



INSTITUTE FOR HOMELAND SECURITY



**Sam Houston
State University**

TEXAS CRITICAL INFRASTRUCTURE SUPPLY CHAIN PROTECTION REACHING THE TRANSPORTATION INDUSTRY

**Institute for Homeland Security
Sam Houston State University**

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INTRODUCTION

The Homeland Security Institute of Sam Houston State University commissioned this paper as part of a series of papers regarding to help in marketing the need for Supply Chain *Preparation, Response, Resilience and Recovery* to the four Texas Critical Industries (Health Care, Energy, Chemical and Transportation).

Supply chain disruptions will occur – it is not a question of “if” but “when.” They may come from natural disasters, industrial accidents, internal or external attackers, but they will come. Preparing for them is the best way to help Texas Critical Infrastructure stay online, in business and prepared to serve the people of the state.

The purpose is to identify:

- 1) Transportation supply chain requirements.
- 2) Potential supply chain threats affecting transportation and logistics.
- 3) What Texas transportation and logistics business sectors are “Critical Infrastructure.
- 4) Approximately how many transportation businesses of various sizes exist in Texas
- 5) Ways to plan for Supply Chain Disruptions.
- 6) Existing resources available to the Transportation industry for supply chain protection.

Having identified the above, CI protection materials should be able to be prepared that focus on the needs of small vs. large companies, knowing those may be different.

Note that this document does not focus extensively on internet or information-related vulnerabilities. They will be mentioned but the breadth of that threat is beyond the scope of this paper.

SUPPLY CHAIN REQUIREMENTS AND VULNERABILITIES

What Are Supply Chains?

A useful definition of supply chain is a “linked set of resources and processes... that begins with the sourcing of products and services and extends through the design, development, manufacturing, processing, handling, and delivery of products and services to the acquirer.”¹

Virtually all supply chain definitions include movement between various stages and linking them into an overall system. Modern supply chains emphasize:

Short Delivery Times

Efficient supply chains have become more important over recent decades, due in part to:

1. Increasing customer expectations for short product lead times.
2. Just-in-time purchases to minimize the cost of stocking inventory for manufacturing.
3. Just-in-time deliveries to minimize finished goods inventory stocking.

Efficient Physical Transportation

Any loss of product movement along the supply chain can lead to downstream disruptions. An example comes from labor shortages during the 2020 Covid-19 pandemic. In that case, those shortages led to:

1. Manufacturing plants being unable to produce product.
2. Truck movements being delayed.
3. Severe disruptions in port loading and unloading.
4. Customers experiencing severe product delivery delays.
5. Food spoilage during transit from farm to customers.
6. Product price inflation resulting from shortages.

Product Tracking

As part of scheduling, inventory management and just-in-time deliveries, product locations must be tracked and kept updated all along the way. Reasons for this include ensuring:

1. Product is accurately tracked and accounted for.
2. Manufacturing schedules can be met.
3. Demand can be planned for.
4. Deliveries can be accurately forecast.
5. Ensuring product freshness, especially in the food and drug fields.

Any loss of data communication, whether in computers, the network, or software can result in severe disruptions to product movement and freshness.

Manufacturing Supply chain examples

Tables 1 and 2 show simplified examples of the physical and communication paths in two manufacturing supply chains. Both show how physical transportation is a crucial factor in all manufacturing supply chains. *Most supply chains are actually much more complex.*

¹ Risk Management Framework for Information Systems and Organizations; A System Life Cycle Approach for Security and Privacy, National Institute of Standards and Technology Special Publication 800-37 Revision 2, <https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-37r2.pdf>

Table 1: Food Canning Supply Chain

This diagram illustrates the supply chain for food can manufacturing, along with supply chain phases and communication paths. It also shows a some computer data communication paths between different phases of the process.

While cans are manufactured and canned goods consumption occur year-round, food canning is intensely seasonal, typically over a few months. To ensure can supplies are adequate for demand and “good until” dates stay within required parameters, planning manufacturing, tracking canning dates, and storage locations of canned goods are all critical.

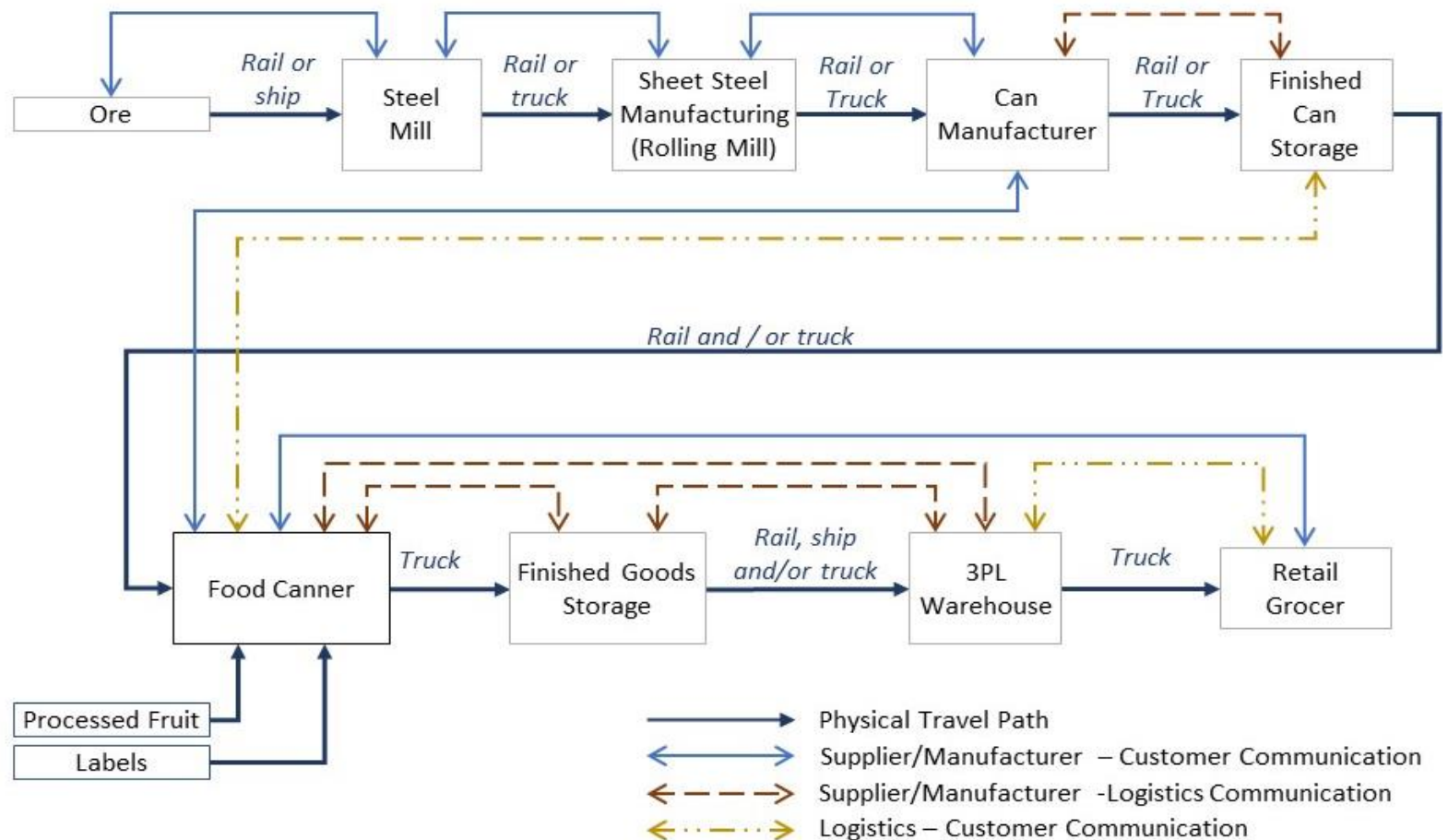
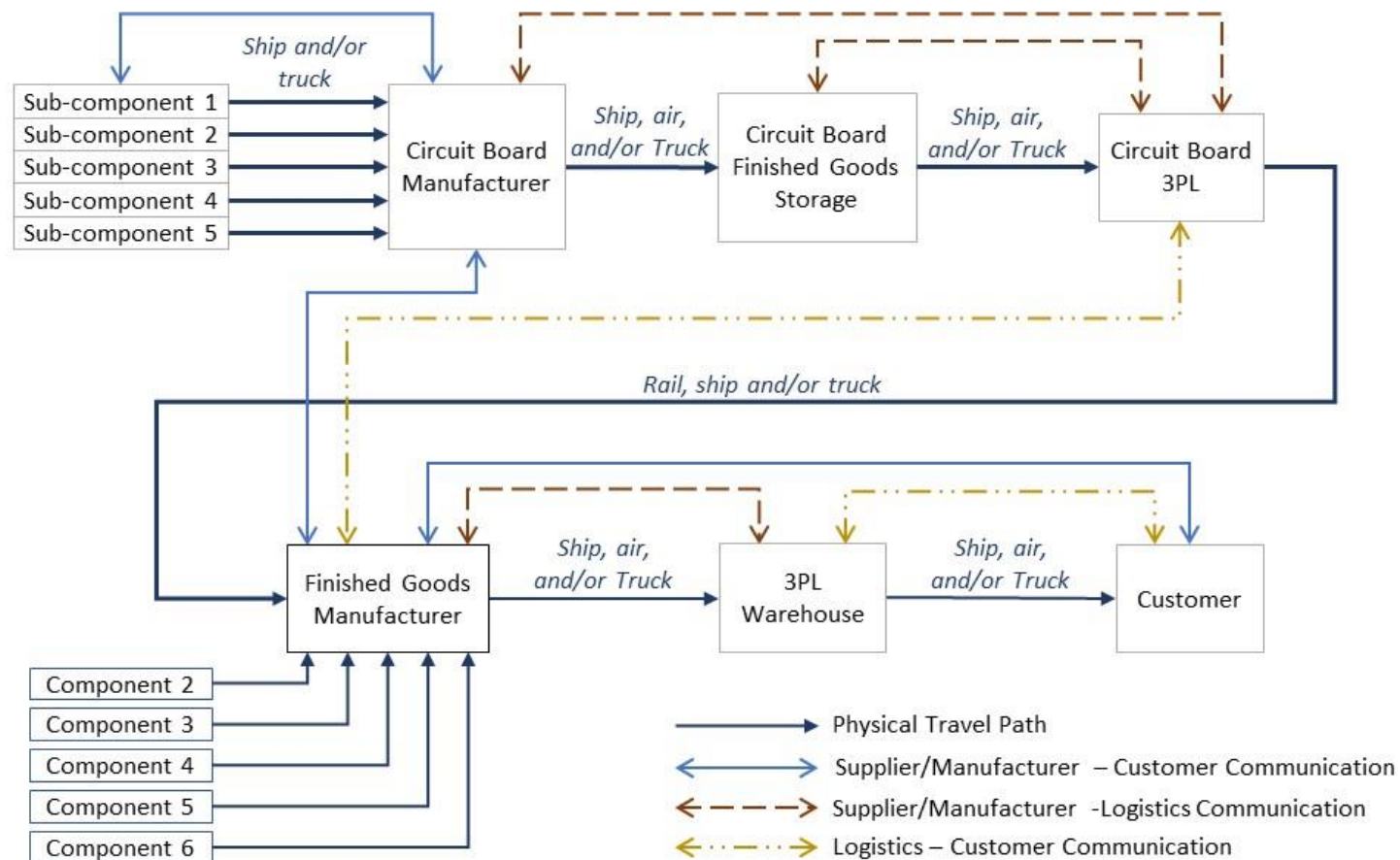


