Practical Program Evaluation*, William C. Adams (2015) discusses the details and approach of

SSIs. SSIs are conducted with one respondent, utilize a mix of questions including “how” or “why” follow-ups and can be expected to last about 1 hour. Adams recommends SSIs for researching lesser-known problems where open-ended questions are beneficial for conducting preliminary research. These characteristics make SSIs an appropriate choice for our circumstances. In our semi-structured interviews, our primary areas of focus were:

1. Verification of results from the research phase regarding stakeholder interactions, current state of market and primary causes for trailer theft.
2. Recommendations regarding shipper and driver cooperation in the implementation of anti-theft measures.
3. Interviewee’s understanding of anti-theft measures that have been attempted in the motor carrier industry and what their point of failure was if they were not successful.

Further details on interview design will be discussed in section 4.3.

4. RESULTS

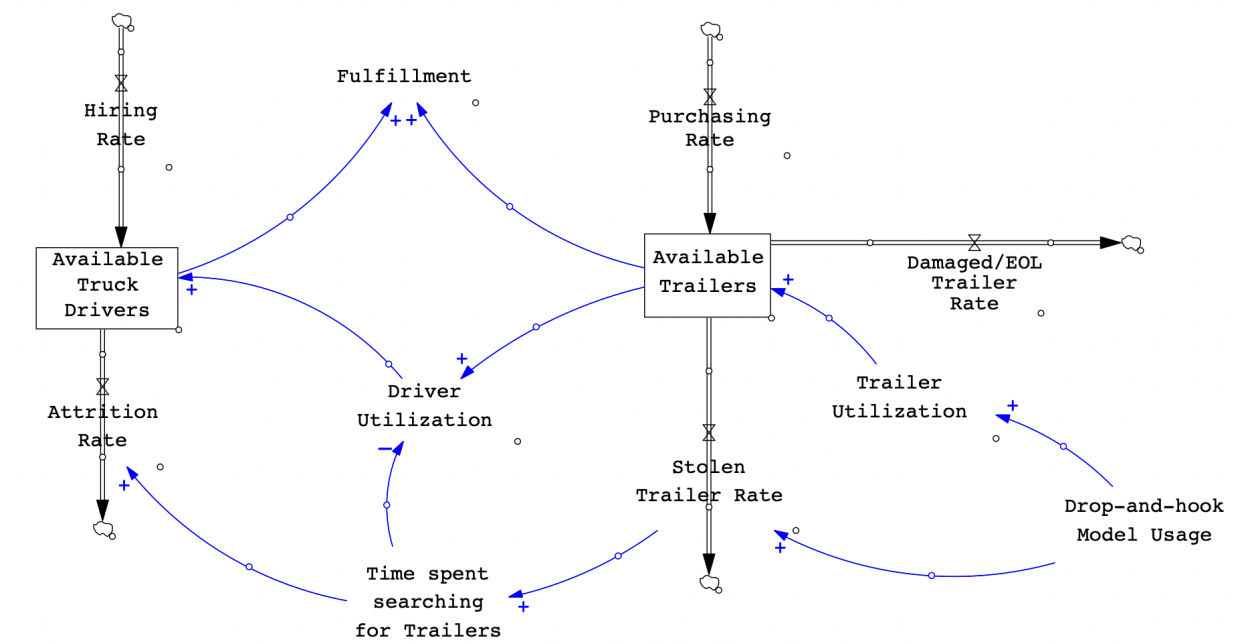
After completing industry research, site visits and speaking with our sponsor company, we organized our trailer management findings in a systems dynamics diagram. In parallel, we completed seven interviews with industry experts and assembled the results into a unique list of recommendations. Our results highlight the challenges that are faced in the trailer-management space and the solutions that aim to solve the trailer theft problem.

4.1 Research Results

Using the information gathered from our industry research and discussions with our sponsor company, we mapped out trailer management challenges that carriers are facing in a system dynamics model as shown in Figure 3. This model illustrates how the different stakeholders and decisions impact one another, giving rise to the simultaneous problems surrounding asset and labor management.

Figure 3

System Dynamics Model - Carrier Challenges



In the transportation industry, how much fulfillment a carrier is able to provide can be constrained by the availability of both truck drivers and trailers. These two stocks, drivers and trailers, are displayed in Figure 3 in rectangular boxes. The inflows and outflows that affect the level of stock over time are represented in the diagram by the straight double-lined arrows. The inflows of both stocks (i.e., the hiring rate of drivers and purchasing rate of trailers) have been decreasing in recent years. This is attributed to industry-wide driver shortages and supply chain disruptions driving up the prices of trailers. With lower stock inflows, it becomes crucial that the carrier carefully manages stock outflows to maintain high levels of fulfillment. Reducing the outflow of available trailers (i.e., the stolen trailer rate) is the focus of this project.

