NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

CAPSTONE APPLIED PROJECT REPORT

WARGAMING THE IMPACT OF EXTERNAL RISKS TO THE FUEL SUPPLY CHAIN

December 2023

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13. ABSTRACT (maximum 200 words)

Air Force Operational Energy (SAF/IEN), in partnership with Hacking for Defense (H4D), offered at the Naval Postgraduate School, is looking to address the challenges related to contested fuel logistics. The Air Force's current wargaming capability needs to be more agile to test at the scale needed to understand the impact of a fuel supply chain disruption. In order to explore this impact, the use of commercial off-the-shelf software will require training and education of both students and instructors on identifying alternate courses of action to mitigate the effects of degraded fuel logistics while improving the "lethality per gallon." This project will continue the efforts started in MN3307, Enterprise Innovation Design. The purpose of this project will be to simulate the impact of a fuel supply disruption along the colonial and plantation pipelines, which run from Petroleum Administration for Defense Districts (PADD) 3 to PADD 1, and from the buckeye pipeline, which moves fuel from PADD 2 to PADD 1. Using the software platform Resilinc will provide a real-time and realistic impact of externalities on fuel flow from the point of origin through multiple intermediate points and onto selected Air Force bases in PADD 1.

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WARGAMING THE IMPACT OF EXTERNAL RISKS TO THE FUEL SUPPLY CHAIN

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Submitted in partial fulfillment of the
requirements for the degree of

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WARGAMING THE IMPACT OF EXTERNAL RISKS TO THE FUEL SUPPLY CHAIN

ABSTRACT

Air Force Operational Energy (SAF/IEN), in partnership with Hacking for Defense (H4D), offered at the Naval Postgraduate School, is looking to address the challenges related to contested fuel logistics. The Air Force's current wargaming capability needs to be more agile to test at the scale needed to understand the impact of a fuel supply chain disruption. In order to explore this impact, the use of commercial off-the-shelf software will require training and education of both students and instructors on identifying alternate courses of action to mitigate the effects of degraded fuel logistics while improving the "lethality per gallon." This project will continue the efforts started in MN3307, Enterprise Innovation Design. The purpose of this project will be to simulate the impact of a fuel supply disruption along the colonial and plantation pipelines, which run from Petroleum Administration for Defense Districts (PADD) 3 to PADD 1, and from the buckeye pipeline, which moves fuel from PADD 2 to PADD 1. Using the software platform Resilinc will provide a real-time and realistic impact of externalities on fuel flow from the point of origin through multiple intermediate points and onto selected Air Force bases in PADD 1.

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LIST OF ACRONYMS AND ABBREVIATIONS

COTS   Commercial Off-the-Shelf

CRADA   Cooperative Research and Development Agreement

DLA   Defense Logistics Agency

DOD   Department of Defense

H4D   Hacking 4 Defense

JP-8   Jet Propellant–8

MMC   Mission Model Canvas

MVP   Minimum Viable Product

NPS   Naval Postgraduate School

PADD   Petroleum Administration Defense District

SAF/IEN   Air Force Operational Energy

USAF   United States Air Force

VPC   Value Proposition Canvas

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Lastly, I am immensely thankful to my family, especially my wife, Nicole, for her constant encouragement, understanding, and support during this demanding journey. Her unwavering belief in my abilities has inspired me, motivating me to push through challenges and strive for excellence.

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I. PROBLEM STATEMENT

Air Force Operational Energy (SAF/IEN), in partnership with the Hacking 4 Defense (H4D) Program offered at the Naval Postgraduate School (NPS), looked to address the challenges related to degraded fuel logistics. Current wargaming capability needs to be more agile to test at the scale necessary to understand the impact of a fuel supply chain disruption effectively. To explore this, SAF/IEN initiated a comprehensive search for a commercial-off-the-shelf (COTS) software solution. We envisioned this solution to train and educate students and provide realistic simulations that allow decision-makers to test and develop response strategies. Hadley (2022) found that the objective is to equip them with the skills necessary to counteract and mitigate the adverse effects of degraded fuel logistics while simultaneously improving "lethality per gallon."

MC2, the team leading the effort on this project, set out on a mission to either produce or develop COTS software capable of simulating the impact of degraded fuel logistics. This software would need to have a specific capability, which is the ability to simulate a fuel supply chain disruption at any point along the extensive network of pipelines stretching over 9,700 miles (Baron et al., 2021; Kinder Morgan, n.d.), which is the critical lifeline for transporting fuel from the Gulf Coast to the 12 Air Force Bases (AFBs) along the East Coast (Department of the Air Force, n.d.). More specifically, the COTS software was required to have a high level of complexity. Per Poland (2020), it will be used to model and replicate the potential consequences of degraded fuel logistics at 120 disruption points between the refineries in the Midwest and the Air Force bases along the East Coast.

The software functionality would have to extend beyond theoretical simulations. It needs to integrate simulated disruptions and real-world events, allowing users to study and understand the impact and how to react to an actual supply chain disruption effectively. This software will focus on simulating a fuel supply disruption on the Colonial and Plantation Pipelines, which cover approximately 5,500 and 3,100 miles, respectively (Baron et al., 2021; Kinder Morgan, n.d.). Their pathway connects the Gulf Coast refineries

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in Petroleum Administration for Defense Districts (PADD) 1 to the 12 AFBs on the East Coast in PADD 1 (Department of the Air Force, n.d.).

Furthermore, this software will also incorporate the Buckeye Pipeline into the simulation. This pipeline extends roughly 1,100 miles from the Midwest in PADD 2 to the Northeast in PADD 1 (Magellan Midstream Partners, 2023). The software will provide valuable information about vulnerabilities, training opportunities, and educational opportunities for students and decision-makers by simulating a supply chain disruption along these pipelines..

II. HACKING 4 DEFENSE EXPERIENCE

MC2's journey through the H4D process of developing the simulation and wargame encompassed 12 steps, as shown in Figure 1. H4D teaches a Build-Measure-Learn loop method for prototype innovation and learning. We break down each step into further detail in the following sections.

Adapted from Ries (2011, p. 81)

Figure 1.   H4D Experience

A.   STEP 1: PROBLEM IDENTIFICATION

The foundation for the entire H4D process began with SAF/IEN identifying that the Air Force lacked the capability to wargame the impact of external risks on the fuel supply chain. On May 7, 2021, the Colonial Pipeline, which carries gasoline and jet fuel mainly to states along the East Coast of the U.S., was the target of a ransomware attack that caused operations to be shut down for six days, resulting in fuel shortages impacting mission readiness at 12 AFBs (Department of the Air Force, n.d.). In response to this event, SAF/IEN received the task of developing a wargame to simulate a fuel supply chain disruption on oil pipelines anywhere in the United States. Due to the limited Department of Defense (DOD) software capabilities, SAF/IEN could not create a wargame on the scale necessary to simulate an event like the Colonial Pipeline incident. Therefore, the organization reached out to NPS to explore the options of using COTS software to develop a wargame to educate students on fuel supply chain logistics while also providing realistic, accurate, and relevant information to decision-makers..

B.   STEP 2: TEAM FORMATION

Sponsors across the DOD presented problem statements and contact lists to the NPS innovation capstone course. The course enrolled students who submitted their skill preferences and then assigned them to teams that best matched the needs of the sponsors. The members of MC^2 were assigned to assist SAF/IEN in addressing the problem identified in Step 1. The team consisted of two Air Force personnel with experience in contracting and one Navy personnel with a background in logistics. A diverse team brings together individuals with different perspectives, experiences, and areas of expertise, allowing for the identification of potential blind spots in simulation development and leading to a more well-rounded understanding of the sponsor's problem statement, which then leads to the development of a more accurate and tailored wargame.

C.   STEP 3: CUSTOMER DISCOVERY

MC^2 engaged in lengthy interviews with SAF/IEN members based on the contact list provided in Step 2 to better understand the problem statement, the issues to address, and what software would be an effective solution..

After several interviews, MC^2 was able to gain insight into:

- The SAF/IEN requirement
- Scope of the fuel logistics network
- Required capabilities of COTS software
- Requirement that COTS software be used for training and real-world decision making.

D. STEP 4: ITERATE AND PIVOT

The team found Iterate and Pivot valuable for the following reasons:

- Learning mindset and adaption
- Feedback and validation

Iterate and pivot are two key strategies the team uses to adapt and improve the simulation in response to customer feedback. Iteration fostered a learning mindset and allowed the team to adapt quickly to sponsor feedback. Iterating led to increased learning from stakeholders' insights, development process mistakes, and alternate pathways for developing a viable product. Quickly, the team uncovered what did and did not work, facilitating informed and calculated adjustments while pivoting from one Minimum Viable Product (MVP) to the next. Iteration also gave the team time to gather feedback and incorporate it into each subsequent iteration. Benefiting from the team's ability to gather feedback and incorporate changes allows for the quick validation of assumptions, resulting in the team assembling a product that evolved from a simple drawing to a functional wargame in Resilinc's logistics software. As a result, MC2 presented SAF/IEN with several iterations (versions) of COTS software to elicit feedback, used to make course corrections (pivots) required for the team to make incremental improvements, resulting in three changes to the problem statement and the creation of five minimum viable products (MVPs) in only ten weeks.

E. STEP 5: PROBLEM STATEMENT REFINEMENT

MC^2 refined the problem statement thrice based on the responses from interviews conducted during Step 3. Figure 2 shows the evolution of the problem statement.
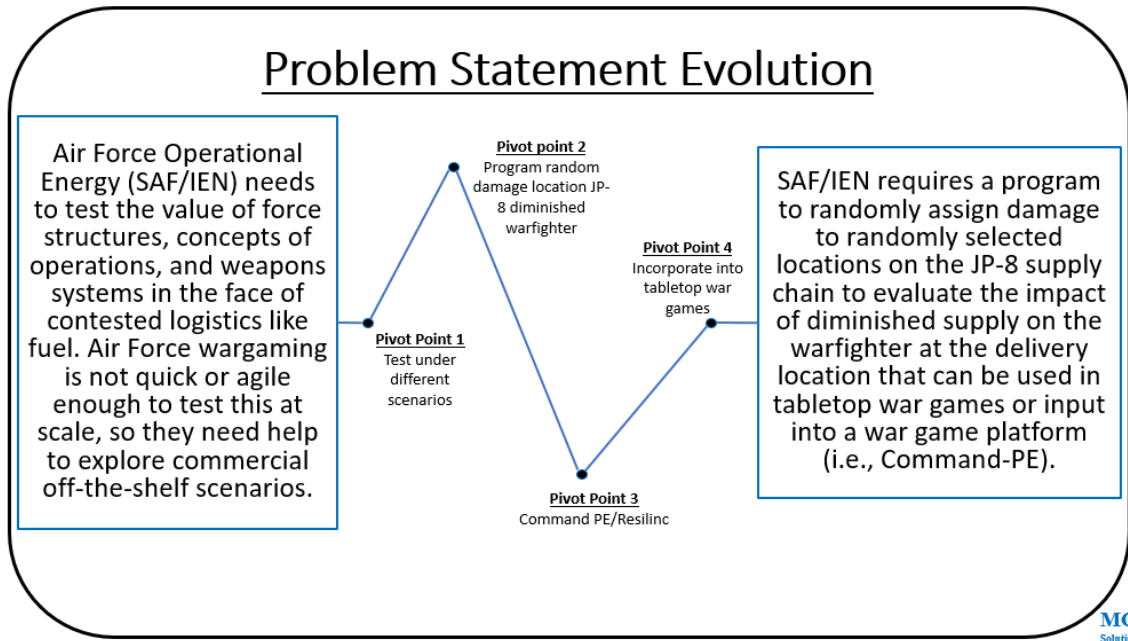
Figure 2.   Problem Statement Evolution

The initial problem statement had been that SAF/IEN needed to test the value of force structures, concepts of operations, and weapons systems in the face of contested logistics for fuel. Current Air Force wargaming platforms had not been quick or agile enough to test a realistic supply gain at a scale the size of the United States, so they decided to explore other options such as COTS.

Pivot Point 1

Initially, when MC^2 developed the first version of the simulation, the team utilized Microsoft Excel to focus on one type of supply chain disruption event. Figure 25 depicts the sinking of a fuel supply ship, as examined in the study. MVP Iteration 1. This scenario was the starting point, which would serve as proof of concept and a baseline for showing

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off the capabilities of the simulation. MC2 was able to demonstrate the core functionality of the software. However, it lacked weather conditions, navigation, kinetic attacks, and other relevant issues that would have caused the ship to sink and disrupt the fuel supply chain.

The project sponsor approved of the software's progress but expressed a desire to expand the scope of the simulation to include not just ships but also physical locations such as fuel refineries and storage depots while incorporating other types of events, such as cyber-attacks, explosions, and chemical spills. As a result, the team created a simulation that showed these events at refineries in Houston, Texas, and Atlanta, Georgia, along the Colonial and Buckeye Pipelines.

Pivot Point 2

The team emphasized maintaining variability and realism while creating different scenarios for fuel supply chain disruptions. While the team demonstrated the simulation's versatility by incorporating several supply chain disruption events, the numerical values used to calculate the damage were static, which meant that the damage output would be constant, lacking the dynamic nature of an actual world event. The team created a system allowing users to introduce variability into any simulation to address this limitation.