Table 2: Digital Product Supply Chain (Abbreviated)

This diagram illustrates simplified supply chain phases and communication paths for a product containing electrical circuitry. The example goes from manufactured components to an assembly to manufacturing the finished product. It does not include sub-component manufacturing from raw materials to finished sub-components.

The diagram also shows a few of the computer communication paths between different phases of the process. It does not describe the type of information communicated.



Requirements in the Transportation Supply Chain

As shown in Tables 1 and 2, delivering freight from one point to another requires common items and functions to move and track freight and carriers. Each type of carrier requires a supply chain of its own to operate, including the ability to operate:

Equipment	Consists of the planes, trains, trucks, and ships carrying cargo.
Consumables	Include fuel, lubricants and other items regularly used to power the equipment.
Infrastructure	Includes roads, railway tracks, loading and unloading facilities, loading and unloading equipment, freight storage facilities and electricity to run the systems used to execute orders.
Processes	Includes the tools (usually electronically based) to: 1. Ensure a product is available to purchase or sell (or know when it will be available). 2. Process purchase or sales orders. 3. Identify where the product is physically located in a warehouse or network. 4. Efficiently pick loads or put them away. 5. Communicate load pickup and delivery locations. 6. Route products to ensure efficient deliveries. 7. Track it along its travel path.

Examples of these are below, along with how they are used and related Critical Infrastructure that may affect their availability.

Table 3 Common Supply Chain Requirements

General Description of Items In Transportation			Related Critical Industry Affecting Supply Chain		
Item Description	Item Type	General Use	Energy	Chemical	Transportation
Carrier (Airplane, Railway cars, Trucks, Ships)	Equipment	Operation	x	x	x
Repair Parts	Equipment	Operation		x	x
Lubricants, other for truck operation	Consumable	Operation	x	x	
Fuel	Consumable	Operation	x	x	
Clear travel paths (road, rail, air and sea) and infrastructure	Infrastructure	Operation			x
Loading / unloading	Infrastructure	Operation	x		
Storage (Warehouse) facilities	Infrastructure	Logistics	x		
Warehouse environmental control	Infrastructure	Logistics	x		
Electricity	Infrastructure	Logistics	x		
Timely delivery	Process	Logistics			
Load and Carrier Equipment tracking	Process	Logistics	x		
Order entry (Product ID, Pick & Drop Locations)	Process	Logistics	x		
Traffic routing (mapping, routing, road updates, etc.)	Process	Logistics	x		
Traffic control	Process	Logistics	x		
Navigation (GPS / SatNav, etc)).	Process	Logistics	x		

TRANSPORTATION SUPPLY CHAIN VULNERABILITIES

Supply chain vulnerabilities are many. General categories of these vulnerabilities follow.

Infrastructure

Maintaining infrastructure is critical, especially with respect to rail and road transportation. While the rail industry maintains tracks, road maintenance is usually a public function and thus subject to changing budgets and priorities. Declining roadways and transportation infrastructure can also lead to increased truck maintenance, cargo damage and fuel consumption.

Capacity Limitations

Limits on the ability to move products include:

- Container shortages, esp. with growth in international trade
- Lack of cargo capacity on key trade lanes causing bottlenecks in the overall chain.”²
- Insufficient warehouse / storage space in the supply chain.
- Increased shipping demand from e-commerce growth (magnified by the Covid pandemic).
- Availability of cartons and other packaging materials.

When coupled with demand growth, capacity limits not only affect how much cargo which can be moved but also lead to higher shipping costs. For example, the cost to ship 20’ containers rose from \$600 in October 2020 to over \$4,500 in April 2022.³

Labor Shortages and Disputes

Again, magnified by the Covid pandemic, the availability of labor adversely affected product transportation.

Labor disputes have led to recent supply chain disruptions. Broken down by transportation mode or location, 2021 disruptions occurred in the following locations:

Facility Operations	63.20%
Ground Transportation	18.40%
Sea Transportation	10.40%
Air Transportation	4.10%
Rail Transportation	3.90% ⁴

As can be seen, most 2021 labor disruptions struck warehouses. This was partially a response to Covid 19, but also reflected relatively low warehouse wages and the repetitive nature of the work.

A separate concern is that plant managers frequently mention their inability to find workers who can pass drug tests required for safe plant operation.

² Supply Chain Brain, How Air Cargo's Recovery Hinges on Passenger Travel, David Buss, March, 2023, <https://www.supplychainbrain.com/blogs/1-think-tank/post/34778-how-air-cargos-recovery-hinges-on-passenger-travel#:~:text=The%20air%20cargo%20industry%20is,space%2C%20and%20backed%20up%20shipments.>

³ Harper Petersen Charter Rates Index, Harper Petersen & Co. <https://www.harperpetersen.com/harpex>

⁴ British Standards Institution, BSI Supply Chain Risk Insights Report, November 2021, p 58.