The curved blue lines in Figure 3 connect stocks to the factors that affect these stocks. For example, we observe in the bottom right of Figure 3 that there is a positive blue arrow pointing from “Drop-and-hook model usage” to “Trailer Utilization”. This represents how, all else remaining the same, an increase in drop-and-hook model usage will lead to an increase in trailer utilization. However, there is another blue arrow connecting “Drop-and-hook model usage” to “Stolen Trailer Rate” outflow, indicating that an increase in the usage of the drop-and-hook model leads to an increase in the rate of stolen trailers. This correlation is explained by the drop-and-hook model requiring trailers to be easily accessible in yards, which leaves them vulnerable to theft.

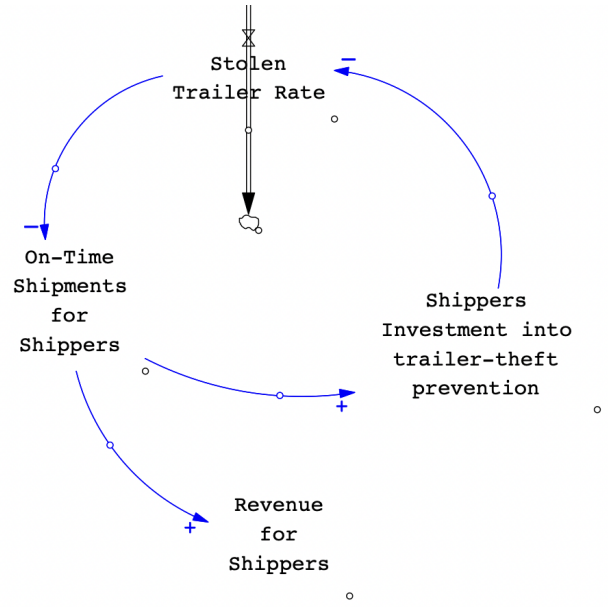
The outflow of available trailers also impacts driver utilization and availability. This is represented in Figure 3 by the series of blue arrows connecting “Stolen Trailer Rate” to “Available Truck Drivers”. When drivers are not able to find their allocated trailer, they have to spend time searching and traveling to find a new load. This can be frustrating for drivers, especially since they are only paid for the miles driven delivering a shipment and not while they are searching for a load. In our framing of this issue, we assert that this frustration could contribute to an outflow of available drivers, as they turn to other carriers with more efficient processes or driving jobs with dedicated lanes.

To reduce the outflow of stolen trailers, our hypothesis in section 1.3 was that shippers would be willing to cooperate in anti-theft solutions if they are adequately incentivized to do so. Figure 4 uses system dynamics to help us illustrate the details of our hypothesis by showing a feedback loop where fewer stolen trailers could lead to more on-time shipments for the shippers. If shippers are able to recognize that this is a benefit to them and could increase their revenues, they would be more willing to invest

in trailer-theft prevention. In this scenario, a positive reinforcing loop could potentially be formed.

Figure 4

System Dynamics Model - Hypothesized Shipper Incentive Dynamics



Using system dynamics to illustrate the trailer theft problem allowed us to piece together information from our sponsor company and industry research in a cohesive manner. It provided us a solid framework to work upon and understand where potential solutions may fit in. Using this model, we are able to display the expected effects of potential solutions on other aspects of a carrier's business.

4.2 Interview Respondents

As the second part of our two-step methodology, we interviewed seven individuals, with a diverse set of backgrounds including shippers, carriers, supply chain

security experts and law enforcement. Additionally, we attended a virtual workshop hosted by the Transportation and Logistics Council (TLC) focused on cargo theft.

To help ensure accurate unbiased responses from candidates, we committed to keeping the interviewees anonymous. The profiles for our interviewees are shown in Table 1.

Table 1

Interviewee Profiles and Categories

#	Profile	Category
1	Founder and Managing Partner for a full-service truckload and transportation provider	Carrier
2	Director of a Driver's Association	Industry Expert/Law Enforcement
3	Process Leader at a large consumer goods company	Shipper
4	Senior Manager of Continuous Improvement at a large food and beverage company	Shipper
5	Director of Direct Store Delivery and Customer Service at a large food and beverage company	Shipper
6	CEO of a Security Consultancy focusing on vulnerability assessments	Supply Chain Security Expert
7	Cargo Theft Expert	Supply Chain Security Expert

4.3 Interview Design

When interviewing our seven candidates, we utilized a semi-structured interview methodology, therefore, the interviews generally allowed the conversation to flow with “how” and “why” questions to allow for more free thinking from candidates. As a result, themes were more important than specific questions in the interviews. The consistent core questions discussed with candidates are listed here:

1. Can you please describe your background?
2. Can you please describe your experience with trailer theft?
3. Can you please describe solutions you have witnessed to prevent trailer theft?