As a result, the team incorporated several vital updates.

The first was the incorporation of logical expressions to calculate damage. These created a customizable simulation with logical rules and conditions to determine the impact of a supply chain disruption. The next update incorporated randomizing values. The simulation was modified so that the user could incorporate values that were either static, randomized, or both when applying damage to pathways and nodes.

The final update consisted of a user interface design overhaul. To facilitate the incorporation of these new capabilities with a user-friendly experience, the team would centralize the location of all input values, as seen in Figure 43: User Interface with Randomized Conditions. The user needed help to swap seamlessly between randomized and static inputs.

Pivot Point 3

Until this point in development, the team had focused on simulating a fuel supply chain disruption using Microsoft Excel. However, as the project scope began to increase, it became apparent that Microsoft Excel was inadequate when scaling up the simulation to accurately reflect the intricacies of a complex fuel supply chain disruption, which meant that MC^2 would now have to look for more robust software that specialized in supply chain management. In response, the team began looking for alternative options, such as command P.E. and Resilinc.

Initially, the team considered Command PE the software of choice, as the DOD already utilized it in various simulations. Therefore, the team assumed that it would be the platform of choice. However, after several interviews with the project sponsor, it was determined that the software did not provide the level of detail needed to make an informed decision in the face of a fuel supply chain disruption.

As for Resilinc, after careful evaluation of the program and feedback from project sponsors, it was determined that the platform contained the capabilities necessary to simulate a complex fuel supply chain disruption. Those features included advanced modeling and analytical tools, real-time data integration, and providing detailed insights into supply chain vulnerabilities and recovery strategies.

Pivot Point 4

Once MC2 had determined that Resilinc would be the best option for simulating a fuel supply chain disruption, the next step was to develop a wargame scenario that could show the platform's reliability and realism. Hence, the team constructed a scenario in Chapter IV Wargame to simulate a cyberattack, explosion, and chemical spill.

Eventually, the team finalized the following statement with the sponsor: "SAF/IEN had required a program to randomly assign damage to randomly selected locations on the Jet Propellant (J.P.)-8 supply chain to evaluate the impact of diminished supply on the warfighter at the delivery location. This program could be used in tabletop war games or input into a war game platform."

F.   STEP 6: SOLUTION IDEATION

MC[2] brainstormed a range of COTS solutions to address the defined problem, which are found in Table 1.

Table 1.   Commercial Platforms Considered

Program	Pros	Cons
Anylogic[1]	Interactive simulation of Fuel Flow within the US	Program owned and operated by a company that resides in an adversarial state.
Crystal Ball[2]	A powerful tool able to run 1000 simulations	Not user-friendly and little customer support for errors
Microsoft Excel	Used to create MVP for H4D, simple, easy to use, and user-familiar with the software, little cost	Difficult to modify (add and remove nodes and shipping lanes); since this is developed internally, there would be no continued customer support
Resilinc Event Watch	Uses GIS Mapping, Maps Tier 1,2,3, Real time updates, and large customer support.	Can only be used per the Cooperative Research and Development Agreement (CRADA)

[1] Any Logic (n.d.)

[2] Oracle (n.d.)

[3] Resilinc (n.d.)

With the potential COTS software identified, the team built the attribute matrix seen in Table 2. MC2 used this framework to evaluate and compare each platform's strengths and weaknesses systematically and objectively. Furthermore, the team benefited from this approach, including but not limited to structure comparison, objective evaluation, transparency, informed decision-making, and a holistic view.

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Table 2.   Commercial Software Comparison

Factor	Anylogic	Crystal Ball	Excel	Resilinc
Accurate	X			X
Scalability		X		X
Flexibility	X	X	X	X
Familiarity	X		X	X
Integration		X	X	X
User Friendly			X	X
Support				X

Adapted from Pugh (1981, p. 497)

G.   STEP 7: VALUE PROPOSITION CANVAS

Using the Value Proposition Canvas (VPC), MC2 aligned its solution development process more effectively with the sponsor's needs, as seen in Figures 3, 4, and 5. This alignment facilitated crucial sponsor concerns, the development of a consumer-focused solution, and the refinement of the product through feedback and validation.

Interviews with the members of SAF/IEN were a crucial step in the project's development. These were tools to gain insights and a deeper understanding of the project's intent and purpose. These shed greater insight into clarifying the project's scope, alignment with SAF/IEN goals, integration of SME feedback, and identification of use cases.

The senior analyst, the project sponsor, has extensive experience and expertise in fuel supply chain logistics. This individual offers a strategic perspective that helps align the simulation with the SAF/IEN goals and objectives and ensures that the project addresses the most critical issues. Furthermore, the individual provided information about

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the vulnerabilities, risks, and challenges the simulation should consider when building a robust simulation. Finally, they recommended data sources such as EIA.gov, which is crucial when designing a simulation that relies on accurate and relevant data.
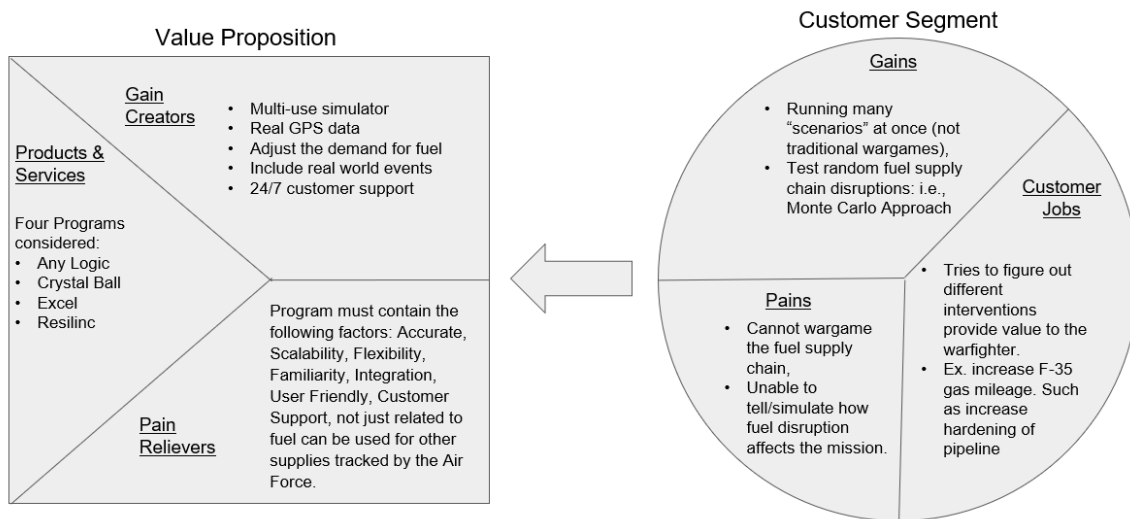
Figure 3.   Value Proposition, Senior Analyst. Adapted from Osterwalder et al. (2015, pp. 8–9)

The Chief of Logistics and Sustainment maintains the operational role of SAF/IEN. Interviewing this individual provided MC^2 with valuable insights into the day-to-day challenges and requirements of managing a fuel supply chain. Furthermore, this individual oversees resource allocation, which is essential for any simulation as it helps the team design a simulation that reflects real-world constraints. Also, they provide guidance on performance metrics and logistic strategies and tactics, which helps the team develop a game plan for building a wargame and how current efforts within SAF/IEN can benefit from using the simulation.

Chief of Logistics and Sustainment
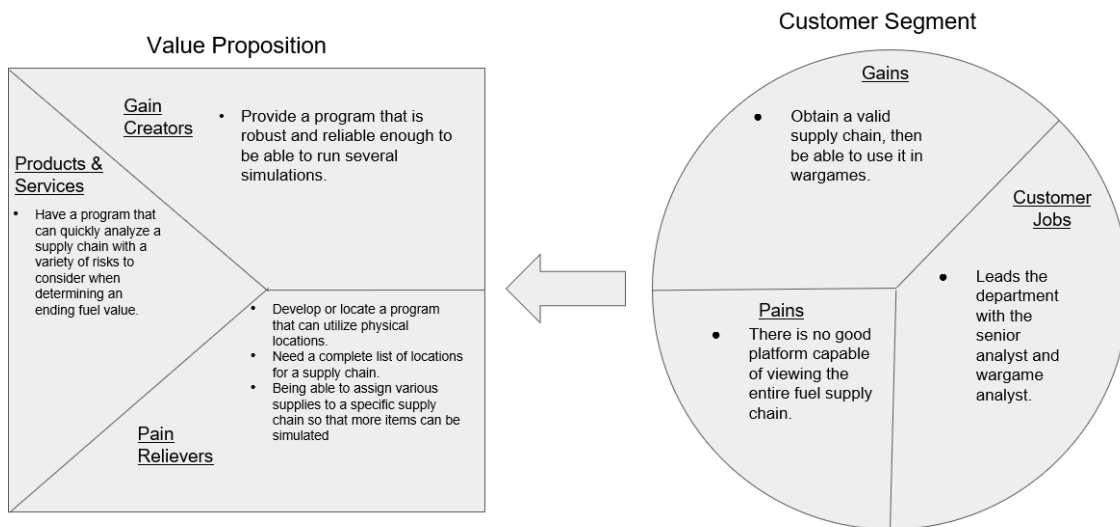
Figure 4.   Value Proposition, Chief of Logistics and Sustainment. Adapted from Osterwalder et al. (2015, pp. 8–9)

The wargame analyst specializes in designing and reunifying scenarios that simulate real-world events, such as supply chain disruptions while balancing strategy and decision-making. Interviews with this individual also provided insight into decision-making processes, adversarial thinking, and conflict resolution. Having input on decision-making processes under uncertainty can help improve the decision-making aspects of the simulation developed for this project. As for adversarial thinking, since the simulation's focus was to simulate a cyberattack from a foreign nation or entity, having information on competitive elements was highly relevant to the project's development. In the final stage, conflict resolution, the focus lies on evaluating the outcomes of different strategies. It demands expertise in designing a simulation that accurately mirrors the consequences of decisions made..

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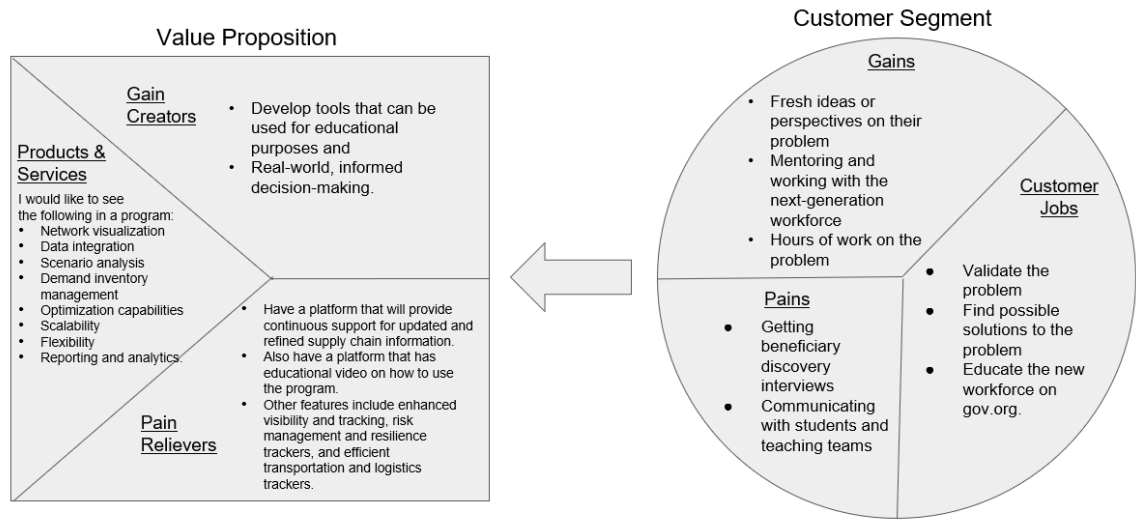
Wargaming Analyst

Figure 5.   Value Proposition, Wargaming Analyst. Adapted from
Osterwalder et al. (2015, pp. 8–9)

1.   Value Proposition

Figure 6 breaks down how MC^2 used each section of the Value Proposition of the MMC to develop a wargame and simulation.
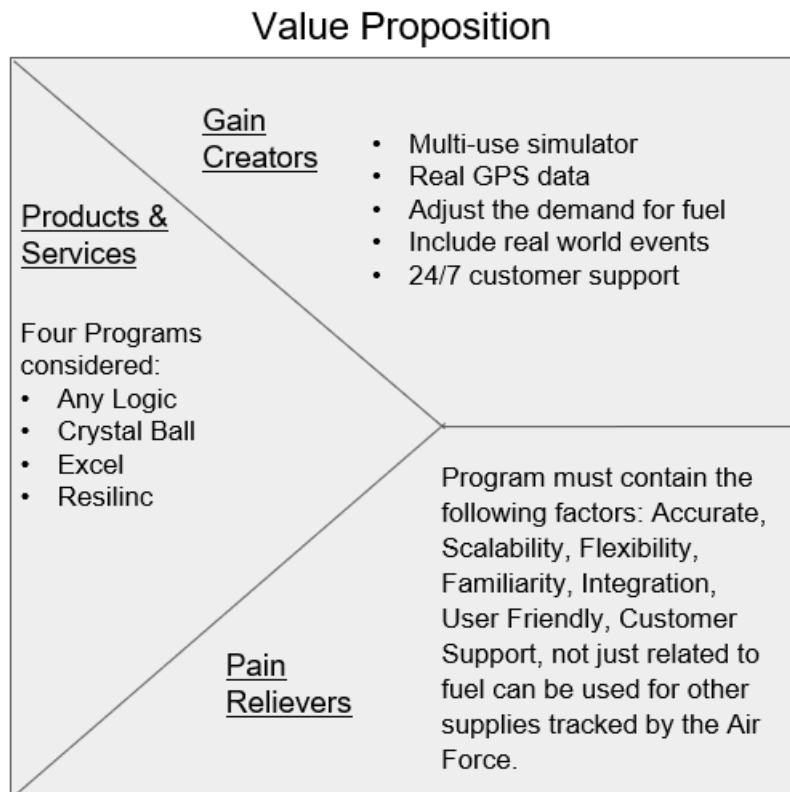
Value Proposition

Figure 6.   Value Proposition. Adapted from Osterwalder et al., (2015, p. 8-9)

The canvas's left side enabled the team to identify gain creators and pain relievers for each stakeholder. Initially, the team had four options for COTS solutions: Any Logic, Crystal Ball, Excel, and Resilinc. After considering the options, the team determined that Resilinc's platform was the best choice for delivering gain creators and pain relievers.