The US trucking industry has projected labor shortages in 2022 of more than 100,000 drivers. The UK projected a similar projected shortage, with Europe overall expected to have a shortage of 400,000 truck drivers.^{5,6}

(Self-driving vehicles have been touted as a possible way to offset driver losses. However, challenges to this include labor opposition and a need for significant infrastructure, especially with respect to travel paths, safety, and fast automatic recharging. As a result, automated cargo carriers are not expected to have a significant effect on transportation before approximately 2030.)

Environmental issues

These can range from “simple” weather-based disruptions to more complex social issues.

- | | |
|--------------------|---|
| Natural disasters: | Whether hurricanes, earthquakes, or large-scale weather events, these affect transportation, especially by truck and air, but also by train and ship. |
| Global warming: | Concerns are causing government agencies to look at requiring trucks, airplanes, ships, and port equipment to develop low-carbon fuel systems. This in turn may lead to trucking companies putting off investing in trucks if they have no way to tell if that equipment will be allowed to operate in five-to-ten years. |

Geopolitical issues

These regularly provide unexpected transportation disruptions. Some examples include:

- | | |
|-----------------|--|
| Conflict zones: | Flights operating in these areas are at risk. |
| Corruption | Can be found in both criminal and government circles, especially in places with low political and economic stability. |
| Tariffs | These can cause delays as manufacturers resource their suppliers and as resulting delays affect product availability in the destination country. |

Social Unrest

Civil and social unrest can not only lead to strikes but can also change how transportation security must be deployed.

Prior to 2020, most cargo theft in Nigeria was from trucking (approximately 2/3 of thefts). In 2020, social unrest in Nigeria (over SARS and governmental policies) led to changes in where supply chain thefts occurred. Facilities became the highest source of recorded theft incidents. When the unrest fell off, the major source of thefts shifted again to trucking.⁷

Other factors such as forced labor, child labor and human rights violations can lead to restrictions in doing business with different countries. As a result, supply chains are disrupted.

⁵ <https://www.prologis.com/blog/role-transportation-supply-chain-management>

⁶ British Standards Institution, BSI Supply Chain Risk Insights Report, November 2021, p 48
<https://www.bsigroup.com/globalassets/localfiles/en-gb/supply-chain-solutions/resources/bsi-supply-chain-risk-insights-report-nov-2021.pdf>

⁷ British Standards Institution, BSI Supply Chain Risk Insights Report, November 2021, p. 44

“Bad Actors” In the Supply Chain

Far and away, the most discussed concern in supply chain security are “bad actors” stealing cargo or using it for illegal purposes. Criminal activity is a tremendous, ongoing and growing threat, and they strike from multiple directions at all parts of the supply chain.

Supply chain theft

Following is cargo theft information from the British Standards Institution’s “BSI Supply Chain Risk Insights Report.” Global in nature, it reflects potential supply chain concerns for Texas businesses and provides a great amount of information on supply chain threats.

Examples of how criminal individuals or groups steal include:

- Cargo theft.
- Criminal groups posing as warehouse distributors, DCs, transportation companies.⁸

Theft locations in the supply chain include:⁹

- | | |
|------------------------------|-----|
| • In-Transit | 34% |
| • Warehouse | 27% |
| • Production Facility | 6% |
| • Parking lot | 6% |
| • Unsecured roadside parking | 5% |
| • Rest Area | 4% |
| • Other | 18% |

Methods by which cargo is stolen break down as:¹⁰

- | | |
|--------------------------------|-----|
| • Hijacking | 26% |
| • Theft from facility | 22% |
| • Theft of vehicle | 9% |
| • Theft from container/trailer | 10% |
| • Theft from vehicle | 8% |
| • Theft of employee belongings | 6% |
| • Other | 19% |

Supply chain companies have the unenviable task of trying to adapt to constantly shifting types of theft and smuggling attacks all along their supply chain.

⁸ Ibid, p. 18

⁹ Ibid, p. 61

¹⁰ Ibid, p. 60

Primary countries with theft by hijacking

Internationally, the potential for supply chain disruptions increase both according to the country of origin and the type of transportation involved. This can be a function of low wages, corruption, and lack of security infrastructure.

Top countries for hijackings¹¹ in 2021 were:

Mexico	209	Brazil	187
South Africa	47	India	33
Chile	36	Argentina	27

Illegal shipments and market conditions

Protecting shipment integrity is important because drug smugglers have long relied on inserting drugs or human cargo into normal cargo shipments. This type of “supply chain contamination”, can be seen in:

- Counterfeit production
- Cargo contamination / smuggling
- Human trafficking, including inadequately documented passengers

Drug smugglers have their own supply chain concerns, including:

- Their chemical supply chains for drug manufacturing.
- Optimal drug manufacturing locations.
- Ease of inserting drugs into shipments.
- Law enforcement effectiveness.
- Proximity to the destination.

Examples of this include:

1. Drug shipments seizures from certain countries rose dramatically from 2021-2022.¹²

Ecuador	386%	Iran	350%
Brazil	92%	Spain	63%
Colombia	56%	Costa Rica	17%

2. During that time, ocean freight smuggling grew by over 50% (based on smuggling seizures).
3. Between 2019 and 2021, there was a shortage of chemicals used to process cocaine. As a result, the leading types of drugs shipped changed from cocaine, followed by cannabis, then amphetamines to amphetamines, followed by then cocaine, then cannabis.¹³

The cartels have their own supply chain issues. Regrettably, they adapt quickly.

These changes indicate a dynamically shifting security environment for companies wishing to ship products into or out of Texas. Importers are advised to be aware of the potential for theft and smuggling in their shipments.

¹¹ British Standards Institution, BSI Supply Chain Risk Insights Report, November 2021, p. 60

¹² Ibid, p. 17

¹³ Ibid, p. 13

Communication, Data Security and Cyber-attacks

Core to all transportation, without exception, is data security. Literally every aspect of the supply chain includes electronic information transmission. “Bad actors”, power failures, even sunspots and other phenomena can all cause failures or corruptions in transmitting information. Staying current on information security threats is one of the hardest areas for small businesses to manage, as it is frequently beyond the ability of small business owners. As a result, they often live with fingers crossed, hoping their internet providers and data storage companies are secure.

A few illustrating examples of major incidents include:

- In June of 2017, malware released by the Russian military accidentally infected the network of Maersk, a worldwide logistics and shipping company. By shutting down servers and laptop computers it was estimated that the malware had cost the company between \$250 million and \$300 million.

This same malware also cost trucking companies tens of millions of dollars, TNT Express lost about \$400 million and Merck \$870 million in sales and IT costs. The disruption to the global supply chain, of which Maersk is a major component, was extensive, and losses accumulated into the billions.¹⁴

- While transportation and logistics is one of the most industries in the world, it is so heavily dependent on technology that it is one of the industries most vulnerable to cybercrime. “the first half of 2020 revealed a staggering increase in ransomware incidents, with an overall 715% year-over-year increase.”¹⁵
- Per IBM transportation was in 2021 the target of ten percent of all attacks observed by IBM on networks with Operational Technology (this can be defined as computers and systems used to monitor and control physical devices, including manufacturing and production equipment). Attacks on transportation overall were four percent (seventh place) of all industry attacks, but ten percent of all attacks in Asia.¹⁶
- In July, 2021, Bay & Bay Transportation, a Minnesota trucking and logistics company, was hit by a ransomware attack that locked up the system the company uses to manage a 300 truck fleet. The payment and subsequent security upgrades cost over \$100,000.

¹⁴ Industrial Cybersecurity Pulse, Throwback Attack: How NotPetya accidentally took down global shipping giant Maersk, Daniel E. Capano, September 30, 2021 <https://www.industrialcybersecuritypulse.com/threats-vulnerabilities/throwback-attack-how-notpetya-accidentally-took-down-global-shipping-giant-maersk/>

¹⁵ Cyber Management Alliance, Cybersecurity Attacks & the Transportation Industry, October 19, 2021, April Miller, <https://www.cm-alliance.com/cybersecurity-blog/cybersecurity-attacks-the-transportation-industry>

¹⁶ IBM Security, X-Force Threat Intelligence Index 2022, p. 26, 42, 37

Cascading Effects of Supply Chain Disruptions

Supply chain disruptions affect the shipping company, people buying food or other items for home consumption. They also disrupt manufacturing leading to reduced economic output. The effects are far-reaching and can include:

Cascading Effect	Affected Party
• Manufacturing schedule disruptions	Manufacturer, Shipper, Customer
• Port congestion	Manufacturers, Shipper, customer
• Missed shipping schedules	Shipper, Customer
• Missed shipper transportation connections	Manufacturer, Shipper, Customer
• Order Fulfillment delays	Customer
• Contract violations and resulting consequential damages	Manufacturer, shipper
• Employee lost wages due to manufacturing stoppages	Manufacturer, Customer
• Food or product spoilage	Grower, Shipper, Customer
• Health consequences (food, medicines, medical devices)	Manufacturer, Customer
• Accidents due to traffic control or navigation	Shipper, customer
• Inability to manage inventory, leading to loss or delay	Shipper, Customer
• Inflation due to unsatisfied demand	Public
• Panic with shortages	Public

Related, companies are becoming aware that centralized inventory locations make them vulnerable to the loss of that facility.