After completing these core questions, we then had an understanding of their level of expertise as well as under which circumstances they have dealt with trailer theft. More specific and in-depth questions were then asked based on both the reply to the core questions as well as the theme of the interview. The focus themes for each interviewee category are shown in Table 2.

Table 2

Interview Themes for Each Interviewee Category

Category	Primary Focus of Interview Questions
Carrier	- Do you currently own your own trailers? - If so, what solutions are you currently employing to reduce the theft of your assets from yards, and also contract violations?
Shipper	- Would you be willing to cooperate with a carrier to reduce their trailer theft? If so, what would be an incentive to you? - If a carrier's trailer were stolen from your yard, what process would you complete to help recover the trailer?
Security Expert	- What types of services do you provide? - How do these services provide value for your carrier customers? - What types of solutions have you witnessed to reduce asset theft?
Law Enforcement	- How can the law enforcement process be improved to make filing a missing trailer faster? - What can carriers do to assist law enforcement in the recovery of stolen trailers?

4.4 Interview Results

From our interviews with various industry experts, we gained valuable insight on the current industry climate and on both of our hypotheses. First, we confirmed our first hypothesis that a layered approach would be necessary to create an effective anti-theft solution. Next, we partially disproved our second hypothesis that both large and small shippers would reliably partake in anti-theft measures.

4.4.1 Theft Prevention Implementation Timing

Interviewees suggested that now might be an opportune time to implement theft prevention measures, both because of a current soft freight market and a greater acceptance of technology. In 2022, fourth-quarter freight shipments were the lowest they had been in 9 years (Rosa, 2023). This is partially driven by both increases in spending on services rather than goods, as well as inflation (Rosa, 2023). The importance of implementing changes now was emphasized in an interview with a founder of a carrier.

> "A lot of new people in the market that are willing to change with the industry's needs, in the past we've had a reluctance to technology in our industry, that's changed the last few years as a new generation comes into the industry. It also allows you to test your processes when you have time to correct or fine tune them. During a freight up swing you want good processes in place already to allow you to grow with the market and be prepared for customers' needs as they grow. A good training program should include all employees so everyone is aware of the challenges we face in our industry."

It is important to take advantage of this slower market now, so that when it inevitably improves, carriers can move forward with more technologically advanced systems that their employees are sufficiently trained on.

4.4.2 First Hypothesis Analysis

We were able to confirm our first hypothesis that a layered approach utilizing multiple solutions from one or more of the three theft prevention measures listed here would be necessary:

1. Behavioral Design
2. Physical Infrastructure and Technology
3. Process Design

This hypothesis was further reinforced by two interviewees' persistence that one of the best solutions to prevent theft is making continuous and incremental improvements. This is primarily driven by thieves' persistence in developing new workarounds, and that the transportation industry itself is evolving. From our interviews, we learned that complacency is a key enabler of theft.

Throughout our interview process many theft prevention tactics were recommended. Several of these tactics are already being employed by our sponsor company. When further speaking with the founder of a carrier, he emphasized the importance of tracking as well as joining industry organizations.

> “All carriers should have GPS tracking on both their trucks and trailers and if it’s a high value product I would suggest working with your shippers on putting tracking on the product as well for next steps.... I’d also suggest you join an association such as the ATA, TIA, or OOIDA. All these associations have lunch and learns and training sessions on what is happening in the marketplace and suggestions on how to help protect yourself.”

In addition to the many ideas we received in interviews, we also heard why many solutions have failed, and therefore, why redundancy and having multiple solutions could act as an important safety net in theft prevention.

In the instance of Type 1 theft (direct theft from trailer pools), many solutions can be circumvented, especially GPS. Not only can GPS be removed from a trailer or vehicle, it can also be stopped from transmitting (GPS jamming) or redirected (GPS spoofing). Additionally, thieves are aware of current locks and physical prevention measures on the market and have tools available to bypass these measures. Typical locks can be cut off with an angle grinder, and if they have the intent of scrapping a trailer for parts, damage is less of a concern. It seems impossible to stop thieves, until you consider many of these solutions combined, especially ones that may not be suspected. Interviewees recommended interesting solutions such as two GPS units, with one hidden and one obvious.