When it came to gaining creator, Resilinc's platform is a highly versatile, scalable, and customizable multi-use platform capable of simulating a wide range of scenarios and real-world events necessary for developing a fuel supply chain wargame. By incorporating GPS data and coordinates into the simulation, Resilinc could accurately model the flow of fuel from the refineries to 12 AFBs along the East Coast (Department of the Air Force, n.d.). As for the pain reliever, it possessed the following key attributes: accuracy, scalability, flexibility, familiarity, integration, user-friendliness, and customer support. First, accuracy was addressed by the platform, as it was able to utilize geocoordinates and

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real-time activity to simulate fuel supply chain distributions, providing precise and reliable data to support the decision-making process. It had scalability, as there were no limitations on the number of nodes and paths that could be incorporated into the platform, allowing users to expand their simulations over time.

Furthermore, the flexibility allowed SAF and EIN to tailor the event scenarios to their training and decision-making needs, ensuring the platform aligned seamlessly with their goals and objectives. Familiarity was also essential; Resilinc utilizes Microsoft Excel to upload data to its platform. Any user familiar with Excel will find it easy to navigate and upload data to the platform, minimizing the learning curve and maximizing productivity and scenario outcomes, which aligns with the platform's integration capabilities and user-friendly appearance. The web-based platform did not need installation on any computer (a workaround to avoid going through the communication squadron for approval), enabling its utilization on any network. Further, Resilinc's use of Excel, a program available on all Air Force networked computers, meant that anyone with knowledge of this office product could build a realistic simulation. Finally, robust customer support was vital to maintaining the gain creators and pain relievers through timely and responsive assistance from technical experts and support staff to resolve issues promptly and ensure maximum program effectiveness.

2. Customer Segment

Figure 7 breaks down how MC2 used each section of the customer segment of the MMC to develop a wargame and simulation.
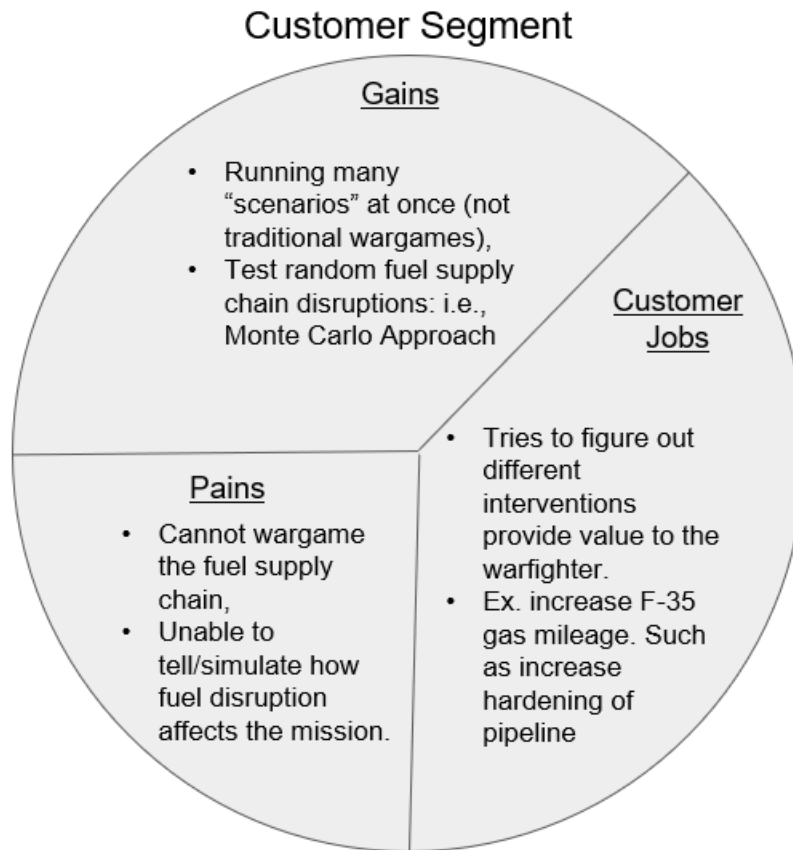
Figure 7. Customer Segment Adapted from Osterwalder et al., (2015, p. 8-9)

The right side of the canvas focused on developing an understanding of the sponsor's role in the organization (customer jobs), pains (challenges, frustrations, and problems), and gains (desired outcomes, benefits, and goals they sought). The sponsor for this project, who held the position of Senior Analyst within SAF/IEN, was focused on understanding the impact of degraded fuel logistics on the production of JP-8 fuel. The goal was to identify or anticipate these disruptions, enabling the taking of actions to both fortify pipelines and develop alternative or backup options in case the JP-8 fuel supply chain collapsed.

For pains, the main concern was that the A.F. needed more software capable of utilizing real-world and simulated events necessary to educate students and inform decision-makers. For gains, the sponsor was looking for a tool that could be updated in

real-time to improve the decision-making process and serve as a foundation for teaching both leaders and students about the supply chain logistics for JP-8 fuel. Resilinc achieves those within a single platform using multi-tier mapping, manual and automatic generation of scenarios (such as kinetic attacks or cyber-attacks), the utilization of real-world locations, and weighted risk.

H.   STEP 8: MINIMUM VIABLE PRODUCT

While developing the tool for the fuel supply chain wargame, MC^2 iterated for several reasons, including receiving early validation, enhancing learning, responding to feedback, iterative development and improvement, risk mitigation, and resource optimization (time). As a result, the team produced five minimum viable products (MVPs).

MVP 1, a fast and inexpensive sketch, allowed the team to explore multiple ideas and concepts without committing significant time and resources. In the early stages of iterative development, validating ideas and concepts took priority over detailed deliverables. As the sketch is not finalized, it can be easily modified during meetings, which is crucial for both parties to develop a mutual understanding of the deliverables. After receiving approval for the sketch, MC2 started developing a program to run the fuel supply chain wargame. Therefore, MVP 2 marked the team's initial attempt to utilize COTS software (Microsoft Excel) to build a supply chain network. Employing logical equations with randomization, users could enter a starting fuel value into the network, producing a realistic ending fuel value. To enhance the realism of the software, we added multiple pathways and incorporated randomization of damage, risk, pathway conditions, and nodes.

After MVP 2 was reviewed and approved, the team quickly began development of MVP 3. During this MVP, the MC2's primary focus was to create macros that would execute simulations, record the data, and then repeat the process a predetermined number of times by the user. Three buttons, labeled Run 1, Run 10, and Run 100, were given to the user, each representing the number of times the process would repeat. After approval of the simulation and that macro functionality, the sponsor requested more control over the risk and damage factors applied to all nodes and pathways for MVP 4. The initial step

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involved crafting a new user interface, allowing users to toggle between randomizing and manually selecting those factors. To accommodate this, we replaced all numbers with cell references connected to the user interface. To illustrate this, when the user selected "no random" from the user interface, the equation values were directed to the designated risk and damage columns.

With MVP 4 completed and approved, the team removed unneeded features, corrected formatting issues, centralized the action buttons, and improved the network visuals. The Run 1, Run 10, and Run 100 buttons were removed and replaced with Run 0–250, Run 251–500, Run 501–750, and Run 751–1000 buttons, alongside the creation of a clear table content button, which led to the development of MVP 5.

With the completion of MVP 5, MC2 sought out feedback from the sponsor. After a lengthy discussion on this project's future, Microsoft Excel needed to be more robust to simulate the fuel supply disruptions to the level of accuracy required for the requirement. As a result, the team would switch to Resilinc to develop MVP 6. A step-by-step guide can be found in attachment two on how the simulation was built in Resilinc's platform, while attachment 3 is a step-by-step guide on how to input the data to run the simulation.

I.   STEP 9: ITERATION DEVELOPMENT

The team completed five iterations of the fuel supply chain network. See Appendix A for the complete iteration development.

J.   STEP 10: MISSION MODEL CANVAS

1.   MMC Evolution

Since the MMC is a living document, several changes to its nine parts were made during the development as the team learned more about beneficiaries, value proposition, cost, and objectives.

a.   *Version 1*

Figure 8 displays the initial version of the MMC developed by MC2.

The Mission Model Canvas

Key Partners	Key Activities	Value Propositions	Buy-in & Support	Beneficiaries
- Jordan Eccles; Senior Analyst, SAF/IEN - Matthew "Ziggy" Sigstad; Chief, Logistics and Sustainment, SAF/IEN - Dominick Wright; Wargaming Analyst, SAF/IEN - Toniann Fisher; OSD Energy - DLA	- Problem refinement - Possibly connecting supply chain models to current or proposed War gaming platforms	- Enhancing the ability to test out specific scenarios and the effect on fuel supply	- DLA (controls fuel supplies)	- War fighter (pilots) / support techs

Mission/Problem Description: Designed by: Date: Version:

Key Resources
- Explore capabilities of both SCRAM and Command-PE
-

Deployment

Mission Budget/Cost
- the salaries of our three member team!

Mission Achievement/Impact Factors

DESIGNED BY: Strategyzer AG & Steve Blank

Strategyzer
strategyzer.com

Figure 8.   Mission Model Canvas: Version 1. Adapted from Osterwalder and Blank (n.d.).

b.   Version 2

Figure 9 illustrates the second version of the MMC developed by MC2.

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The Mission Model Canvas

Key Partners
- Supply Chain Mapping Ktrs
- MIT Center for Transportation & Logistics
- Oil companies

Key Activities
- Problem refinement
- Possibly connecting supply chain models to current or proposed War gaming platforms
- Software expertise
- Funding

Key Resources
- Data on fuel supply chain (additives)
- SME's on process of creating JP-8
- SME's on data behind the fuel supply chain
-

Value Propositions
- Enhancing the ability to test out specific scenarios and the effect on fuel supply

Buy-in & Support
- DLA (controls fuel supplies)
- SAF/IEN
- Industry
- Comm (network access)

Deployment
- Map one lane of supply
- Mapping entire fuel network
- Acquisition process
- Create fuel war game

Beneficiaries
- Dpty Secretary Guerrero
- Sr. Analyst (currently Dr. Eccles)
- Chief, Logistics and Sustainment, SAF/IEN
- War gaming Analyst, SAF/IEN
- War fighter (pilots) / support techs
- Defense Logistics Agency
- Base commanders

Mission Budget/Cost
- DoD, no funding currently needed

Mission Achievement/Impact Factors
- Uninterrupted fuel supply to the war fighter
- Instantaneous feedback on fuel supply chain disruptions
-

Figure 9.   Mission Model Canvas: Version 2. Adapted from Osterwalder and Blank (n.d.).

c.   Version 3

Figure 10 presents the third version of the MMC developed by MC2.