TEXAS TRANSPORTATION “CRITICAL INFRASTRUCTURE”

This section defines what Texas businesses can be considered as Critical Industries with Transportation. It also provides an approximation of the number and size of Texas-based companies in these sectors.

Defining Texas Transportation “Critical Infrastructure” Sectors

For the terms of this paper, Transportation Critical Infrastructure is defined as supply chains specific to transportation which are critical to the state of Texas. This designation is based on the potential for supply chain disruptions to affect:

1. Economic disruption.
2. Psychological Disruption.
3. Cascading (downstream) effects of disruption.

Non-CI Business Sectors

Some transportation sectors are determined not to be CI for the purposes of this paper. This is because they:

1. Constitute a relatively small portion of the Texas economy.
2. Are considered unlikely to be targeted for attack.
3. Are unlikely to have a large effect on the overall economy or psyche of Texans if disrupted.

Both CI and non-CI business segments are identified so the reader can adapt which ones they might determine to be critical for their own purposes.

Identifying and Defining Texas Critical Infrastructure Sectors

To identify and define transportation CI business sectors, this paper uses NAICS (North American Industry Classification System) codes. NAICS codes are a standardized method used to define business types. Used by the US Census bureau, they allow approximation of the number of businesses of each category and the number of employees in those businesses.

Most of the businesses discussed as CI are from NAICS 48 (primarily transportation of people or goods) and NAICS 49 (primarily warehousing). However, this paper also includes NAICS 447110 (Gas Stations with Convenience Stores) and NAICS 447190 (Other Gasoline Stations, meaning gas stations, truck stops without convenience stores and marine fuel depots). While gas stations are individually unlikely to be attacked by terrorists, a general disruption of the gasoline or diesel supply chain would cripple freight movement.

A list and description of all codes is in [Appendix 3](#).

Large Vs. Small Business Treatment

Both large and small businesses are vulnerable to Supply Chain Disruptions. However, according to CBT Networks, small businesses lead the list in terms of what industries experience cyberattacks. Targets for Supply:

- Small businesses¹⁷
- Healthcare institutions
- Government agencies
- Energy companies
- Higher education facilities

Based on the idea that it is important to reach both large and small businesses, this paper assumes:

1. There is a need for a “marketing message” about the importance of protecting Critical Industries, to be addressed to those industries.
2. Large businesses (with more than 100 employees and/or \$6 million in annual gross receipts are more likely to have their staff to help with supply chain planning than small businesses.
3. Small businesses (defined under Texas law as independently owned and operated, having fewer than 100 employees or less than \$6 million in annual gross receipts) are less likely to have access to those resources or even understand what resources are necessary.
4. Creating a “marketing message” will be most effective if it understands the different needs, concerns and psychology of large and small businesses.

The goal of this differentiation is to identify the number of large vs. small businesses. The intent is to enable those developing CI awareness information to prioritize their efforts as appropriate.

¹⁷ The Industries Most Vulnerable to Cyber Attacks in 2021, CDNetworks, January 12, 2021, <https://www.cdnetworks.com/cloud-security-blog/the-5-industries-most-vulnerable-to-cyber-attacks/>

TEXAS SUPPLY CHAIN MODES, NODES AND BUSINESS SIZES

This section briefly discusses each sector of the transportation industry in Texas, as well as the approximate numbers and sizes of transportation businesses. Again, the purpose is to help identify what methods of communication might most effectively “get the attention” of those who need Supply Chain support.

Note that each transportation type (Air, Rail, Road, and Rail) is regulated differently. However, working with their regulators may provide an additional path by which information might be communicated to them.

Table 4 below uses US Census 2017 Annual Business Survey data to estimate the number of businesses of each type which fall under transportation CI.

Table 5 uses the same data source to identify “Non-Critical” infrastructure in Texas transportation.

Note that the NAICS data does not include Texas railroad lines. This is because all Class 1 (\$447 million annual revenue) or Class II (between \$35 million and \$447 million annual revenue) railroad companies are headquartered outside of Texas.

Table 4: Texas CI Businesses and sizes

NAICS Code	NAICS Code Summary Description	Businesses with <100 Employees			Businesses with <100 Employees		
		Number of businesses	% of all Sector Businesses	Number of Employees	Number of businesses	% of all Sector Businesses	Number of Employees
481111	Scheduled Passenger Air Transportation	21	16%	98	108	84%	63,833
481112	Scheduled Freight Air Transportation	15	42%	97	21	58%	409
481211	Nonscheduled Chartered Passenger Air Transportation	116	81%	1,020	28	19%	1,973
481212	Nonscheduled Chartered Freight Air Transportation	20	80%	153	4	16%	196
481219	Other Nonscheduled Air Transportation	42	88%	129	0	0%	0
488111	Air Traffic Control	3	12%	8	0	0%	0
488119	Other Airport Operations	102	52%	1,182	96	48%	12,555
488190	Other Support Activities for Air Transportation	369	79%	2,682	98	21%	11,971
447110	Gasoline Stations with Convenience Stores	6,356	61%	33,256	4,090	39%	51,799
485410	School and Employee Bus Transportation	17	14%	206	106	86%	8,313
485991	Special Needs Transportation	105	91%	1,353	10	9%	1,475
488490	Other Support Activities for Road Transportation	133	47%	914	149	53%	2,653
447190	Other Gasoline Stations	544	58%	3,250	398	42%	10,150
484110	General Freight Trucking, Local	2,262	93%	11,653	170	7%	6,153
484121	General Freight Trucking, Long-Distance, Truckload	3,460	85%	16,311	634	15%	40,441
484122	General Freight Trucking, Long-Distance, Less Than Truckload	238	38%	1,436	389	62%	25,704
484220	Specialized Freight (except Used Goods) Trucking, Local	2,089	92%	15,268	186	8%	9,761
484230	Specialized Freight (except Used Goods) Trucking, Long-Distance	979	78%	6,734	273	22%	19,072
485113	Bus and Other Motor Vehicle Transit Systems	16	38%	164	24	57%	4,722
485210	Interurban and Rural Bus Transportation	34	41%	407	36	44%	691
483111	Deep Sea Freight Transportation	24	63%	114	0	0%	0
483112	Deep Sea Passenger Transportation	3	100%	8	0	0%	0
483113	Coastal and Great Lakes Freight Transportation	39	72%	563	15	28%	1,460
483211	Inland Water Freight Transportation	15	63%	71	6	25%	1,843
488310	Port and Harbor Operations	22	71%	404	7	23%	604
488320	Marine Cargo Handling	27	45%	544	33	55%	6,708
488330	Navigational Services to Shipping	77	87%	634	12	13%	981
486110	Pipeline Transportation of Crude Oil	12	7%	47	168	93%	3,126
486210	Pipeline Transportation of Natural Gas	30	7%	424	395	91%	9,303
486910	Pipeline Transportation of Refined Petroleum Products	6	4%	36	142	95%	1,970
486990	All Other Pipeline Transportation	4	40%	27	6	60%	50
493110	General Warehousing and Storage	382	33%	3,927	766	67%	72,562
493120	Refrigerated Warehousing and Storage	56	47%	661	64	53%	3,009
493130	Farm Product Warehousing and Storage	37	64%	366	21	36%	434
493190	Other Warehousing and Storage	102	35%	753	188	65%	8,107
488999	All Other Support Activities for Transportation	12	75%	26	4	25%	338
488510	Freight Transportation Arrangement	1,980	75%	14,333	657	25%	20,643
492110	Couriers and Express Delivery Services	378	50%	3,652	371	50%	57,687

Cells highlighted in yellow are industries with 50% or more fitting the column category. Along with number of sector employees, the number of small businesses may indicate a focus point in education efforts.