Not all solutions for Type 1 theft are technological or physical. In one interview with a security professional who conducts vulnerability assessments, their benefits were made clear. Completing vulnerability assessments keeps you in tune with your security which is essential since the thieves are the ones writing the rules. When conducting a vulnerability assessment, it is important to think creatively and “out of the box”. It was also emphasized that if through this process, you don’t find any vulnerabilities, then you are likely doing it wrong. Additionally, there should be a focus on making a few improvements every year. Vulnerability assessments are a constant reminder to focus on continuous improvement and can be a useful tool in preventing theft.

Additionally, many interviewees recommended security signs clearly stating the protective measures that have been taken, with a common reference to home security system signs that many people have in their front yards. One of the greatest assets in preventing theft can be your reputation. Signs are a clear way to help spread the word that you are taking active measures to prevent theft of your assets.

In the instance of Type 2 theft (contract violations), it was found that security redundancy could be created through greater driver vetting and stricter contracts with liens on personal assets. Given that Type 2 theft is largely a result of people taking advantage of an inherently chaotic system, the focus should be on improved asset tracking and chain-of-custody. If it could be determined who is in possession of the trailer, and how long they had it, then with proper contractual agreements they could be billed for their use of the trailer.

Lastly, our scanning of the market uncovered a recent market entrant, GenLogs, who are working on a new tracking system that will employ highway cameras or sensors rather than GPS. This could provide an interesting addition to current GPS technology and would increase the visibility of trailers, while also providing video evidence.

4.4.3 Second Hypothesis Analysis

From our conversations with experts, we partially disproved our second hypothesis that both large and small shippers would be willing to cooperate in an anti-theft solution if the carriers are able to provide adequate incentives for them to do so. We did learn, however, that some larger shippers would likely be willing to help retroactively, and that there could be potential for shipper participation in the future.

The concept of shipper participation was met with skepticism by industry experts as we were told that although shippers certainly do not support theft, they are simply too busy managing their own operations to add complexity for something that is not their direct responsibility. The monetary benefits and the theoretical increase of on-time shipments is difficult for shippers to quantify and therefore unlikely to be used as an incentive to prevent trailer thefts.

In contrast to our discussions with experts, we were surprised to hear from shippers that they would possibly be willing to help recover assets and provide information. In this instance, however, the focus was primarily on remedial measures rather than preventative. It is also important to note that the shippers we spoke with were leading companies with excellent security and strong industry relationships, which does not completely reflect the diverse array of shippers present in the market.

When one large shipper was asked how they would manage a situation where a contracted carrier has reported a stolen trailer from their yard, they replied “I personally would escalate to the local authorities and get a police report written up. I would check any security footage that the site has as well that might help catch the person that did it.” This same shipper also indicated that their relationship with the carrier would be relevant to their handling of the theft saying, “I would be more likely to go above and beyond to help out a carrier that I had a better relationship with.” Although this is a positive indicator that there could be solutions from working with shippers, it is important to note that this shipper could not recall any theft that they had experienced in the past.

Although we are concluding that both large and small shippers would not be likely to participate in theft reduction programs, it certainly is not impossible in the future

and is worth further investigation. One founder of a carrier indicated that there could be a positive trend in shipper participation to help with theft, by stating “I do see a lot more shippers getting involved in theft prevention the last few years.” Shipper participation should certainly be evaluated further with specific larger shippers in a carrier’s network, but it should not be expected that many of the smaller shippers will be easily incentivized. Including shippers in a theft prevention plan could provide opportunities for greater network visibility, another option for a location to stop stolen assets, and video surveillance at shipper sites could be used to provide evidence.

4.4.4 Complete Interview Recommendations

From our interviews, we were provided with a large number of varying insights. By cross-referencing our interview results, discussing ideas further with our sponsor company and conferring internally, we created a unique summary of the recommendations for preventing trailer theft in Table 3:

Table 3

Descriptions of recommendations suggested by interviewees

#	Description
1	**Post Signs:** Place signs directly on trailers stating carrier's tracking and strict enforcement of laws. This should be reinforced with visuals that evoke emotion such as an image of human eyes.
2	**Emphasize Workplace Environment Improvement:** Ensure a positive and open workplace environment that encourages cooperation among those involved with daily trailer management.
3	**Install Redundant GPS Units:** Install two GPS units to provide both a back-up and a false sense of security to thieves if they remove the visible unit. Ideally, this should include the traditional GPS as well as a hidden GPS with a battery life of 2-3 years.
4	**Employ Geofencing**: Use industry software and GPS technology to create a digital perimeter. If a trailer leaves the perimeter when not approved, notifications can be sent to a designated team to investigate the circumstances.
5	**Explore Alternative Asset Tracking:** Tracking solutions, other than GPS, would provide not only a layer of redundancy, but could also provide additional evidence. A recent market entrant, GenLogs, is currently working on technology to monitor assets on highways using sensors or state owned traffic cameras.
6	**Utilize Remotely Locking Trailer Doors:** Long-range remotely activated locks on the inside of trailer doors could be used to render trailers unusable for regular business on command.
7	**Enforce Stricter Interchange Agreements:** Create stronger interchange agreements that include liens on personal assets.
8	**Withhold Driver or Carrier Payments:** Withhold payments from carriers or drivers who do not complete the specified job with proof of trailer return.
9	**Join Industry Organizations:** Industry organizations such as ATA[1], OOIDA[2] and TIA[3] provide lunch and learns as well as training focused on protecting organizations from theft.
10	**Vet Drivers and Carriers:** Utilize industry services such as RMIS[4], Carrier411[5] and mycarrierpackets[6] to evaluate drivers and carriers who may be used for contracting.
11	**Assign a Dedicated Team:** Encourage incremental and continuous improvement focused on security across the organization with a specialized team. Staff the team not only on qualifications, but also creativity.
12	**Conduct Vulnerability Assessments:** Assessments of a carrier's security vulnerabilities should be conducted regularly to identify weak spots and develop solutions proactively.

[1] American Trucking Associations is the largest trucking industry trade association
[2]Owner–Operator Independent Drivers Association is focused on defending the rights of small business truckers
[3] Transportation Intermediaries Association is an organization for third-party logistics professionals
[4] Registry Monitoring Insurance Services provides insurance monitoring and compliance tracking
[5] Carrier411 provides data to help with carrier selection and managing carrier compliance
[6] Mycarrierpackets is an online carrier packet and onboarding service

5. DISCUSSION

After our interviews, we organized the interviewee suggestions into a framework for carriers looking to reduce both Type 1 and Type 2 trailer thefts. Our research and interviews provided us with a wide range of solutions, but we also identified potential shortcomings to our methodology. We have compiled our research limitations and future recommendations in sections 5.1 and 5.2.

5.1 Limitations

Our interviews were constrained by a number of limitations. We did our best to evenly select appropriate candidates from each category (i.e., carrier, shipper, security expert and law enforcement), however, it cannot be assumed that each member of that category group would hold similar opinions. In particular, the shippers that we interviewed were all large-scale shippers with standardized business procedures. It would have been helpful to gather the feedback of smaller shippers to understand whether they face different trailer management issues.

Additionally, many of our candidates have had longstanding careers in the trucking industry, providing them with valuable insights and experience. This time frame, however, also provided the opportunity for them to form strong opinions and biases. It is possible that because of personal past experiences with shippers or carriers, our interviewees do not believe that some solutions are possible, when in fact they could be new innovative ideas that have not been tried before.

The findings from our interviews are still highly valuable, as they show both the likelihood of success and adoption throughout the industry. However, given more time

and resources, our results would have benefitted from interviewing a larger number of candidates across each category.

5.2 Recommendations

From the list of solutions recommended by our interviewees, we will first discuss the characteristics of a strong anti-theft solution. After that, we will provide recommendations on how carriers should layer individual solutions on top of one another to build a robust trailer security system.