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Figure 10.   Mission Model Canvas: Version 3. Adapted from Osterwalder and Blank (n.d.).

d.   Version 4

Figure 11 showcases the fourth version of the MMC developed by MC2.
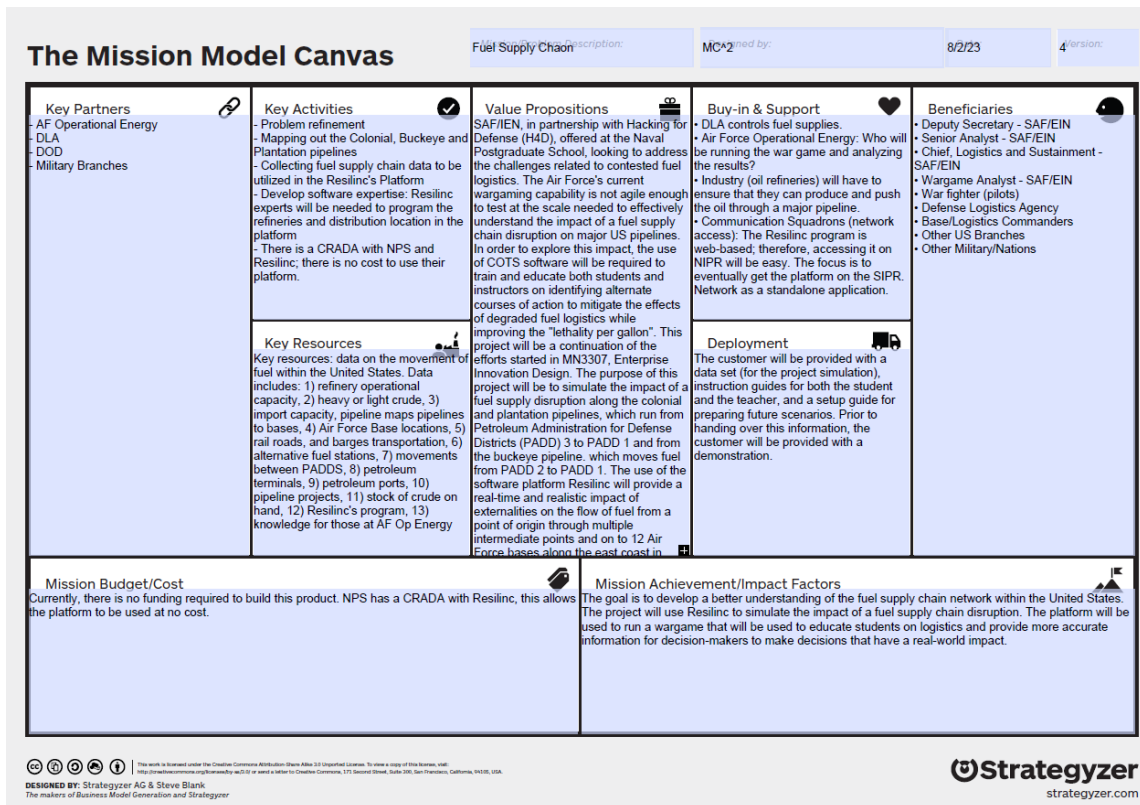
Figure 11. Mission Model Canvas: Version 4. Adapted from Osterwalder and Blank (n.d.).

2. Part 1: Key Partners

MC2 utilized the key partners section of the MMC to determine the organizations that were essential to this project's immediate and long-term success. Resilinc, through a Cooperative Research and Development Agreement (CRADA) with the NPS, provided their logistics software. In contrast, members at SAF/IEN provided expertise on how the platform could support a fuel supply chain wargame. Other potential key partners include DLA, DOD, and U.S. military branches.

- AF Operational Energy
- DLA
- DOD
- military branches

3. Part 2: Key Activities

Key activities listed on the MMC represented the core actions necessary for an MC2 to fulfill its mission and create value for all stakeholders. Identifying and defining these key activities resulted in a more transparent comprehension of the specific actions needed to create a product that would add value to SAF/IEN. This understanding facilitated effective resource management, strategic planning, and expert communication. Such efforts ensured a well-informed approach toward creating a value-added product.

- Problem refinement
- Mapping out the Colonial, Buckeye, and Plantation Pipelines
- Collecting fuel supply chain data to be utilized in the Resilinc's Platform
- Develop software expertise: Resilinc experts will be needed to program the refineries and distribution location in the platform.
- There is a CRADA with NPS and Resilinc; there is no cost to use their platform.

4. Part 3: Key Resources

The key resources section represented the essential assets and capabilities required for the team to deliver value to SAF/IEN and its mission. Resources encompassed a wide range of both tangible and intangible assets. In this project, resources (see below) included data on the United States fuel supply chain network (#1–12), access to Resilinc's program (#13), and subject matter experts (#14). By allocating and managing these resources, the team optimizes its operations, minimizes risk, and capitalizes on opportunities. The project's success relied heavily on the data acquired from EIA.gov, Resilinc's supply chain mapping, and the expertise of SAF/IEN members to validate the simulation produced within the program to be used for wargaming.

Key resources: data on the movement of fuel within the United States. Data includes:

1. refinery operational capacity
2. heavy or light crude

3.   import capacity, pipeline maps

4.   pipelines to bases

5.   Air Force base locations

6.   railroads, and barges transportation

7.   alternative fuel stations

8.   movements between PADDS

9.   petroleum terminals

10.   petroleum ports

11.   pipeline projects

12.   the stock levels of crude on hand

13.   Resilinc's program

14.   Air Force Operational Energy Subject Matter Expert Knowledge

5.   Part 4: Value Proposition

The value proposition section focused on helping the team define and communicate the value, benefits, features, and differentiators that each product (software) the team was considering using to build a supply chain simulator would offer to SAF/IEN. Furthermore, this section was necessary for the team to maintain a consumer-centric focus, justify each product's value, and assist in deciding where to utilize resources.

SAF/IEN, in partnership with Hacking for Defense (H4D), offered at the NPS, is looking to address the challenges related to contested fuel logistics. The Air Force's current wargaming capability is not agile enough to test at the scale needed to effectively understand the impact of a fuel supply chain disruption on major U.S. pipelines. To explore this impact, we will require COTS software to train and educate students and instructors on identifying alternate courses of action to mitigate the effects of degraded fuel logistics while improving the "lethality per gallon." This project will be a continuation of the efforts started in MN3307, Enterprise Innovation Design. The purpose of this project will be to

simulate the impact of a fuel supply disruption along the Colonial and Plantation Pipelines, which run from Petroleum Administration for Defense Districts (PADD) 3 to PADD 1, and from the Buckeye Pipeline, which moves fuel from PADD 2 to PADD 1. The use of the software platform Resilinc will provide a real-time and realistic impact of externalities on the flow of fuel from a point of origin through multiple intermediate points and onto 12 Air Force bases along the east coast in PADD 1 (Department of the Air Force, n.d.). Further value can be found by preparing students for real-world scenarios, such as the Colonial Pipeline attack, and developing methods to mitigate the damages related to the shutdown of both pipelines and refineries.

6. Part 5: Buy-in and Support

The buy-in and support section of the MMC was necessary because it allowed the team to identify and engage the stakeholders who had a critical role in the development of a fuel supply chain wargaming for SAF/IEN. Furthermore, this section was necessary for stakeholder engagement, risk mitigation, and long-term sustainability.

When it came to stakeholder engagement, identifying the needs and expectations of these individuals helped the team develop strategies to engage them effectively. For example, working with the SAF/IEN Senior Analyst and building a solid relationship through continuous communication and visible progress increased the likelihood that his organization would be willing to support the outcome of this project. With risk mitigation, having the buy-in of members of SAF/IEN helped mitigate the potential risk and resilience related to adopting or utilizing our solution. Finally, long-term sustainability was essential to ensuring this program remained relevant to the organization's mission. Building a relationship between Resilinc and SAF/IEN ensured the company would provide ongoing support and collaboration for developing a more detailed supply chain management program. Lines of support include:

- DLA controlling fuel supplies.
- Air Force Operational Energy: Who will run the war game and analyze the results?

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- Industry (oil refineries) ensuring they can produce and push the oil through a significant pipeline.
- Communication Squadrons (network access): The Resilinc platform is web-based; therefore, accessing it on NIPR will be easy. The focus is to eventually get the platform on the SIPR—network as a standalone application.

7.   Part 6: Deployment

The deployment section of the MMC focused on delivering a product to the customer and ensuring its successful implementation. The team addressed operational considerations when converting the value proposition into reality. Furthermore, this section was necessary for feedback and iteration, execution planning, and customer experience.

The customer will receive a data set (for the project simulation), instruction guides for the student and the teacher, and a setup guide for preparing future scenarios. The customer will receive a demonstration before receiving this information.

8.   Part 7: Beneficiaries

The MMC beneficiaries section focused on the primary beneficiaries the team aimed to create value for with the deliverable. Identifying individuals and organizations helped to identify and understand the target audience and maintain focus on the primary purpose of locating fuel supply chain software. This understanding aided in designing meaningful solutions, measuring impact, and communicating effectively with stakeholders. Identifying these factors increases the capstone's chance of success.

Beneficiaries include:

- Deputy Secretary—SAF/IEN
- Senior Analyst—SAF/IEN
- Chief, Logistics and Sustainment—SAF/IEN
- Wargame Analyst—SAF/IEN
- War fighter (pilots)

- Defense Logistics Agency
- Base/Logistics Commanders
- Other U.S. Branches
- Other Military/Nations

9. Part 8: Mission Budget/Cost

Currently, no funding is required for the initial development of this simulation, and furthermore, no additional financial resources are required beyond what is agreed to in the CRADA between NPS and Resilinc.

The key points are as follows:

- No funding is required for initial development. This means the resources necessary have been acquired through the existing CRADA to cover the cost associated with the development of the simulation.
- CRADA with Resilinc is a legally binding agreement between NPS and Resilinc. Such an agreement involves collaboration on research and development efforts, which in this case involves the development of a fuel supply chain network. In this context, the CRADA grants NPS students access to the Resilinc Platform without incurring licensing fees or software costs.
- There is no cost for building the simulation. Due to the CRADA, NPS can utilize Resilinc's platform to build a simulation at no direct cost. This single step reduced the overall cost burden, so the team could use their existing time and resources to focus on designing the simulation.
- The mission and budget/cost section provided the team with a detailed understanding of the financial aspect of the mission. This section focused on understanding the costs of the Air Force Operational Energy's Mission. It helped the team forecast resource allocation, realistic planning and risk assessment, and evaluation of success.

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10. **Part 9: Mission Achievement/Impact Factors**

Part 9: Mission Achievement/Impact Factors

The goal is to understand better the fuel supply chain network within the United States. The project will use Resilinc to simulate the impact of a fuel supply chain disruption. The platform will run a wargame to educate students on logistics and give decision-makers more accurate information to make decisions with a tangible real-world impact. Upon finalizing the MMC, the team determined that Excel was not a credible solution for developing a fuel supply simulation. As a result, the team pivoted toward utilizing Resilinc as an effective alternative for simulating a fuel supply chain disruption. The factors presented in Table 2 influence this choice.

K. STEP 11: VALIDATION AND TESTING

After each iteration of the MVP, MC^2 showcased the product to the sponsor. After each meeting, the team utilized key takeaways to develop the next iteration of the tool. Key takeaways can be found in the section labeled minimum viable product.

L. STEP 12: FINAL PRESENTATION

At the end of the capstone course, the team presented their findings to the sponsor, which summarized the team's effort and highlighted the potential benefits and limitations of their solution.

M. WRAP-UP

As MC2 progressed through the 12 steps of the H4D experience, the team amassed a wealth of data throughout the development process. Each stage served as an opportunity to gather valuable data, leading to essential insights and metrics about the fuel flow through the pipelines within the United States. The following section will provide a list of the publicly available websites the teams utilized to gather data, which was instrumental in shaping the project's direction.

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III. DATA

This project began by collecting qualitative data through interviews to gain insight into the complexity of a fuel supply chain disruption. MVPs are key in validating the product's performance and ensuring it aligns with the project sponsor's requirements. However, those MVPs did not provide all the required knowledge, as additional quantitative data was necessary to model a fuel supply chain accurately. This data contains information essential to the development of a holistic simulation.

Table 3 lists the websites used to collect data for this project.

Table 3. Websites for Data Collection

Title	Data Element	URL
US Energy Information Administration	Provide numerical data on fuel consumption per PADD.	https://www.eia.gov/petroleum/gasdiesel/
EIA Atlas Mapping	This interactive map contains information on all oil pipelines in the United States.	https://atlas.eia.gov/pages/cebf469e9fc149eea7e3ff77c311b1db
National Pipeline Mapping System	Used to map out the paths of the Colonial, Plantation, and Buckeye Pipelines.	https://pvnpms.phmsa.dot.gov/PublicViewer/
Location of Air Force Bases	Contains the addresses of Air Force bases along the East Coast.	https://media.defense.gov/2007/Apr/17/2000790881/-1/-1/0/070417-F-ZZ000-536.JPG
Refinery and Pipeline Mapping	An interactive map containing information on each pipeline and their respective refineries.	https://ft.maps.arcgis.com/apps/webappviewer/index.html?appid=0cdff7e116c0425fa55d1226e9204477
Map of Colonial Pipeline	Used to map out the various refineries, storage depots, and delivery points along the Colonial Pipeline.	https://colpipe.s3-us-west-1.amazonaws.com/media/Pages/News-Media/Colonial-Overview.pdf?mtime=20190605111537&focal=nonehttps://tankterminals.com/?gclid=EAIaIQobChMIt8uPxIfk_QIVow2tBh1pHwMeEAMYASAAEgKWUfD_BwE

Title	Data Element	URL
Map of the Plantation Pipeline	Used to map out the various refineries, storage depots, and delivery points along the Plantation Pipeline.	https://www.kindermorgan.com/Operations/Asset-Maphttps://colpipe.s3-us-west-1.amazonaws.com/media/Pages/News-Media/Colonial-Overview.pdf?mtime=20190605111537&focal=none
Map of the Buckeye Pipeline	Used to map out the various refineries, storage depots, and delivery points along the Buckeye Pipeline.	https://www.buckeye.com/what-we-do/asset-map/ https://www.kindermorgan.com/Operations/Asset-Map

The following data was pulled from EIA.gov:

- Total crude oil and petro by product type

- Total crude oil and petroleum products supply and disposition data

- County of origin—pad 1—crude oil—monthly 1000 barrels per day template

- County of origin—pad 1—crude oil—monthly 1000 barrels per day

- County of origin—pad 2—crude oil—monthly 1000 barrels per day

- County of origin—pad 3—crude oil—monthly 1000 barrels per day

- County of origin—pad 4—crude oil—monthly 1000 barrels per day

- County of origin—pad 5—crude oil—monthly 1000 barrels per day

- County of origin for import of oil types—pad 1

- County of origin for import of oil types—pad 2

- County of origin for import of oil types—pad 3

- County of origin for import of oil types—pad 4—5

- County of origin for import of oil types

- Refinery capacity data by individual refinery

- Number and capacity of operational petro refineries—pads

- Fuel consumed at refineries—type

- Refinery receipts of crude oil by method of transportation pads

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- Total movement between pads

- Capacity of operable petroleum refineries

- Crude oil production by pad-state

MC2 spent a significant amount of time collecting qualitative and quantitative data. Qualitative data collected through the H4D process was necessary for understanding the user's needs, expectations, feedback, and goals for this project. At the same time, we collected quantitative data from government and commercial websites, creating a dataset related to fuel flow within the United States, which was crucial for developing an accurate simulation. Combining these two data types showcases the team's desire to have a comprehensive and well-rounded knowledge of the fuel logistics essential in developing the wargame to test and validate our simulation.