Table 5: Texas Non-CI Businesses and sizes

NAICS Code	NAICS Code Summary Description	Businesses with <100 Employees			Businesses with <100 Employees		
		Number of businesses	% of all Sector Businesses	Number of Employees	Number of businesses	% of all Sector Businesses	Number of Employees
484210	Used Household and Office Goods Moving	592	88%	5,110	83	12%	2,622
485310	Taxi Service	76	99%	499	0	0%	0
485320	Limousine Service	188	96%	1,119	5	3%	584
485510	Charter Bus Industry	52	87%	919	8	13%	645
485999	All Other Transit and Ground Passenger Transportation	73	75%	510	24	25%	576
487110	Scenic and Sightseeing Transportation, Land	32	100%	221	0	0%	0
488410	Motor Vehicle Towing	762	99%	5,115	9	1%	405
483114	Coastal and Great Lakes Passenger Transportation	10	91%	16	0	0%	0
483212	Inland Water Passenger Transportation	8	100%	38	0	0%	0
487210	Scenic and Sightseeing Transportation, Water	60	95%	169	0	0%	0
488390	Other Support Activities for Water Transportation	75	82%	518	16	18%	227
492210	Local Messengers and Local Delivery	312	87%	2,777	47	13%	3,020
487990	Scenic and Sightseeing Transportation, Other	8	100%	29	0	0%	0
488991	Packing and Crating	116	89%	1,105	14	11%	1,208
488210	Support Activities for Rail Transportation	79	35%	824	144	65%	6,490
488999	All Other Support Activities for Transportation	12	75%	26	4	25%	338

Cells highlighted in yellow are industries with 50% or more fitting the column category.

Air

Per a 2018 Texas Department of Transportation study, aviation contributed to more than 778,000 jobs, \$30.1 billion in payroll and \$94.3 billion in total economic output.”¹⁸ Two Texas airlines (American and Southwest) combine to control 36.7% of US domestic market share.¹⁹ Texas airports ranked sixth in the US (after CA, KY, TN, AK, and FL) for cargo landed.²⁰

Note that air transportation not only has an economic effect on the state, but disruptions to it have disproportionately large psychological effects. Therefore, this paper designates all aspects of the air transportation sector as CI.

While there are more small employers than large in Texas, most people are employed by larger businesses, as shown in this information from Table 4.

NAICS Code	NAICS Code Summary Description	Number of Establishments		Employees by Business Size	
		Small	Large	Small	Large
481111	Scheduled Passenger Air Transportation	21	108	98	63,833
481112	Scheduled Freight Air Transportation	15	21	97	409
481211	Nonscheduled Chartered Passenger Air Transportation	116	28	1,020	1,973
481212	Nonscheduled Chartered Freight Air Transportation	20	4	153	196
481219	Other Nonscheduled Air Transportation	42	0	129	0
488111	Air Traffic Control	3	0	8	0
488119	Other Airport Operations	102	96	1,182	12,555
488190	Other Support Activities for Air Transportation	369	98	2,682	11,971

Note that with the “other” categories are operating airports and cargo handling (488119) and aircraft maintenance (488190).

Road

Virtually all movement of goods to end users is at some point by road. Therefore, maintaining that business sector and its supply chain is economically and psychologically critical.

The table below shows the number of small and large Texas road freight and transportation businesses.

¹⁸ <https://www.txdot.gov/inside-txdot/division/aviation/eco-impact-aviation.html>

¹⁹ <https://business.uoregon.edu/files/media/airline-industry-report.pdf>

²⁰ https://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/cy21_cargo_airports

NAICS Code	NAICS Code Summary Description	Number of Establishments		Employees by Business Size	
		Small	Large	Small	Large
447110	Gasoline Stations with Convenience Stores	6,356	4,090	33,256	51,799
447190	Other Gasoline Stations	544	398	3,250	10,150
484110	General Freight Trucking, Local	2,262	170	11,653	6,153
484121	General Long Distance Freight Full Load	3,460	634	16,311	40,441
484122	General Long Distance Freight LTL	238	389	1,436	25,704
484220	Specialized Freight Trucking, Local	2,089	186	15,268	9,761
484230	Specialized Freight Trucking, Long-Distance	979	273	6,734	19,072
488490	Other Road Transportation Support Activities	133	149	914	2,653
485113	Bus and Other Motor Vehicle Transit Systems	16	24	164	4,722
485210	Interurban and Rural Bus Transportation	34	36	407	691
485410	School and Employee Bus Transportation	17	106	206	8,313
485991	Special Needs Transportation	105	10	1,353	1,475

Following are a few notes on the road transportation sector.

- Gasoline stations may not be critical on an individual basis, but they are collectively the delivery point of fuel and thereby included as CI.
- Other than LTL freight carriers) between 60% and 80% of Texas freight carriers not only employ under 100 employees, but they employ under fewer than ten. Offsetting this somewhat is that, while there are fewer large businesses than small, large businesses employ more people overall. But all can be expected to be vulnerable to disruptions of order transmission, order tracking and GPS disruptions.
- Bus transportation is included not because it is economically critical to the overall economy, but because protecting it is highly critical from the psychological perspective.

Rail

Rail freight moves much of the bulk fuel, manufacturing raw materials and food in the country, plus well as domestic and imported manufactured goods. Note that, per NAICS codes, Texas has no railway companies headquartered within the state. Therefore there is no chart for this sector.

Per Amir Levintal, former director of the Israel Defense Forces' cyber research and development unit and CEO of cybersecurity firm Cylus:

- Modern command centers "use wireless connections to control activities, like monitoring train speeds or regulating traffic signals. It's these types of wireless signals can expose a network's vulnerabilities and leave the infrastructure wide open for attack.
- "Some train networks use Wi-Fi connections to control critical components of the train, like brakes and doors. Attackers can find ways to access the wireless network to send commands to those components and change the behavior of the train."²¹

²¹ Business Insider, Railway systems could be hackers' next big target — and derailling trains wouldn't be that hard, Rosie Perper May 17, 2018, <https://www.businessinsider.com/cyber-attacks-targeting-railway-systems-next-2018-5>

Principal disruption concerns in the rail industry include:

- Labor shortages. This applies to both railway employees and at load/unload points.
- Potential internet-related threats.
- Infrastructure damage / destruction and repair, which would affect traffic flow and routing.

While railways are a Critical Infrastructure, this paper will not focus on its supply chain because:

- Rail carrier “culture” is one of self-support, with extensive supply chain planning required to support tens of thousands of miles of track.
- Most rail carriers have more than 100 employees. The supply chain of the various railroads has the ability and infrastructure to anticipate their own supply chain needs.

Maritime

The Texas maritime industry has a very large effect on the Texas economy. Texas has 12 deep draft and 8 shallow draft ports. Per US Department of Transportation 2020 statistics, Texas ports led the country in handling:

- 23% of all US maritime freight (647,765,713 tons)
- 42% of all US exports (346,002,314)
- 18% of all US imports (118,153,320 tons)²²

Per the Texas Ports Association:

- Revenue generated through Texas ports represents 25% of Texas (GDP).²³
- The industry provides over 128,000 direct Texas jobs and \$8.7 billion in personal income.
- The industry contributes \$7.8 billion annually in state and local tax revenues.²⁴

The only sector where most marine businesses have over 100 employees is Marine Cargo Handling:

NAICS Code	NAICS Code Summary Description	Number of Establishments		Employees by Business Size	
		Small	Large	Small	Large
483111	Deep Sea Freight Transportation	24	0	114	0
483112	Deep Sea Passenger Transportation	3	0	8	0
483113	Coastal and Great Lakes Freight Transportation	39	15	563	1,460
483211	Inland Water Freight Transportation	15	6	71	1,843
488310	Port and Harbor Operations	22	7	404	604
488320	Marine Cargo Handling	27	33	544	6,708
488330	Navigational Services to Shipping	77	12	634	981

While most companies are small businesses, most workers are employed by larger ones.

²² <https://www.bts.gov/principal-ports>

²³ <https://www.texasports.org/>

²⁴ <https://www.texasports.org/wp-content/uploads/2020/10/NationalEconomicImpactoftheTexasPorts-2018-7-25-2019.pdf>

Pipelines

Outside of coal, most petroleum products in Texas are moved by pipeline. As pipeline delivery drives most electricity and much heating fuel availability, protecting pipeline infrastructure may be considered one of the top priorities of infrastructure protection.