5.2.1 Identifying Anti-theft Solutions

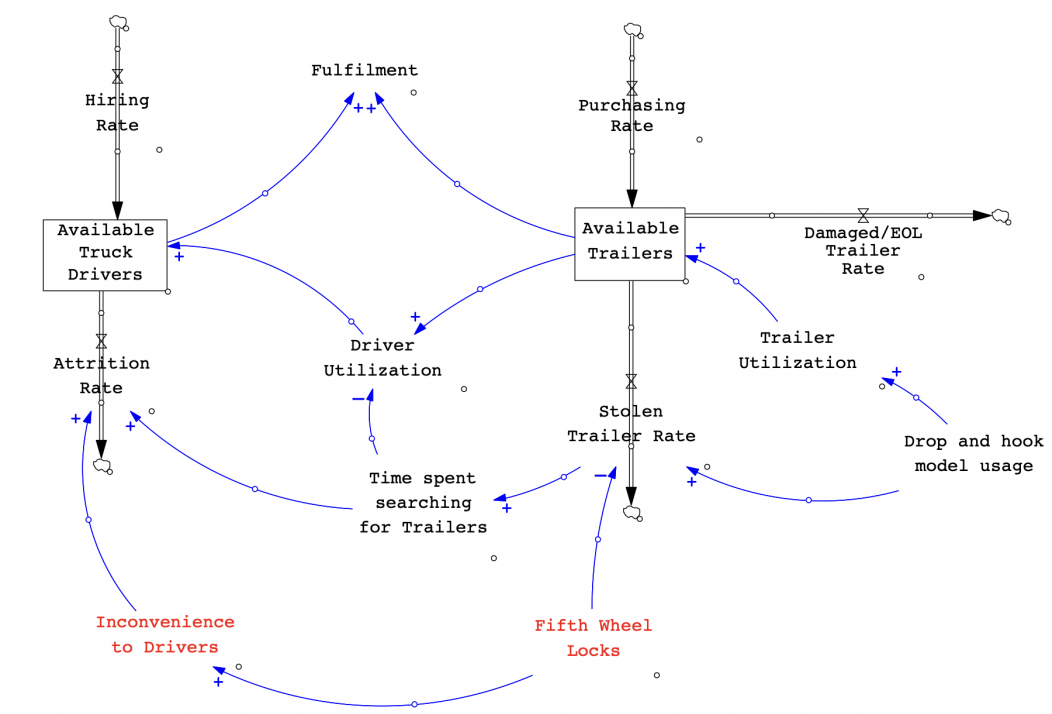
We examined the list of recommendations provided by our interviewees (detailed in Table 3) to better understand characteristics of a strong solution and why they were commonly shared by industry professionals. The recommended solutions were ones that have shown to effectively reduce trailer theft without inconveniencing the carrier's partners (i.e., shippers and drivers). While every solution has its limitations, the preferred solutions were ones that were low-touch and scalable, but most importantly did not negatively impact a carrier's existing business.

Before further expounding what makes a solution strong, we will first share an example of a weak solution. Figure 5 builds on our previous system dynamics model to demonstrate how a weak solution negatively impacts a carrier's business. In this example, the anti-theft solution we are evaluating are fifth wheel locks (i.e., A lock for the hitch attachment that connects tractors to trailers). In figure 5, we observe that there is a negative-signed blue arrow pointing from 'Fifth Wheel Locks' to 'Stolen Trailer Rate'

indicating that utilizing fifth wheel locks leads to a decrease in stolen trailers as more trailers are physically secured. However, there are positive-signed arrows pointing from ‘Fifth Wheel Locks’ to ‘Inconvenience to Drivers’ to ‘Attrition Rate’, indicating that the presence of these locks creates inconveniences to drivers, and may lead to a higher attrition rate of drivers.

Figure 5

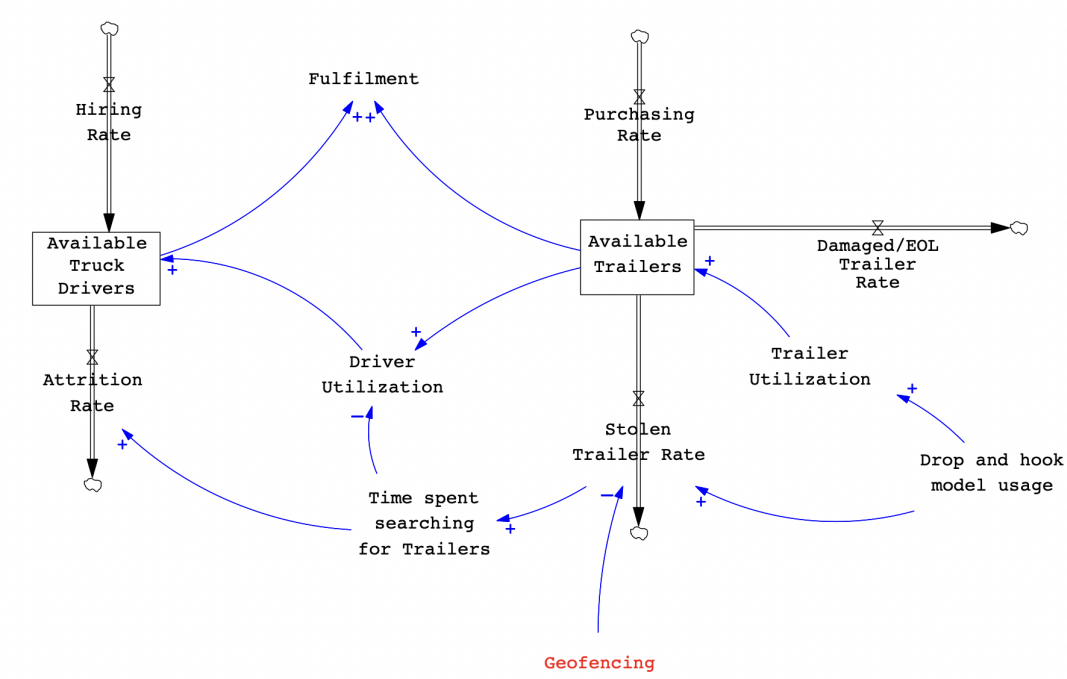
Fitting Potential Solutions into the System Dynamics Model - A Weak Solution



A stronger solution would be one that does not negatively affect other areas of the system dynamics model. Figure 6 illustrates an example of geofencing (i.e., Using industry software and GPS technology to create a digital perimeter) and how it reduces the stolen trailer rate by advanced monitoring. In contrast to the weak example in Figure 5, geofencing does not negatively impact drivers or any other portion of the model.