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IV.   WARGAME SCENARIO

We crafted this wargame scenario to showcase the functionality of Resilinc's platform. In this wargame, we provide participants with a situation background, assign their roles, and then present them with various injects to test their abilities in reacting and responding to mitigate the events, ensuring the continuous flow of fuel from refineries in PADD 3 to 12 AFBs on the East Coast (PADD 1) (Department of the Air Force, n.d.).

To ensure that everyone involved has a clear understanding of the scenario and objectives of the exercise, we will provide participants with background information on the wargame's scope. The background information is intended to assist participants in making informed decisions throughout the simulation, as illustrated in Figure 12.

Figure 12.   Background Slide

The following parts of the wargame would define a participant's role so that individuals can determine the perspective used to make decisions, as seen in Figure 13.

Figure 13.   Role Slide

We will use wargame injections to introduce dynamic and unpredictable events essential for simulating the ever-changing nature of real-world events. The purpose is to test a participant's ability to adapt strategies and decision-making processes in response to the new development. This wargame aims to provide and maintain a constant flow of fuel to bases along the East Coast (PADD 1). These challenges would impact the supply chain infrastructure or other factors that are critical to maintaining the flow of fuel,

Figures 14, 15, and 16 show the injected events in this scenario. Scenario 1 is cyber-attacks at the Oil refineries in Houston, Texas; Baton Rouge, Louisiana; Atlanta, Georgia; and Linden, New Jersey. Scenario 2 is an explosion at the Houston Texas Oil Refinery. Scenario 3 is a fire at the Atlanta, Georgia, Oil Refinery.

Figure 14.   Scenario #1: Cyber Attacks
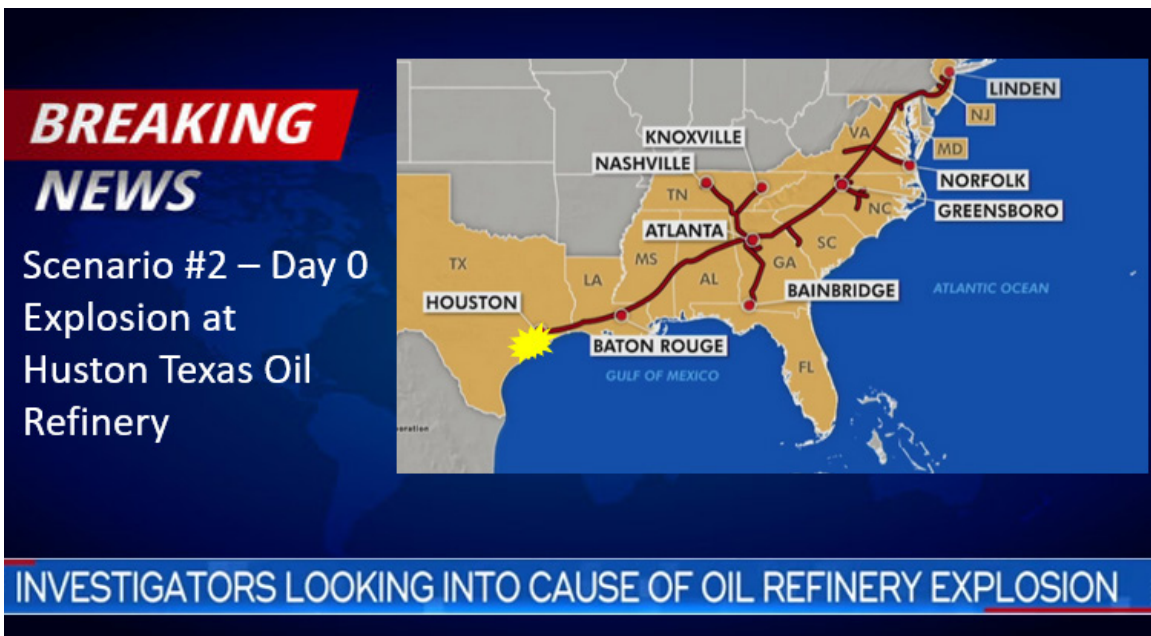
Figure 15.   Scenario #2: Explosion at Huston Texas Oil Refinery

Figure 16.　Scenario 3: Fire at Atlanta Georgia Oil Refinery

Following each injection, we will inform the participants about the event's consequences, which may impact the fuel supply chain, disrupt the distribution network, and prompt changes in demand and response efforts, as illustrated in Figures 17, 18, and 19. Furthermore, this establishes a chain reaction of events so that participants can see how the initial disruption affects the other refineries and distribution centers further down the supply chain. Ultimately, this will empower individuals to explore multiple options for addressing this issue and outlining potential future outcomes.

Figure 17.   Scenario #1: Impact

Figure 18.   Scenario #2: Impact

Figure 19.   Scenario #3: Impact

Providing participants with this information in response to the events is critical to creating a realistic and dynamic scenario with the war game. The purpose is to add complexity to the decision-making process as the individual or team navigates the challenges posed by the fuel supply chain disruption. In a dynamic scenario like the one in this war game, several factors, including the injected events and their consequences, can induce the fuel demand at each base, as illustrated in Figures 20, 21, 22, and 23. Understanding how demand changes in response to them is essential for participants to practice managing the supply chain and allocation of resources.

Figure 20.　Fuel Demand: Scenario #1

Figure 21.　New Fuel Request: Scenario #2

Figure 22.   Fuel Reduction Efforts: Scenario #3

Figure 23.   Fuel Supply Chain Impact

Providing the scenario results based on success is essential to the wargaming experience, as seen in Figure 24. Knowing the outcome offers closure, insight into decision-making processes, and a chance to learn from their strategies.

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Figure 24.　Results

The wargame successfully tested and validated the simulation, representing a critical milestone in the project's development. The effort to design scenarios, create realistic simulations, and ensure a faithful representation of the goals and objectives of the project sponsor. We subjected the wargame to scrutiny, which involved identifying its strengths, weaknesses, and areas for improvement. Ultimately, reliability and accuracy were validated, instilling confidence in its utility.

Now that the sponsors have given their approval, this greenlights the team to begin planning on transferring valuable information, insights, and outcomes that occurred during the development of the simulation to the SAF/IEN's training and education office.

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V. TECH TRANSFER

With this capstone's successful completion and approval, the process seamlessly transferred files from the academic realm to practical implementation. Based on the SAF/IEN Senior Analyst's recommendation, DOD Safe was the most streamlined method to securely transfer files to the Air Force Department of Energy Education and Training office. We selected the following resources to complement and support Resilinc's platform during a wargame event to enable the practical application of the findings.

Student Resource: These files are to be used in conjunction with Resilinc

(1)   Individual Refinery Capacity: contains information necessary to understand the output capabilities of refineries in the United States.

(2)   Number of Refineries Per PADD: contains information on the distribution of refineries across the United States.

(3)   Operational Capacity: contains information about the operational capacity of refineries necessary for having a comprehensive view of potential output.

(4)   Product Capacity: contains information on refinery capacity for various products, allowing for a comprehensive assessment of the U.S. refineries capabilities.

(5)   Refinery Yield of Kerosene-Type Jet Fuel: contains information regarding the production capacity of Kerosene-Type Jet Fuel, which is important for emergency planning.

(6)   Resilinc User guide: which will give step by step instructions on how to create a simulation

Supply Chain Mapping: This file was used to create the simulation in Resilinc

(1)   NAVAL POSTGRADUATE SCHOOL_V15-Condensedv4: contained information necessary to recreate the flow of fuel through the Colonial, Plantation, and Buckeye Pipeline.

Scenario: this file contains a wargame

(1)   Scenariov3—contains the wargame that was created for the capstone to demonstrate the use of the Student Resources and the Resilinc Program.

Presentation Versions: These were the various versions of the presentation created based on the needs of the sponsor.

(2)   Presentation—Original—No Voice

(3)   Presentation—Original—Extended—Full—Voice

(4)   Presentation—Original—Extended—Short—No Voice

(5)   Presentation—Original—Extended—Full—No Voice

Presentation—SES: Out brief for the Capstone Project

This was the presentation that was given to the Deputy Assistant Secretary of the Air Force for Operational Energy, Office of the Assistant Secretary of the Air Force for Energy, Installations, and Environment. It outlined the benefits offered by Resilinc's platform.

Now that MC2 had ensured the seamless transfer of knowledge, insights, and outcomes derived from the simulation, the team focused on examining the simulation's limitations. In this phase, we thoroughly evaluated the simulation contracts, focusing on examining data accrual assumptions and other factors that could affect their reliability and applicability. Future project teams can create a more robust and reliable simulation by addressing these limitations.

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VI. LIMITATIONS

Developing a fuel supply chain network is a complex endeavor, and therefore, we considered several limitations and challenges during the development process.

The first limitation considered was data availability and accuracy.

The availability of accurate and up-to-date information is crucial for building a realistic simulation. The data quality related to fuel demand, movement, and refinery capacity significantly affects the simulation's accuracy. When we pulled data from the EIA.gov website, we rounded most of the figures to the nearest thousandth of a gallon, which impacted the accuracy of the results.

The second limitation considered was based on simplicity of the model and assumptions of the impact of fuel supply chain disruptions.

Simulations require simplicity and assumptions to make them computationally manageable. Originally, when this product was developed using Microsoft Excel, the team decided that this platform was too simple to produce accurate results and required transitioning to Resilinc to increase the scope of those assumptions and improve accuracy. However, these simplified examples may not fully capture the complexity of a real-world supply chain disruption.

The third limitation considered was model validation.

It can be difficult to validate the accuracy of the fuel supply chain simulations because there is little historical information available for comparison. This project is the first attempt to develop a fuel supply chain simulation in Resilinc, and because of this, many of the current values in the simulation had to serve as proxies for values in which the user would be interested. For example, revenue at risk would serve as a proxy for fuel at risk. This means that if there was a fuel disruption event and the result produced a value of $14,000 in revenue at risk, this would mean that 14,000 gallons of fuel were lost. As for the Air Force, this project was the introduction to the website and will require some learning to ensure that the results produced are accurate.

Now that the limitations have been identified, the teams will begin looking at the exploratory area for future study. During the next part of the project, the team will focus on identifying unexplored dimensions of the simulation gained during its development. By doing so, future efforts on this project will contribute to the development of better simulations and expanding the knowledge of fuel supply chain logistics in the United States.

VII. AREAS OF FUTURE RESEARCH

There are several areas in which this research can be expanded. The first area is expanding the number of nodes and pathways used to build the Colonial, Plantation, and Buckeye Pipelines. Currently, this simulation covers 121 nodes, but the ability to expand this scope by incorporating additional refineries, storage depots, and transportation routes will deliver a more realistic and accurate representation of the fuel supply chain network. This increased level of coverage improves risk mitigation efforts, dynamic response capability, and informed decision-making. Furthermore, it contributes to the supply chain's resilience and enables better strategic planning. As a result, this expansion is a strategic investment in ensuring the reliable operation of these vital U.S. oil pipelines.

The second area to expand upon is incorporating other major pipelines into the simulation, which will provide significant advantages in transforming the simulation into a comprehensive and holistic tool necessary to manage the complexity of the entire fuel supply chain in the United States. Broadening the scope of analysis will allow SAF/IEN to view specific pipelines in the context of the more extensive oil pipeline network, resulting in more significant insights into interdependencies, potential bottlenecks, and resource allocation.

Furthermore, including other pipelines enhances the accuracy of the model. Since pipelines often interact and share resources, such as refineries and storage depots, modeling these interactions can provide a more realistic representation of how the supply chain will operate. Also, this holistic approach allows for a more comprehensive risk assessment. With multiple pipelines in the simulation, SAF/IEN can better evaluate the impact of a supply chain disruption on the entire fuel supply chain network.