Risks to Texas pipelines are primarily associated with:

- Physical attacks
- Hacking. The latter is exemplified by hackers gaining entry into Houston-based Colonial Pipeline through via a single password into a virtual private network account (was intended for employees to remotely access the company's computer network). While the company could still pump fuel, the attack disrupted their billing system, leading them to shut down operation of one of the largest fuel pipelines in the country. This in turn led to gas, diesel and jet fuel supply disruptions across the East Coast.

Employee counts of Texas pipeline businesses are:

NAICS Code	NAICS Code Summary Description	Number of Establishments		Employees by Business Size	
		Small	Large	Small	Large
486110	Pipeline Transportation of Crude Oil	12	168	47	3,126
486210	Pipeline Transportation of Natural Gas	30	395	424	9,303
486910	Pipeline Transportation of Refined Petroleum Product	6	142	36	1,970
486990	All Other Pipeline Transportation	4	6	27	50

Of the 763 pipeline companies in Texas, 95% may be considered "large" companies and are therefore most likely to have the resources to protect their infrastructure.

Warehousing

Warehousing provides storage locations (nodes) all along the supply chain. These storage or distribution locations provide a way for manufacturers to have either centralized or local distribution points in support of their distribution channels.

While warehouses are not "high visibility", they are tempting attack targets for several reasons:

- All require extensive computer communication, making them susceptible to remote hacking.
- Logistically, a targeted physical attack can destroy a large amount of product at once.
- As distribution points, a disruption at one can leverage into downstream product availability across a wide geographical area or a broad number of customers.
- Fresh goods warehouses are particularly susceptible to electricity loss, resulting in rotting of perishable products.
- Companies with single-point distribution are extremely vulnerable to disruption if their one warehouse is taken out of operation by any means..

NAICS Code	NAICS Code Summary Description	Number of Establishments		Employees by Business Size	
		Small	Large	Small	Large
493110	General Warehousing and Storage	382	766	3,927	72,562
493120	Refrigerated Warehousing and Storage	56	64	661	3,009
493130	Farm Product Warehousing and Storage	37	21	366	434
493190	Other Warehousing and Storage	102	188	753	8,107

As can be seen, the vast majority of warehousing employees are employed by large businesses.

(This category does not include manufacturer-owned warehouses but represents independent warehouse and third-party (3PL) logistics, omnichannel distribution and other logistics services.)

Freight Transportation Arrangement

This sector arranges freight transportation shippers and carriers. These establishments are usually known as freight forwarders, marine shipping agents, or customs brokers and offer a combination of services spanning transportation modes. Note that most of these businesses and a large number of people are in the small business category.

NAICS Code	NAICS Code Summary Description	Number of Establishments		Employees by Business Size	
		Small	Large	Small	Large
488510	Freight Transportation Arrangement	1,980	657	14,333	20,643

Couriers and Express Delivery Services

This sector includes large companies like FedEx, UPS and DHL, as well as smaller and local delivery services. The quantity of small vs. large businesses are split approximately 50/50, but the large companies have vastly larger numbers of employees, as follows:

NAICS Code	NAICS Code Summary Description	Number of Establishments		Employees by Business Size	
		Small	Large	Small	Large
492110	Couriers and Express Delivery Services	378	371	3,652	57,687

PLANNING FOR TRANSPORTATION SUPPLY CHAIN DISRUPTIONS

The goal of this section is to help businesses decide what they need to operate and how to decide what vulnerabilities to address first to protect their supply chain. It is written primarily with small businesses in mind.

While small businesses often don't have the internal resources to handle their emergency planning for Supply Chain Disruptions (SCD), they often have an advantage in that company leadership aware is closer to and therefore more aware of the company's operating needs. Leadership can use this knowledge to help prepare their business for the tasks of Response, Resilience and Recovery.

Deciding what vulnerabilities to address will most likely be a function of:

1. Identifying operating needs: Minimum requirements to continue company operation.
2. Customer expectations in terms of the security of your operation.
3. Likelihood of threats or attacks particular to your business occurring.
4. The cost-effectiveness of different security methods.

Comparing the cost resilience planning during a disruption can allow a company to make decisions about where to prioritize efforts. Costs might include lost business, damaged relationships, etc. Understanding the likelihood of individual disruptions, lost business costs, and protection costs should allow companies to prioritize their security efforts.

Identifying operating needs

Following are simple tasks to help companies prepare for Supply Chain Disruptions. Note that a company may not need to remain "fully operational" to function during a disruption. It may be cost-effective to only continue business-critical services and reduce non-critical ones. Primary areas to consider could include:

Computers

Take simple steps to prepare computers. This is listed first because it is both simple and can prevent many outside cyberattacks. Some of these are listed in [Appendix 1](#).

Processes

Develop a list of the minimum functions and services your company needs in order to operate. These might include deliveries, inventory tracking, order fulfillment, billing, outside connections to other systems, etc. This knowledge, along with the power consumption of equipment, will help determine any backup power requirements.

Network Communication Protection

Communicating with outside networks is much more complex, and beyond the scope of this paper. Some simpler ways to address network protection are in the section on "Avoiding Paralysis by Analysis."

At a minimum a company may wish to have local copies of necessary information, whether paper or computers containing that information which are isolated and protected from network threats. Again, professional IT companies or your suppliers and customers may have appropriate and recommended ways to do this.

Equipment

Includes the equipment necessary to provide the above processes. These might include trucks, conveyors, computers, secure product storage and refrigerated (for fresh or frozen foods). Because some of these can use large amounts of power, it may be important to choose what is necessary vs. what would be “nice to have”.

Supply Chain

What does your own supply chain consist of? This might include consumables of any type (fuel, packaging, cartons, labels, wrapping materials, etc.) and may include maintenance items.

It can be helpful to understand what items or services from vendors may be subject to supply chain disruptions. Consider where their raw materials come from and be aware of possible disruptions in those industries.

An example of this is an ongoing shortage and higher prices for cardboard for boxes. Multiple sources have pointed out how, along with already decreasing paper mill output and increasing mail order deliveries, Covid led to a further increase in demand for cardboard for direct shipping to homes. This led many companies to have to pay higher prices and face longer delivery times for corrugated paper and even labels. In turn, they sought alternate paper, box and label sources.

If your suppliers are subject to supply chain disruptions, it may be appropriate to ask them to find additional suppliers or stock inventory, or find your own acceptable alternatives who use a different supply chain than your current supplier.

Infrastructure

Infrastructure is where physical security and utilities necessary for operation come together. Two common examples are physical security and backup electricity.

Physical security requirements

The here is to determine what types of attacks might occur and their likelihood, and what will have to be done to secure product against loss, damage or contamination (whether by smuggling or other means).

Measuring these against customer requirements for product loss or integrity, the type and magnitude of potential losses, the effect on business and other factors, a company should be able to decide on what measures are necessary.

Balancing these to should lead a company to decide on the best method to deter losses. These steps could range from doing nothing to adding guards, modifying existing facilities, making necessary upgrades and even physically relocating. Again, these costs can help a business make economic decisions about physical security.

Backup Electricity

Understanding minimum electrical requirements can allow a company to decide which interruptions are most likely to occur, based on the business type. Steps to determining backup include.

1. Determine your requirements to operate required electrical equipment
2. Determine the costs to provide backup capabilities.

Electricians (yours or contracted) can tell you how much power is required to operate critical systems and their power circuits. This can then be used to get cost estimates for items such as:

1. Modifying existing panels to allow for backup power.
2. Backup generator costs for equipment, fuel, and installation.

Avoiding “Paralysis By Analysis”

For companies with limited resources, there are ways to avoid being overwhelmed by the thought of Supply Chain Disruption planning. Whether because of the vast amount of information available or the many tasks to accomplish, small business owners may end up simply doing nothing rather than moving forward. One way to avoid might be to break the tasks down into steps, thus making the process more manageable:

- First, implement the Basic Computer System Protection tasks. Then list what other tasks might be required and implement them one at a time.
- Ask customers about their requirements regarding their product protection requirements. If approached with the idea that you want to help secure their supply chain, they may also be willing to recommend cost-effective ways to address both physical and security needs.
- List your most critical Supply Chain needs. Fellow employees can help create a list of what might disrupt these supply needs.
- Leverage suppliers to learn how to best protect equipment or networks they supplied.
- Take steps to ensure your external information exchanges are secure. For resources, reference network protection in the “Cyber” section of [Appendix 2](#).
- Combine the information gained in the above steps into an overall “task list”, then address them as appropriate.