Figure 6

Fitting Potential Solutions into the System Dynamics Model - A Strong Solution



From the list of recommendations provided by our interviewees, we found that the stronger solutions are ones that have minimal impact on the carrier's partners and business. Although it is difficult to fully anticipate the long-term business effects of anti-theft solutions, the system dynamics model gives carriers a starting point to consider how these solutions may impact other areas of the business. Carriers looking to find new innovative solutions beyond those listed in Table 3 should thoroughly evaluate how the potential solution fits into the model and whether the desired effects can be achieved.

5.2.2 Implementing Layered Solutions

We organized the interviewee suggestions (detailed in section 4.4.3) into a framework that categorizes solutions aimed at targeting Type 1 and Type 2 thefts. Additionally, the framework also sorts the different solutions into the three categories of prevention measures (i.e., Behavioral Design, Physical infrastructure and Technology, and Process Design). This theft prevention framework is shown in figure 7.

Figure 7

Theft Prevention Framework for Selecting Solutions to Target Type 1 and Type 2 Thefts

	Type 1: *Direct Theft from Trailer Pools*	**Type 2:** *Contract Violations*
	Prevention & Displacement	Tracking & Enforcement
Behavioral Design	• Post Signs • Emphasize Workplace Environment Improvement	• Post Signs • Emphasize Workplace Environment Improvement
Physical Infrastructure and Technology	• Install Redundant GPS Units • Employ Geofencing • Explore Alternative Asset Tracking	• Install Redundant GPS Units • Employ Geofencing • Explore Alternative Asset Tracking • Remote Trailer Doors
Process Design	• Join Industry Organizations • Assign a Dedicated Team • Conduct Vulnerability Assessments	• Enforce Stricter Interchange Agreements • Vet Drivers and Carriers • Withhold Driver or Carrier Payments • Assign a Dedicated Team

The first step in creating an effective multi-layered solution against trailer theft is for carriers to carefully evaluate their own businesses to understand where their vulnerabilities may lie. Solutions can only be effective when they have been tailored to

the unique circumstances of each carrier. Carriers should begin the process by identifying the frequency and locations of Type 1 and Type 2 trailer thefts occurring within their business.

Once the type of trailer thefts has been identified, the carrier is then able to narrow down the appropriate actions to take. For Type 1 thefts, the focus for carriers should be on theft prevention and displacement. For Type 2 thefts, the focus for the carrier should be on trailer tracking and contract enforcement. The focus differs between the two types of theft since the intent of the thieves and the levers to change behavior are largely different. In Type 1 theft, it is primarily malicious and premeditated theft that can only be stopped or displaced through strict measures that are effective enough to either prevent or displace the theft. For Type 2 theft, it is primarily drivers who are holding assets past contractual agreements to decrease their costs. In this case, if the drivers can be effectively tracked and then billed through contracts, carriers can make back their lost money, and the driver's behavior can be expected to change in response to the price for the violation.

Using our framework shown in figure 7, carriers should ensure that they have security measures in place across all three prevention categories. Through our interviews with transportation security experts, we established that a layered solution is necessary. In building this layered solution, we recommend that carriers implement at least one to two solutions within each category. Having solutions selected from different categories ensures that different causes of trailer theft are addressed and that the overall layered solution is more robust. This is in line with the "swiss cheese model" referenced in section 2.2, where each slice of cheese represents a solution while the

holes in each slice represent the shortcomings of the solutions. By adding more slices that have holes in different areas, the overall model can become more effective and complete.

The selection of solutions is ultimately dependent on a carrier's specific needs. Carriers would need to consider the cost of solutions and scale of services required in designing their trailer security system. However, regardless of carrier size, our framework for identifying strong solutions and building layered solutions will be helpful in improving trailer security.

6. CONCLUSION

Trailer management is inherently a difficult task for carriers and is exacerbated by the challenges of the drop-and-hook model and complex relationships with shippers. Our project aimed to answer how trucking companies could incorporate anti-theft measures to improve asset retention and therefore utilization of their trailer pools. Our findings from our research and interviews suggest that a targeted and layered anti-theft solution will yield the strongest results.