The other major pipelines in the United States are:

- Olympic
- Andeavor
- Kinder Morgan
- Santa Fe

- Magellan

- Explorer

- Flint Hills

- Energy Transfer Partner

The third area to expand upon is the movement of fuel across a theater of operation, i.e., the Pacific Theater. This vast and complex region demands a comprehensive approach given its geopolitical importance. Expanding this simulation not only addresses the logical challenges of maritime transport, island-based storage, and multi-country distribution but also enhances resilience against disruptions and supports interconnected operations. Also, it enhances contingency scenario planning and fosters international collaboration, which will strengthen readiness and efficiency across the theater, resulting in a stable supply of fuel across the region.

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VIII. CONCLUSION

The cyberattack on Colonial Pipeline refineries on May 7, 2021, highlighted the vulnerability of fuel supply chains in the United States. Even though the shutdown lasted only six days, it resulted in widespread fuel shortages for commercial and governmental organizations along the East Coast. This event negatively impacted the mission readiness of 12 Air Force bases along the East Coast. To ensure mission readiness in the event of a future supply chain disruption, SAF/IEN received the task of finding COTS software capable of modeling and simulating the complex network of pipelines and distribution centers along the Colonial, Plantation, and Buckeye Pipelines at an educational, training, and decision-making scale. Therefore, MC2 set out on the effort to develop a simulation that could track 121 nodes (consisting of refineries, distribution centers, and drop-off points) and 200 pathways stretching from Houston, Texas, to Linden, New Jersey, and from Lima, Ohio, to Linden, New Jersey.

After three revisions to the problem statement, the development of six MVPs, and the development of a fuel supply chain simulation Excel, the team delivered Resilinc's Platform as the go-to COTS software capable of achieving the SAF/IEN mission. After selecting the platform, we designed a wargame that incorporated a simulation with three supply chain disruptions, student resources, a question bank, a user guide for the Resilinc platform, and the required CDIF file.

This wargame's development will significantly impact the SAF/IEN fuel supply chain management and the Air Force's logistics. The wargame provides a unique opportunity to replicate real-world supply chain networks' complex and interconnected dynamics. It can accurately capture demand fluctuations, inventory management, and unforeseen disruptions. This level of detail allows students and decision-makers to make decisions and test strategies in an environment that closely mirrors the challenges of the Colonial Pipeline cyberattack.

The next benefit this wargame will have for the Air Force is related to strategic decision-making insights. The management of the U.S. critical infrastructure relies on

anticipating outcomes, evaluating tradeoffs, and assessing the impact of different choices. Students and decision-makers can view this game as a virtual laboratory where they can experiment with various scenarios and observe the consequences of their decisions.

The third benefit of this game is related to risk management and resilience enhancement. This wargame's capability to simulate disruptive events, such as cyberattacks, fires, explosions, and geopolitical conflict, equips SAF/IEN to explore disruptions that could impact operations. By identifying vulnerabilities and crafting contingency plans, this war game supports the development of robust risk management strategies that will minimize the negative impact of unexpected events on the fuel supply chain.

The fourth and final benefit was related to learning through experiential education. Traditional classroom instruction needs to provide readers with hands-on experience in dealing with the complexity of supply chain management. This wargame will bridge the gap using experimental education, enabling users to engage in realistic scenarios and learn from successes and failures. This approach will accelerate skill development and cultivate a deeper understanding of supply chain dynamics that extends beyond theory.

MC2 recorded several lessons learned during the fuel supply chain simulation development. The first is related to technical challenges and problem-solving. Several technical challenges emerged when developing accurate, logical formulas to simulate fuel flow and displaying the results within a table. Due to the limitations of Excel, the ability to run macros requires the team to shift to Resilinc later in the project. If the team had identified this early in the development, it could have reduced the time invested in Microsoft Excel and increased the time invested in using Resilinc.

The next lesson learned was related to collaboration and communication. Due to the team's diversity, every member brought unique skills and perspectives, highlighting the importance of communication. Learning to leverage MC2's strengths while maintaining SAF/IEN's vision was a perfect example of the importance of teamwork in developing a complex fuel supply chain simulation.

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The use of agile development and adaptability was the third part of the lessons learned by the team. This development approach emphasized adaptability in response to changing requirements and unforeseen challenges. Regular feedback loops and incremental development were necessary to maintain project development and accommodate the evolving needs of the stakeholders.

The final lesson learned is related to time management and scope control. Managing the project timelines and scope control posed a challenge for MC2. The team had to balance ambitious goals with the practical constraints necessary to prioritize occasional scope adjustments. These experiences have reinforced the need for realistic milestones, progress monitoring, and an informed decision on resource allocation.

This capstone contributed to the Air Force's effort to map out the fuel supply chain within the United States, which will enhance decision-making and strategic planning. Wargames provided a dynamic environment for decision-makers to simulate various strategies and scenarios necessary to understand the interplay of factors influencing fuel supply chain operations. Accurately modeling variables such as demand fluctuations and inventory management, this game is a valuable tool for testing strategies, optimizing resource allocation, and assessing potential risks to improve decision-making and strategic planning processes within SAF/IEN.

The next benefit includes risk management and resilience. One of the primary objectives of SAF/IEN was to reduce vulnerability to unforeseen disruptions due to weather geopolitical conflicts. The wargame's ability to simulate such events and their cascading effects empowers students and decision-makers to identify vulnerabilities and implement risk management strategies. Resilinc allows SAF/IEN to experiment with different contingency plans and evaluate their outcomes, resulting in an enhanced fuel supply chain and a more resilient fuel distribution network.

The game also has an educational purpose by providing supply chain professionals and students with the opportunity to practice managing the complex fuel supply chain within the United States. Using this interactive wargame, participants can develop critical skills in problem-solving, resource optimization, and strategic thinking.

Finally, this game will contribute to research, policy, and insights. The flexibility of the Resilinc Platform to model various supply chain structures and configurations makes it an invaluable tool for DOD researchers investigating different supply chain management strategies. The data produced from this platform could contribute to academic studies, resulting in the development of best practices, efficient improvements, and different supply chain decisions. Furthermore, it could aid policymakers in understanding the implementation of regulations and incentives to harden the United States' fuel supply chain..

APPENDIX A. MVP DEVELOPMENT

A.   GUIDE

Each section of the MVP is broken into three parts. The first part is a brief description of the MVP; the second part is an image of the MVP that was created; and the third part contains a list of changes made based on feedback from the sponsor with a description of how those changes were made.

B.   MINIMUM VIABLE PRODUCT 1

This MVP was a rough sketch for the initial ideation and visualization, as seen in Figure 25. It allowed the team to improve in the following areas: capturing ideas, speed and flexibility, and problem-solving. When it came to capturing ideas, the sketch below was created on paper as the team tried to answer the following questions:

- How do we begin mapping a supply chain?
- What would be the best Commercial off-the-shelf software to map a supply chain?

This drawing allowed the team to externalize their thoughts, making exploring multiple options, concepts, and variations much easier without committing too much time, effort, or resources, resulting in shorter refinement periods. The team achieved speed and flexibility by using drawings like those in MVP 1, which did not necessitate specialized tools or software, enabling the team to iterate on ideas rapidly without being confined by the constraints of a single software development process. As a visual aid, the drawing acted as a reference that allowed the team to revisit ideas and design processes and recall specific details that may have been lost during the iteration process. Eventually, it served as the foundation for more detailed mockups within Microsoft Excel. As a visual problem-solving tool, the drawing helped the team explore the relationships between the various nodes and pathways to determine the best method to map them and develop the equations necessary to run the simulation.

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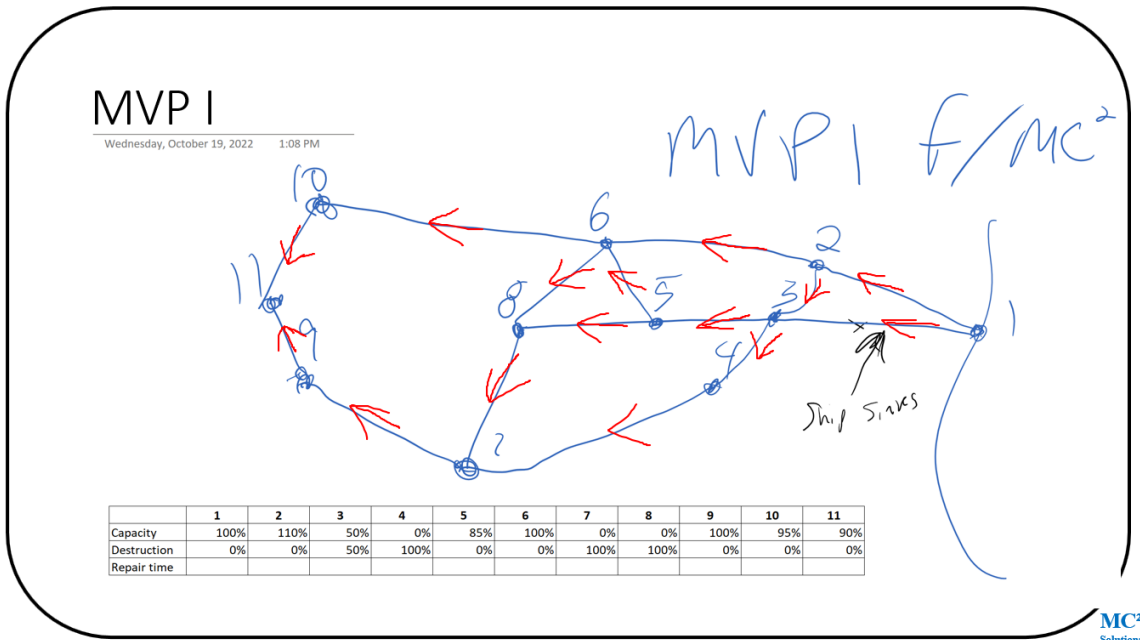|	1	2	3	4	5	6	7	8	9	10	11
Capacity	100%	110%	50%	0%	85%	100%	0%	0%	100%	95%	90%
Destruction	0%	0%	50%	100%	0%	0%	100%	100%	0%	0%	0%
Repair time											

Figure 25.   MVP 1 Iteration

Note: Originally, the Pacific Theater was the primary focus for developing a simulation to demonstrate the impact of a JP-8 fuel supply chain disruption. Hence, each node in MVP 1 represents an island to which shipping lanes would connect.

1.   Change #1: Chose a Commercial off the Shelf Software

Now that the team had the factors, we considered the following software as possible solutions: Any Logic, Crystal Ball (which runs on Excel), Excel, and Resilinc. Excel and Resilinc would be the best platforms for simulating a JP-8 fuel supply chain disruption within the Pacific Theater. Due to the time limitations required to produce a product during the quarter-long MN3307 course, the team developed a simulation using Excel rather than Resilinc.

2.   Change #2: Develop a Mock Fuel Network

The team began to brainstorm ideas of what a map with nodes and pathways would look like, and after a few attempts at building a map in Excel and by hand, the final draft was presented in the image in MVP 1. This drawing would be the basis for the team to build the JP-8 supply chain simulation in Excel. Since the sponsor had no preference for

the number of nodes needed to be in the simulation, the team decided to go with 11, allowing the team to develop a JP-8 fuel supply chain that had enough branching paths that the user would be able to evaluate the availability of alternate pathways if one or more nodes or pathways experienced a disruption.

3. Change #3: Create Nodes and Define their Functions

For simplicity, the team created a network that consisted of one refinery, nine nodes, and one area of operation to see if it was possible to build a fuel supply chain simulator in Excel, as seen in Table 4.

Table 4.   Node Function Assignment

Node	Function
1	Starting Point (Refinery)
2	Storage and Distribution Point
3	Storage and Distribution Point
4	Storage and Distribution Point
5	Storage and Distribution Point
6	Storage and Distribution Point
7	Storage and Distribution Point
8	Storage and Distribution Point
9	Storage and Distribution Point
10	Storage and Distribution Point
11	Area of Operation

4. Change #4: Show the Direction of the Flow of Fuel

To illustrate the flow direction from Node 1 to Node 11, we took two steps. First, we added arrows to the shipping lanes to depict the movement of JP-8. Second, we created a table listing the nodes in left-to-right order, with Node 1 on the far left and Node 11 on the far right. Since the oil only needed to flow in one direction, this approach simplified the equations that would eventually be incorporated into the simulation.

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5. Change #5: Create a Supply Disruption Event

Rather than creating several instances of a supply disruption, the team decided to go with just one to ensure that they understood what was meant by a supply disruption. The example placed in MVP 1 depicts a kinetic weapon striking a ship carrying fuel to an island storage depot. Therefore, a point labeled ship sinks exists between Node 1 and Node 2.

6. Change #6: Record the Flow of Fuel

As a result, we created a table illustrating the flow of JP-8 fuel from Node 1 to Node 11. At each node, we assigned a row to capture the fuel capacity, destruction, and repair time. We captured these specific values to enable the user to determine the following:

- Whether a node could serve as adequate storage or a depot in case of an attack.
- What actions to take if a node was damaged beyond repair.
- How long it would take to bring the node back to normal operating condition if it could be repaired.