Insurance companies as a resource

Note that insurance companies often will help identify potential weaknesses, and sometimes offer rate reductions for infrastructure protection.

Also, some insurance companies offer cyber insurance to protect users against data losses or even ransomware.

Appendix 1 Basic Computer System Protection

A few simple practices can greatly increase a system's protection. Simple steps follow, while more complete ones can be found online.

- 1) Update all computers to ensure software and security "patches" are current.
- 2) Ensure all equipment has "real" login credentials. For example, hackers know that routers come with default login names of "Admin" and passwords like "password" or "Admin". These are easy for you to change and doing so can prevent remote attacks.
- 3) Ensure passwords are not easily guessed. People often use their initials, names and birthdays. Passwords would be much more difficult to guess if they used (for example) the first letter of each word of a sentence the user will remember. Some examples (using well-known books which include the ability to use letters and numbers) might include:

From Hamlet:	"This above all, To thine own self be true,"
Can become:	Taa,2tosbt,

From the Bible:	"For God so loved the world that He gave his Son"
Can become:	4GsltwHghS.

From "Frankenstein":	"Beware, for I am fearless and therefore powerful."
Can become:	B,4lafatp.

- 4) Most modern computer systems can use 2-step login verification, where the software sends a text or email code to a user to verify the login. This can help prevent a remote hacker without the required verification method from logging on to the system.
- 5) Remember that much vendor-supplied is provided with network connectivity. Possible steps with these might include:
 - a) Limiting or eliminate their outside connectivity.
 - b) Ensuring those computers or PLCs are protected in the same way yours are.
 - c) Asking their suppliers to eliminate internet connectivity.

Appendix 2 Transportation Sector Resource Web Sites

Aviation

Texas Department of Transportation <https://www.txdot.gov/inside-txdot/division/aviation.html>

Federal Aviation Administration <https://www.faa.gov/>

Road

Road / Driver <https://www.txdot.gov/driver.html>

Public Transit <https://www.txdot.gov/inside-txdot/division/public-transportation.html>

DriveTexas <https://drivetexas.org>

Federal Highway Administration <https://highways.dot.gov/>

Motor Carrier Safety Administration <https://www.fmcsa.dot.gov/>

Rail

Texas Department of Transportation <https://www.txdot.gov/inside-txdot/division/rail.html>

Federal Railroad Administration <https://railroads.dot.gov/>

Association of American Railroads <https://www.aar.org/>

Maritime

Texas Department of Transportation <https://www.txdot.gov/inside-txdot/division/maritime.html>

Port of Houston <https://porthouston.com/>

US Maritime Administration <https://www.maritime.dot.gov/>

US Maritime Administration <https://www.maritime.dot.gov/ports/strong-ports/emergency-and-preparedness-response>

Pipeline

US DOT Pipeline and Hazardous
Materials Safety <https://www.phmsa.dot.gov/>

Cyber

Texas Department of Transportation <https://www.txdot.gov/inside-txdot/division/information-technology/Cybersecurity/cybersecurity-resources.html>

FCC Cyberplanner <https://www.fcc.gov/cyberplanner>

Small Business Administration <https://www.sba.gov/business-guide/manage-your-business/strengthen-your-cybersecurity>

Cybersecurity and Infrastructure
Security Agency (CISA)
(A library of supply chain resources)

<https://www.cisa.gov/ict-supply-chain-library>
<https://www.cisa.gov/supply-chain-compromise>

Other

Federal Emergency Management
Agency (FEMA)

<https://www.fema.gov/sites/default/files/2020-07/supply-chain-resilience-guide.pdf>

*British Standards Institution Supply
Chain Risk Insights Report*

<https://www.bsigroup.com/globalassets/localfiles/en-gb/supply-chain-solutions/resources/bsi-supply-chain-risk-insights-report-nov-2021.pdf>

ISO 22301:2019 Security and
resilience - Business continuity
management systems – Reqs

<https://www.iso.org/standard/75106.html>

Appendix 3 NAICS definitions

- 481111 Scheduled Passenger Air Transportation
Primarily providing air transportation of passengers or passengers and freight over regular routes and on regular schedules. Establishments in this industry operate flights even if partially loaded. Scheduled air passenger carriers including commuter and helicopter carriers (except scenic and sightseeing) are included in this industry.
- 481112 Scheduled Freight Air Transportation
Primarily providing air transportation of cargo without transporting passengers over regular routes and on regular schedules. Establishments in this industry operate flights even if partially loaded. Primarily providing scheduled air transportation of mail on a contract basis are included in this industry.
- 481211 Nonscheduled Chartered Passenger Air Transportation
Primarily providing air transportation of passengers or passengers and cargo with no regular routes and regular schedules.
- 481212 Nonscheduled Chartered Freight Air Transportation
Primarily providing air transportation of cargo without transporting passengers with no regular routes and regular schedules.
- 481219 Other Nonscheduled Air Transportation
Primarily providing air transportation with no regular routes and regular schedules (except nonscheduled chartered passenger and/or cargo air transportation). These Provide a variety of specialty air transportation or flying services based on individual customer needs using general purpose aircraft. Illustrative Examples: Aircraft charter services (i.e., general purpose aircraft used for a variety of specialty air and flying services), Aviation clubs providing a variety of air transportation activities to the general public.
- 488111 Air Traffic Control
Primarily providing air traffic control services to regulate the flow of air traffic.
- 488119 Other Airport Operations
Primarily (1) operating international, national, or civil airports, or public flying fields or (2) supporting airport operations, such as rental of hangar space, and providing baggage handling and/or cargo handling services.
- 488190 Other Support Activities for Air Transportation
Primarily providing specialized services for air transportation (except air traffic control and other airport operations). Illustrative Examples: Aircraft maintenance

and repair services (except factory conversions, overhauls, rebuilding), Aircraft passenger screening security services, Aircraft testing services.

- 486110 Pipeline Transportation of Crude Oil
Primarily the pipeline transportation of crude oil.
- 486210 Pipeline Transportation of Natural Gas
Primarily the pipeline transportation of natural gas from processing plants to local distribution systems. This industry includes the storage of natural gas because the storage is usually done by the pipeline establishment and because a pipeline is inherently a network in which all the nodes are interdependent.
- 486910 Pipeline Transportation of Refined Petroleum Products
Primarily the pipeline transportation of refined petroleum products.
- 486990 All Other Pipeline Transportation
Primarily the pipeline transportation of products (except crude oil, natural gas, and refined petroleum products).
- 488210 Support Activities for Rail Transportation
Primarily providing specialized services for railroad transportation including servicing, routine repairing (except factory conversion, overhaul, or rebuilding of rolling stock) and maintaining rail cars; loading and unloading rail cars; and operating independent terminals.
- 447110 Gasoline Stations with Convenience Stores
Retailing automotive fuels (e.g., diesel fuel, gasohol, gasoline) in combination with convenience store or food mart items. These establishments can either be in a convenience store (i.e., food mart) setting or a gasoline station setting. These establishments may also provide automotive repair services.
- 447190 Other Gasoline Stations
.Gasoline stations (except those with convenience stores) primarily engaged in (1) retailing automotive fuels (e.g., diesel fuel, gasohol, gasoline, alternative fuels) or (2) retailing these fuels in combination with activities, such as providing repair services; selling automotive oils, replacement parts, and accessories; and/or providing food services. Illustrative Examples: Gasoline stations without convenience stores, Truck stops, Marine service stations.
- 484110 General Freight Trucking, Local
Primarily providing local general freight trucking. General freight trucking establishments handle a wide variety of commodities, generally palletized and transported in a container or van trailer. Local general freight trucking

establishments usually provide trucking within a metropolitan area which may cross state lines. Generally the trips are same-day return.