There are two priorities that carriers should have in eliminating theft: evaluating the current extent of their exposure and defining their goals for improvement. Only once these have been completed, can a layered solution be devised and tailored to the company's specific circumstances.

In the implementation of a layered security solution, it is important to capture solutions from each of the three theft prevention categories (i.e., Behavioral Design, Physical Infrastructure and Technology, and Process Design). Doing so will ensure that the layered solutions work synergistically and help to cover any gaps. Additionally, most carriers will already be implementing many of these solutions. In that case, current solutions should be periodically evaluated for areas of improvement, while others can be added to increase robustness.

Additionally, companies should prioritize retaining momentum in their anti-theft measures. A company's reputation can be one of its greatest strengths, but it is hard to earn and easy to lose. Strict enforcement of strategies, employing new technologies, advertising anti-theft measures, and emphasizing continuous improvement will all help to build and maintain a strong reputation.

An unfortunate reality of trailer theft prevention is its persistence. Thieves will not only continue to steal high-value assets, but also adapt to new security measures. The organizations that will stay ahead of the curve are those that measure their results, are consistent in their approach and follow through with enforcement.

REFERENCES

Adams, W. (2015). Conducting Semi-Structured Interviews. In *Handbook of Practical Program Evaluation Fourth Edition*. Jossey-Bass. https://doi.org/10.1002/9781119171386.ch19

American Trucking Associations. (2021, December 2). *Annual Trucking Trends Report Shows Impact of Pandemic on Industry*. American Trucking Associations. https://www.trucking.org/news-insights/annual-trucking-trends-report-shows-impact-pandemic-industry

Burges, D. (2012). *Cargo Theft, Loss Prevention, and Supply Chain Security*. Butterworth-Heinemann.

Clark, A. (2016, February 16). *The science of stealing*. https://news.ufl.edu/articles/2016/02/the-science-of-stealing.html

Convoy. (2020, December 10). What is drop-and-hook freight? 5 common questions. *Convoy*. https://convoy.com/blog/drop-and-hook-freight/

Correll, D. (2019, November 9). Is There a Truck Driver Shortage or a Utilization Crisis? *MITSupplyChain*. https://medium.com/mitsupplychain/is-there-a-truck-driver-shortage-or-a-capacity-crisis-73a7d7a5bcb

Correll, D. (2022, April 1). What Works and What Doesn't at Truckload Freight Appointments? *MITSupplyChain*. https://medium.com/mitsupplychain/what-works-and-what-doesnt-at-truckload-freight-appointments-38da694c3464

CSCMP, & Kearney. (2022). *Council of Supply Chain Management Professionals (CSCMP's) Annual State of Logistics Report*. CSCMP.

Ekwall, D. (2009). The displacement effect in cargo theft. *International Journal of*

Physical Distribution & Logistics Management, *39*(1), 47–62. https://doi.org/10.1108/09600030910929183

Forrester, J. W. (1994). System dynamics, systems thinking, and soft OR. *System Dynamics Review*, *10*(2–3), 245–256. https://doi.org/10.1002/sdr.4260100211

Leong, C. E. (2014). A Review of Research on Crime Displacement Theory. *International Journal of Business and Economics Research*, *3*(6–1), Article 6–1. https://doi.org/10.11648/j.ijber.s.2014030601.14

Mahoney, N. (2021, December 8). *Cargo theft up as thieves take advantage of increased traffic, idled shipments*. FreightWaves. https://www.freightwaves.com/news/cargo-theft-up-as-thieves-take-advantage-of-increased-traffic

Nettle, D., Nott, K., & Bateson, M. (2012). 'Cycle Thieves, We Are Watching You': Impact of a Simple Signage Intervention against Bicycle Theft. *PLoS ONE*, *7*(12), e51738. https://doi.org/10.1371/journal.pone.0051738

Randall Reilly. (2023). 2022-2023 CCJ What Drivers Want Report. *Commercial Carrier Journal*.

Reason, J. (1990). *Human Error*. Cambridge University Press.

Rosa, J. D. (2023, February 7). U.S. freight volumes fall to lowest levels in 9 years. Talk Business & Politics. https://talkbusiness.net/2023/02/u-s-freight-volumes-fall-to-lowest-levels-in-9-years/

Taube, D., & Campbell, C. (2022, August 11). *Trucking execs see volatile demand as retailers cut inventory*. Transport Dive. https://www.transportdive.com/news/trucking-executives-weigh-in-on-2022-

market-conditions/628895/