It's important to note that we did not use equations to simulate fuel flow in this table. Instead, we sought approval from the sponsor to ensure that the factors (fuel capacity, destruction, and repair time) were accurately represented and displayed, as shown in Table 5.

Table 5.   Flow of JP-8 Fuel

	1	2	3	4	5	6	7	8	9	10	11
Capacity	100%	110%	50%	0%	85%	100%	0%	0%	100%	95%	90%
Destruction	0%	0%	50%	100%	0%	0%	100%	100%	0%	0%	0%
Repair time											

C.   MINIMUM VIABLE PRODUCT 2

The next step involved transforming MVP 1 into the actual software to achieve the following objectives: pinpoint accuracy and precision, practical execution, testing functionality, and debugging, as depicted in Figure 26. Given that MVP 1 was conceptual, it was crucial to translate it into software capable of conveying the requisite detail, accuracy, and precision necessary for implementation. This conversion process ensured that the program would be developed, aligned with the team's intentions, and consistent with the sponsor's goals. Since a drawing only provides a static representation of a fuel supply chain, it needed to be converted into software to enable dynamic execution, offering hands-on experience and functionality. Ultimately, functional software enabled MC2 to identify and address any logical issues and performance bottlenecks.

79
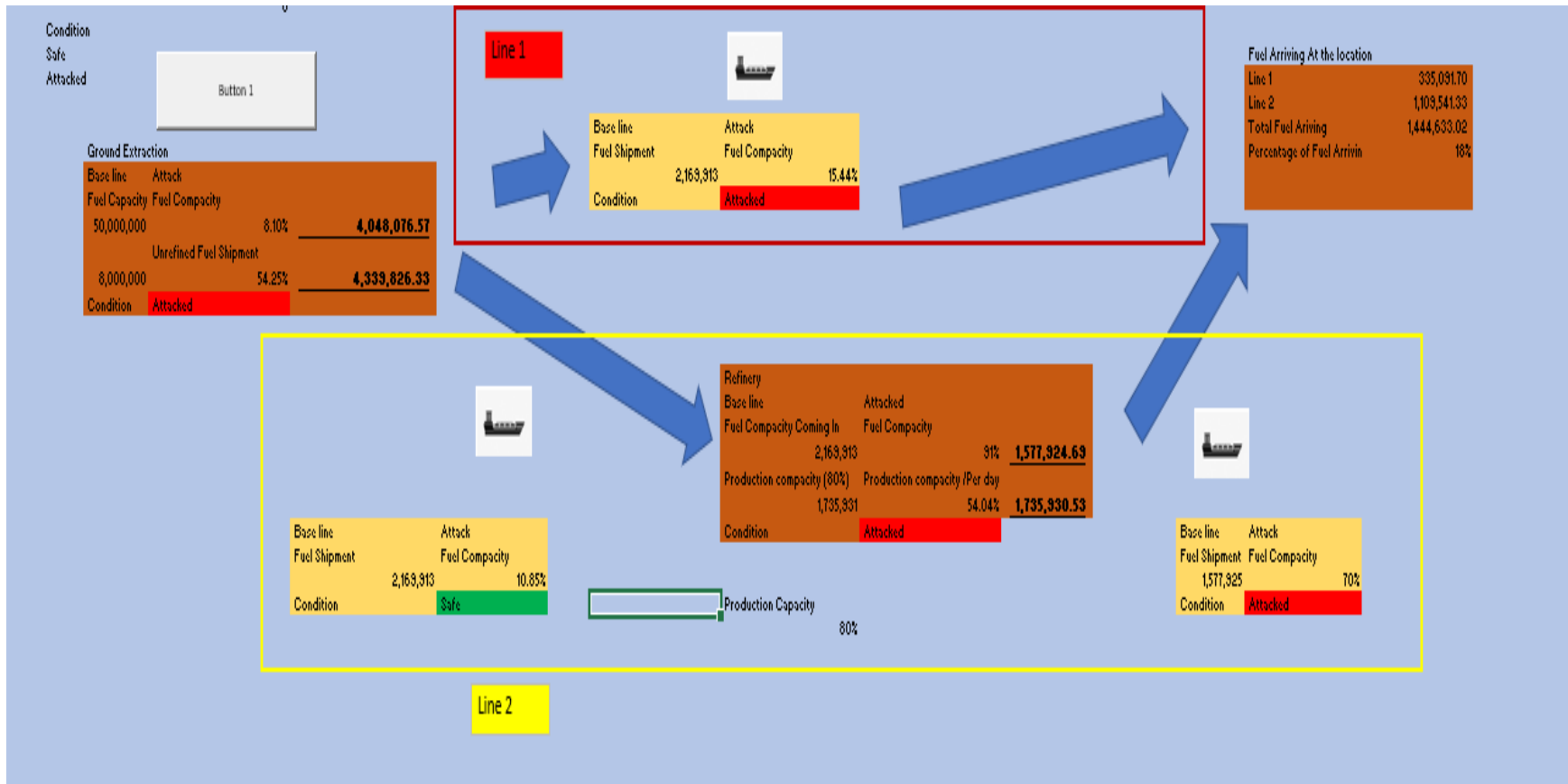
Figure 26.   MVP 2 Iteration

1.   **Change #1: Reduce the Number of Nodes and Paths**

To streamline the process of building MVP 2 and ensure it was moving in the right direction, we reduced the supply chain from 11 nodes and 15 pathways in MVP 1 to 3 nodes and 3 pathways. We also removed the table from MVP 1 as our focus shifted toward visually presenting the supply chain instead of displaying information in a table (still under development). The table will be reintroduced in the next iteration (MVP 3).

2.   **Change #2: Randomize the Condition of Nodes as Attacked or Safe**

To achieve this the following equation would be used: =CHOOSE(RANDBETWEEN(1,2),"Safe","Attacked") which is shown in Figure 27.

Here is the step-by-step guide on how this equation would operate.

The first step involved RANDBETWEEN (1, 2), and this function produced a whole number between 1 and 2. In this case, it randomly selected either 1 or 2. Step 2 involved the CHOOSE function, which allowed the user to select a value from a list based on an index number. Therefore, there were two arguments to return a value from a list. The first argument was between CHOOSE and RANDOMBETWEEN (1, 2). Since RANDBETWEEN (1, 2) randomly generated a number as either 1 or 2, it was used as the index number for the CHOOSE function. The second argument was Safe, which corresponded with index number 1. The third argument was Attacked, which corresponded with index number 2. The third and final step was the CHOOSE function, which evaluated the index number generated by the RANDOMBETWEEN (1, 2) and returned a value associated with the index number. In this case, if the randomized number was 1, it would return as Safe, and if the number was 2, it would return as Attacked.

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Figure 27.   Use of CHOOSE and RANDOMBETWEEN Functions

3.   Change #3: Develop the Random Damage Value

This was done using the following equation: =RAND() which is shown in Figure 28. This equation is broken down into two parts, which are "RAND" and "()." The first part is "RAND" which is the function that is being used. "RAND" stands for random, indicating that Excel will generate a random number. The empty parentheses "()" indicate that there is no argument that the equation will have to act on. When the equation "=RAND()" is used, Excel will generate a new number between 0 (inclusive) and 1 (exclusive) each time the worksheet is recalculated. The generated number could be a decimal value such as .9531. This is the value that will be used to determine the loss of fuel that will occur at a node or pathway if the condition of a location is assigned the value Attacked."

Figure 28.   Use of RAND Function

4.   Change #4: Highlight Location Condition

This was achieved by following this step-by-step guide. First, one went to the Home tab in the Excel Ribbon, then went to the Styles group, and then selected Conditional Formatting and New Rule. In the New Formatting Rule dialog box, one selected Use an equation to determine which cells to format.

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In the option Format Values where this equation was true, one entered the following equation for highlighting a cell red if the value was Attacked: (=Cell Reference="Attacked"). Then, one clicked on the Format button and chose the format setting red fill color. Similarly, one used the following equation for highlighting green if the value was Safe (=Cell Reference="Safe"). After that, one clicked on the Format button and chose the format setting green fill color.

Once the conditional color has been chosen, select OK to close the Format Cells dialog box, and then select OK in the New Formatting Rule dialog box to apply the conditional formatting as shown in Figures 29, 30, 31 and 32.

Figure 29.   Example of the Ground Extraction Node That Is Assigned a Value of Safe

Figure 30.   Example of the Ground Extraction Node That Is Assigned a Value of Attacked
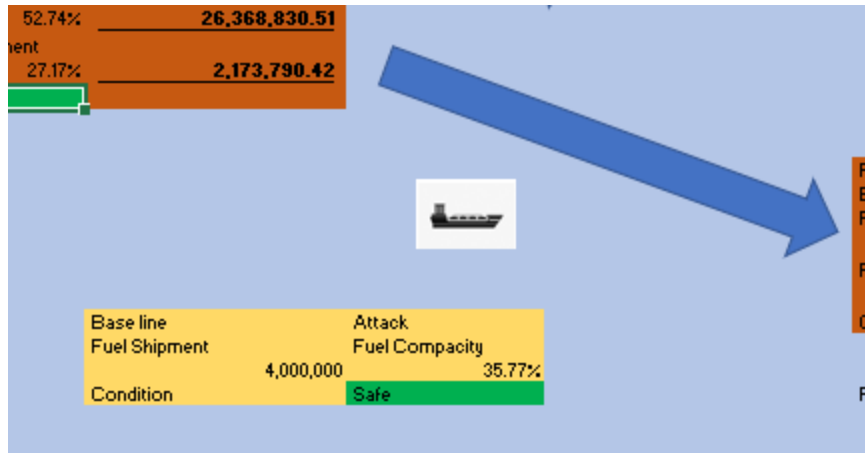
Figure 31.　Example of a Pathway That Is Assigned a Value of Safe
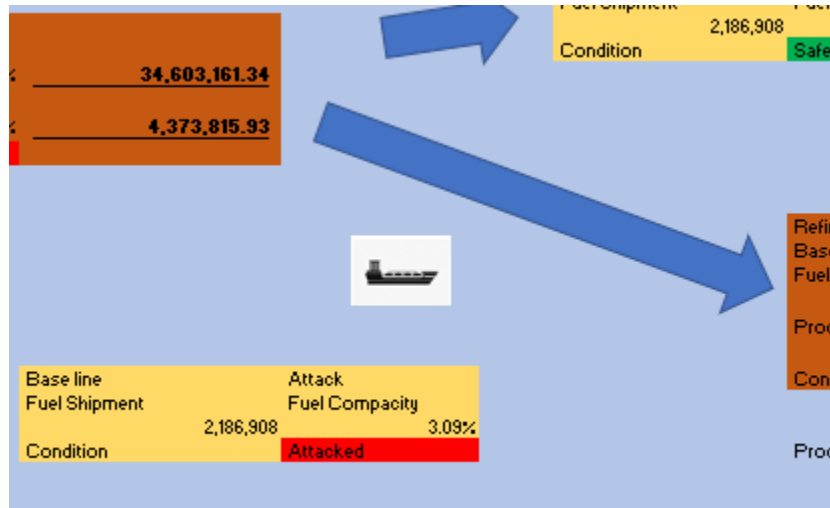
Figure 32.　Example of a Pathway That Is Assigned a Value of Attacked

5.　Change #5: Allow User to Manually Adjust Starting Fuel Amount

Since the Ground Extraction node is the start of the simulation, the user needed to be able to adjust the fuel storage capacity and fuel shipment that would flow to the first two pathways as shown in Figure 33.

Figure 33.   Starting Fuel Capacity

In this example, the user would be able to adjust the following values:

- Fuel Storage Capacity—50,000,000 Gallons

- Fuel Shipment—8,000,000 Gallons

6.   Change #6: Allow User to Manually Adjust Production Capacity

The location labeled Refinery the following equation =I9*I26, gave the user ability to adjust fuel production capacity as seen in Figure 34.

Figure 34.   Adjustable Fuel Compacity

Figure 35 will show the following:

- The incoming amount of fuel to the refinery is placed in cell I19.

- The production capacity is in J26.

- The 80% value could be adjusted to meet the user's needs for the simulation.

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- This 80% value means the 2,169,913 gallons arriving at the Refinery, which is 1,735,931 (2,169,913 * 80%), would be transformed into JP-8.
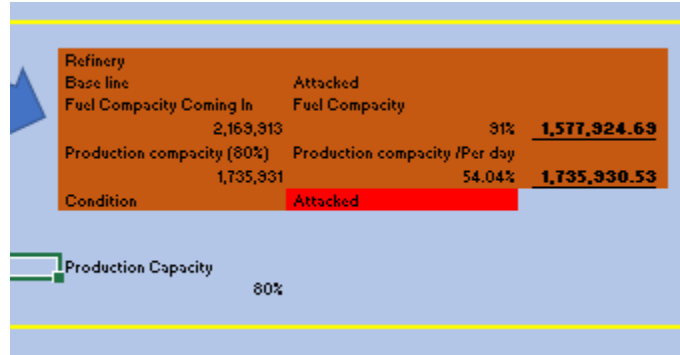
Figure 35.   Refinery Fuel Compacity Calculation

7.   Change #7: Provide a Side-By-Side Comparison of a Location Under both Safe and Attacked Condition

Figure 36 shows both nodes and pathways have two columns: Base line and Attacked. When a location is labeled Safe, the equations in the simulation will pull values from the Base Line column. When a location is labeled Attacked, the equation in the simulation will pull values from the Attack column.