- 484121 General Freight Trucking, Long-Distance, Truckload
Primarily providing long-distance general freight truckload (TL) trucking. These long-distance general freight truckload carriers provide full truck movement of freight from origin to destination. The shipment of freight on a truck is characterized as a full single load not combined with other shipments.
- 484122 General Freight Trucking, Long-Distance, Less Than Truckload
Primarily providing long-distance, general freight, less than truckload (LTL) trucking. LTL carriage is characterized as multiple shipments combined onto a single truck for multiple deliveries within a network. These establishments are generally characterized by the following network activities: local pick-up, local sorting and terminal operations, line-haul, destination sorting and terminal operations, and local delivery.
- 484220 Specialized Freight (except Used Goods) Trucking, Local
Primarily providing local, specialized trucking. Local trucking Provide trucking within a metropolitan area that may cross state lines. Generally the trips are same-day return. Illustrative Examples: Local agricultural products trucking, Local dump trucking (e.g., gravel, sand, top-soil), Local boat hauling, Local livestock trucking, Local bulk liquids trucking.
- 484230 Specialized Freight (except Used Goods) Trucking, Long-Distance
Primarily providing long-distance specialized trucking. These Provide trucking between metropolitan areas that may cross North American country borders. Illustrative Examples: Long-distance automobile carrier trucking, Long-distance refrigerated product trucking, Long-distance bulk liquid trucking, Long-distance trucking of waste, Long-distance hazardous material trucking.
- 485113 Bus and Other Motor Vehicle Transit Systems
Primarily operating local and suburban passenger transportation systems using buses or other motor vehicles over regular routes and on regular schedules within a metropolitan area and its adjacent nonurban areas.
- 485210 Interurban and Rural Bus Transportation
Primarily providing bus passenger transportation over regular routes and on regular schedules, principally outside a single metropolitan area and its adjacent nonurban areas.
- 485410 School and Employee Bus Transportation
Primarily providing buses and other motor vehicles to transport pupils to and from school or employees to and from work.

- 485991 Special Needs Transportation
Primarily providing special needs transportation (except to and from school or work) to the infirm, elderly, or handicapped. These establishments may use specially equipped vehicles to provide passenger transportation.
- 488490 Other Support Activities for Road Transportation
Primarily providing services (except motor vehicle towing) to road network users. Illustrative Examples: Bridge, tunnel, and highway operations, Pilot car services (i.e., wide load warning services), Driving services (e.g., automobile, truck delivery), Truck or weighing station operations.
- 483111 Deep Sea Freight Transportation
Primarily providing deep sea transportation of cargo to or from foreign ports.
- 483112 Deep Sea Passenger Transportation
Primarily providing deep sea transportation of passengers to or from foreign ports.
- 483113 Coastal and Great Lakes Freight Transportation
Primarily providing water transportation of cargo in coastal waters, on the Great Lakes System, or deep seas between ports of the United States, Puerto Rico, and United States island possessions or protectorates. Marine transportation establishments using the facilities of the St. Lawrence Seaway Authority Commission are considered to be using the Great Lakes Water Transportation System. Primarily providing coastal and/or Great Lakes barge transportation services are included in this industry.
- 483211 Inland Water Freight Transportation
Primarily providing inland water transportation of cargo on lakes, rivers, or intracoastal waterways (except on the Great Lakes System).
- 488310 Port and Harbor Operations
Primarily operating ports, harbors (including docking and pier facilities), or canals.
- 488320 Marine Cargo Handling
Primarily providing stevedoring and other marine cargo handling services (except warehousing).
- 488330 Navigational Services to Shipping
Primarily providing navigational services to shipping. Marine salvage establishments are included in this industry. Illustrative Examples: Docking and undocking marine vessel services, Piloting services, water transportation, Marine vessel traffic reporting services, Tugboat services, harbor operation.

- 488510 Freight Transportation Arrangement
Primarily arranging transportation of freight between shippers and carriers. These establishments are usually known as freight forwarders, marine shipping agents, or customs brokers and offer a combination of services spanning transportation modes.
- 492110 Couriers and Express Delivery Services
Primarily providing air, surface, or combined mode courier and express delivery services of parcels, but not operating under a universal service obligation. These parcels can include goods and documents, but the express delivery services are not part of the normal mail service. These services are generally between metropolitan areas, urban centers, or international, but the establishments of this industry form a network that includes local pick-up and delivery to serve their customers' needs. Illustrative Examples: Air courier services, except establishments operating under a universal service obligation, Express delivery services, except establishments operating under a universal service obligation, Courier services (i.e., intercity network), except establishments operating under a universal service obligation.
- 493110 General Warehousing and Storage
Primarily operating merchandise warehousing and storage facilities. These establishments generally handle goods in containers, such as boxes, barrels, and/or drums, using equipment, such as forklifts, pallets, and racks. They are not specialized in handling bulk products of any particular type, size, or quantity of goods or products.
- 493120 Refrigerated Warehousing and Storage
Primarily operating refrigerated warehousing and storage facilities. Primarily the storage of furs for the trade are included in this industry. The services provided by these establishments include blast freezing, tempering, and modified atmosphere storage services.
- 493130 Farm Product Warehousing and Storage
Primarily operating bulk farm product warehousing and storage facilities (except refrigerated). Grain elevators Primarily storage are included in this industry.
- 493190 Other Warehousing and Storage
Primarily operating warehousing and storage facilities (except general merchandise, refrigerated, and farm product warehousing and storage). Illustrative Examples: Bulk petroleum storage, Lumber storage terminals, Document storage and warehousing, Whiskey warehousing.
- 488999 All Other Support Activities for Transportation
Primarily providing support activities to transportation (except for air transportation; rail transportation; water transportation; road transportation; freight transportation

arrangement; and packing and crating). Illustrative Examples: Arrangement of vanpools or carpools, Stockyards (i.e., not for fattening or selling livestock), Independent pipeline terminal facilities.

8111 Automotive Repair and Maintenance

This industry group comprises establishments involved in providing repair and maintenance services for automotive vehicles, such as passenger cars, trucks, and vans, and all trailers. Establishments in this industry group employ mechanics with specialized technical skills to diagnose and repair the mechanical and electrical systems for automotive vehicles, repair automotive interiors, and paint or repair automotive exteriors.

81111 General Automotive Repair Establishments primarily engaged in providing (1) a wide range of mechanical and electrical repair and maintenance services for automotive vehicles, such as passenger cars, trucks, and vans, and all trailers or (2) engine repair and replacement. Illustrative Examples: Automobile repair garages (except gasoline service stations), General automotive repair shops, Automotive engine repair and replacement shops.

81112 Automotive Exhaust System Repair
Establishments primarily engaged in replacing or repairing exhaust systems of automotive vehicles, such as passenger cars, trucks, and vans. Illustrative Examples: Automotive exhaust system replacement and repair shops, Automotive muffler replacement and repair shops

81113 Automotive Transmission Repair
Establishments primarily engaged in replacing or repairing transmissions of automotive vehicles, such as passenger cars, trucks, and vans.

81118 Other Automotive Mechanical and Electrical Repair and Maintenance
Establishments primarily engaged in providing specialized mechanical or electrical repair and maintenance services (except engine repair and replacement, exhaust systems repair, and transmission repair) for automotive vehicles, such as passenger cars, trucks, and vans, and all trailers. Illustrative Examples: Automotive brake repair shops, Automotive radiator repair shops, Automotive electrical repair shops, Automotive tune-up shops.

81121 Automotive Body, Paint, and Interior Repair and Maintenance
Establishments primarily engaged in repairing or customizing automotive vehicles, such as passenger cars, trucks, and vans, and all trailer bodies and interiors; and/or painting automotive vehicles and trailer bodies. Illustrative Examples: Automotive body shops, Automotive body conversion services, Automotive upholstery shops, Automotive paint shops

- 811122 Automotive Glass Replacement Shops
Establishments primarily engaged in replacing, repairing, and/or tinting automotive vehicle glass, such as passenger car, truck, and van glass.
- 811191 Automotive Oil Change and Lubrication Shops
Establishments primarily engaged in changing motor oil and lubricating the chassis of automotive vehicles, such as passenger cars, trucks, and vans.
- 811198 All Other Automotive Repair and Maintenance
This U.S. industry comprises establishments primarily engaged in providing automotive repair and maintenance services (except mechanical and electrical repair and maintenance; body, paint, interior, and glass repair; motor oil change and lubrication; and car washing) for automotive vehicles, such as passenger cars, trucks, and vans, and all trailers. Illustrative Examples: Automotive air-conditioning repair shops, Automotive tire repair (except retreading) shops, Automotive rustproofing and undercoating shops.