For example, in the following image, since the shipping lane was labeled Attacked, the value that is calculated in the Attacked column is 1,577,925 *.70 = 1,109,541.33 gallons. This value is then passed on to the location labeled Fuel Arriving at the Location through Line 2

86
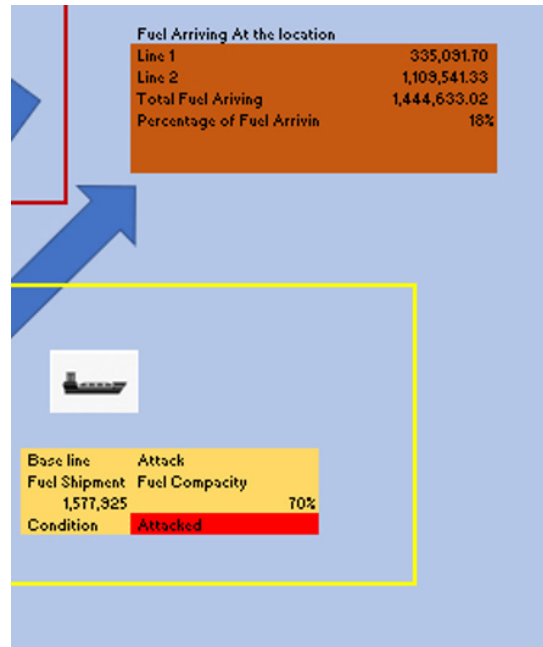
Figure 36.　Side by Side Comparison

8.　Change #8: Show Ending Fuel Amount as a Number and Percentage

Figure 37 shows that once the user has completed one run of the simulation, the ending fuel amount is divided by the beginning fuel amount.

- Starting Value: 8,000,000 gallons
- Ending Value: 1,444,633 gallons

Figure 37.　Ending Value as a Percentage

9.　Change #9: Create an Easy User Into Face to Run the Simulation

Button 1 was assigned a macro that would simulate the pressing of the F4 button to start recalculation of the spreadsheet. Recalculation cycles through the various combinations of absolute and relative values, which would cause the following equations used in this simulation to display a new random value:

=CHOOSE(RANDBETWEEN(1,2),"Safe","Attacked")

"=RAND()"

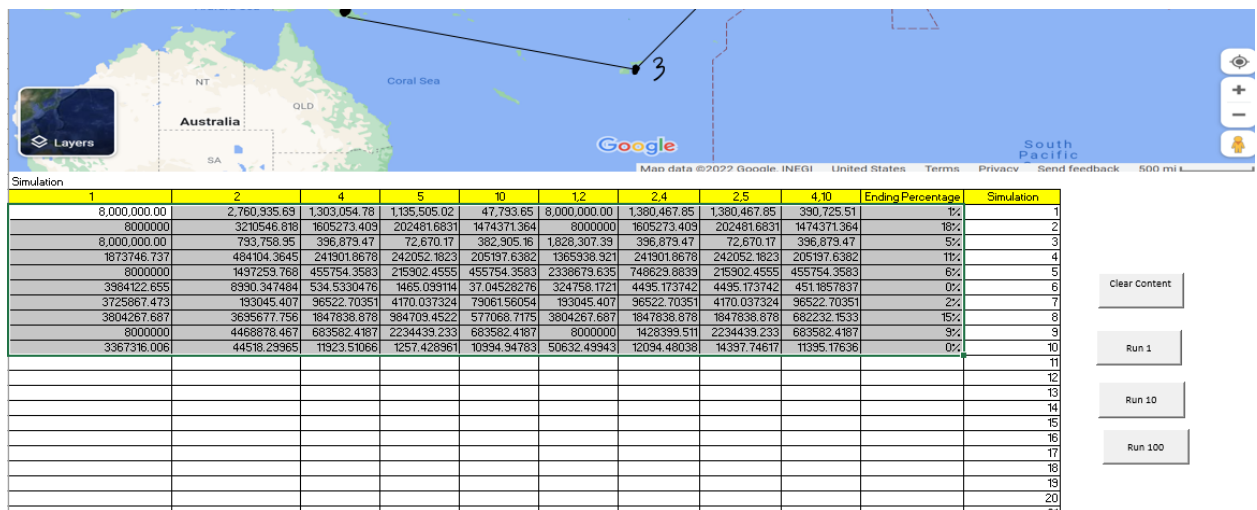## D.　MINIMUM VIABLE PRODUCT 3

The information for MVP 3 will be presented in the following manner: First, the product outcome will be displayed, followed by feedback, and labeled in the order it was received from the sponsor, and a response will be placed under each feedback. The culmination of this effort is shown in Figure 38.

1	2	4	5	10	1,2	2,4	2,5	4,10	Ending Percentage	Simulation
8,000,000.00	2,760,935.63	1,303,054.78	1,135,505.02	47,793.65	#######	1,380,467.85	1,380,467.85	390,725.51	1%	1
8000000	3210546.818	1605273.41	202481.683	1474371.36	8000000	1605273.41	202481.683	1474371.36	18%	2
8,000,000.00	793,758.95	396,879.47	72,670.17	382,905.16	#######	396,879.47	72,670.17	396,879.47	5%	3
1873746.737	484104.3645	241901.868	242052.182	205197.638	1365938.92	241901.868	242052.182	205197.638	11%	4
8000000	1437259.768	455754.358	215902.456	455754.358	2338679.64	748629.884	215902.456	455754.358	6%	5
3384122.655	8390.347484	534.533048	1465.03911	37.0452828	324758.172	4495.17374	4495.17374	451.185784	0%	6
3725867.473	193045.407	36522.7035	4170.03732	79061.5605	193045.407	36522.7035	4170.03732	36522.7035	2%	7
3804267.687	3635677.756	1847838.88	384709.452	577068.718	3804267.69	1847838.88	1847838.88	682232.153	15%	8
8000000	4468878.467	683582.419	2234439.23	683582.419	8000000	1428399.51	2234439.23	683582.419	9%	9
3367316.006	44518.23965	11923.5107	1257.42896	10994.3478	50632.4394	12034.4804	14397.7462	11395.1164	0%	10

Clear Content

Run 1

Run 10

Run 100

Figure 38.   MVP 3 Iteration

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Note: The nodes and pathways used for this simulation are highlighted in Red.

1. Change #1: Improve the Realism of the Simulation

In order to achieve this, the team went to Google Maps and then took a screen shot of the Pacific Ocean with islands (nodes) and shipping lanes (pathways).

2. Change #2: Develop a Table to Record Simulation Runs as Seen in Table 6

The following table was created, which includes both the nodes and the paths. It is important to note that the equations used to calculate the flow of fuel in MVP 2 would be carried over to MVP 3.

Table 6.   Simulation Table

Simulation

1	2	4	5	10	1,2	2,4	2,5	4,10	Ending Percentage	Simulation
4,718,646.48	4,718,646.48	2,359,323.24	2,359,323.24	1,933,336.35	4,718,646.48	2,359,323.24	2,359,323.24	2,359,323.24	41%	1
6463277.736	6463277.736	3231638.868	692818.0544	280.5838656	6463277.736	3231638.868	2666975.317	539212.3739	0%	2
8.000.000.00	6.687.898.28	3.343.949.14	3.343.949.14	3.283.070.88	8.000.000.00	3.343.949.14	3.343.949.14	3.343.949.14	41%	3

3. Change #3: Create a Framework for the Simulation

Figure 39 shows that the simulation only looked at the nodes and pathways highlighted in red, those would be the only ones that would receive the random damage calculator and a randomized assignment of Safe or Attacked. Therefore, each node and pathway used the following equations:

=CHOOSE(RANDBETWEEN(1,2),"Safe","Attacked")

"=RAND()"
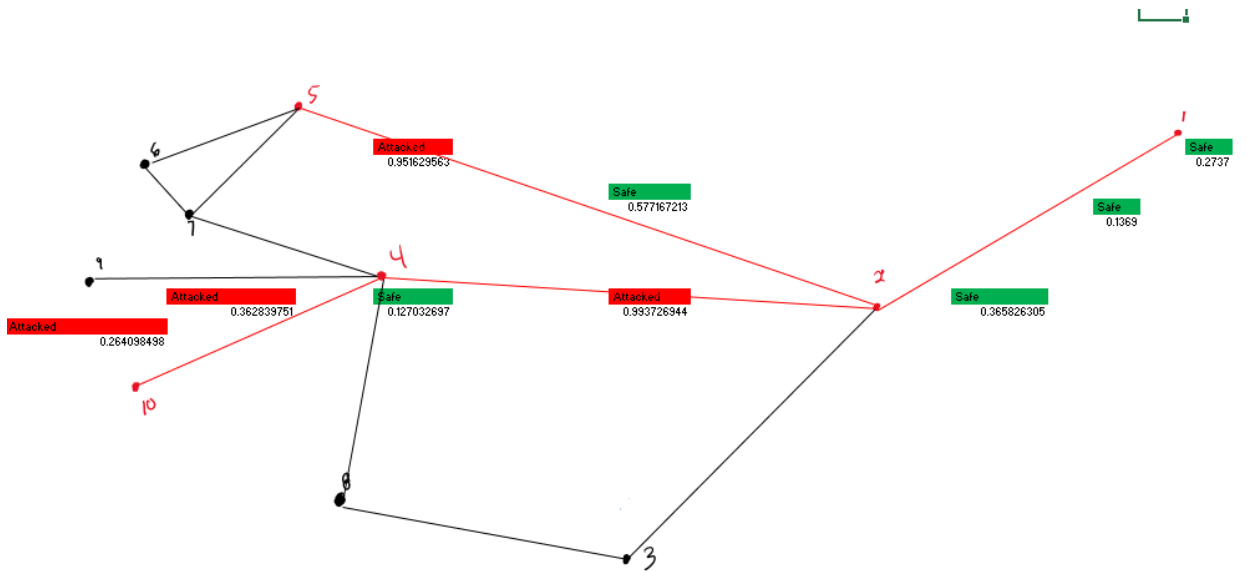
Figure 39.   Fuel Network for MVP 3

4.   Change #4: Create a User-Friendly Interface to Run And Record Simulations

Figures 40 and 41, shows how MC^2 created the user-friendly interface to run and record the simulations.

Therefore, the following buttons were created:

- Run 1
- Run 10
- Run 100
- Clear Content

Run 1, was assigned a macro that would simulate the pressing of the F4 button. The F4 button cycles through the various combinations of absolute and relative values, which would cause the equations to randomize the value and then create a new simulation. After the initial simulation is run, the value will be placed in the In Gallons table. That simulation would then be pasted into the first row of the simulation table. This process would be repeated based on which button was selected.

Figure 40.   Run 1 Simulation

1	2	4	5	10	1,2	2,4	2,5	4,10	Ending Percentage	Simulation
8,000,000.00	2,600,751.71	169,103.25	886,980.94	57,761.83	8,000,000.00	1,300,375.85	1,300,375.85	99,163.96	1%	1

Figure 41.   Run 10 Simulation

1	2	4	5	10	1,2	2,4	2,5	4,10	Ending Percentage	Simulation
8,000,000.00	2,760,935.69	1,303,054.78	1,135,505.02	47,793.65	8,000,000.00	1,380,467.85	1,380,467.85	390,725.51	1%	1
8000000	3210546.818	1605273.409	202481.6831	1474371.364	8000000	1605273.409	202481.6831	1474371.364	18%	2
8,000,000.00	793,758.95	396,879.47	72,670.17	382,905.16	1,828,307.39	396,879.47	72,670.17	396,879.47	5%	3
1873746.737	484104.3645	241901.8678	242052.1823	205197.6382	1365938.921	241901.8678	242052.1823	205197.6382	11%	4
8000000	1497259.768	455754.3583	215902.4555	455754.3583	2338679.635	748629.8839	215902.4555	455754.3583	6%	5
3984122.655	8990.347484	534.5330476	1465.099114	37.04528276	324758.1721	4495.173742	4495.173742	451.1857837	0%	6
3725867.473	193045.407	96522.70351	4170.037324	79061.56054	193045.407	96522.70351	4170.037324	96522.70351	2%	7
3804267.687	3635677.756	1847838.878	984709.4522	577068.7175	3804267.687	1847838.878	1847838.878	682232.1533	15%	8
8000000	4468878.467	683582.4187	2234439.233	683582.4187	8000000	1428399.511	2234439.233	683582.4187	9%	9
3367316.006	44518.29965	11923.51066	1257.428961	10994.94783	50632.49943	12094.48038	14397.74617	11335.17636	0%	10

E.   MINIMUM VIABLE PRODUCT 4

The information for MVP 4 will be presented in the following manner: First, the product outcome will be displayed, followed by feedback, and labeled in the order it was received from the sponsor, and a response will be placed under each feedback. The culmination of this effort is shown in Figure 42.

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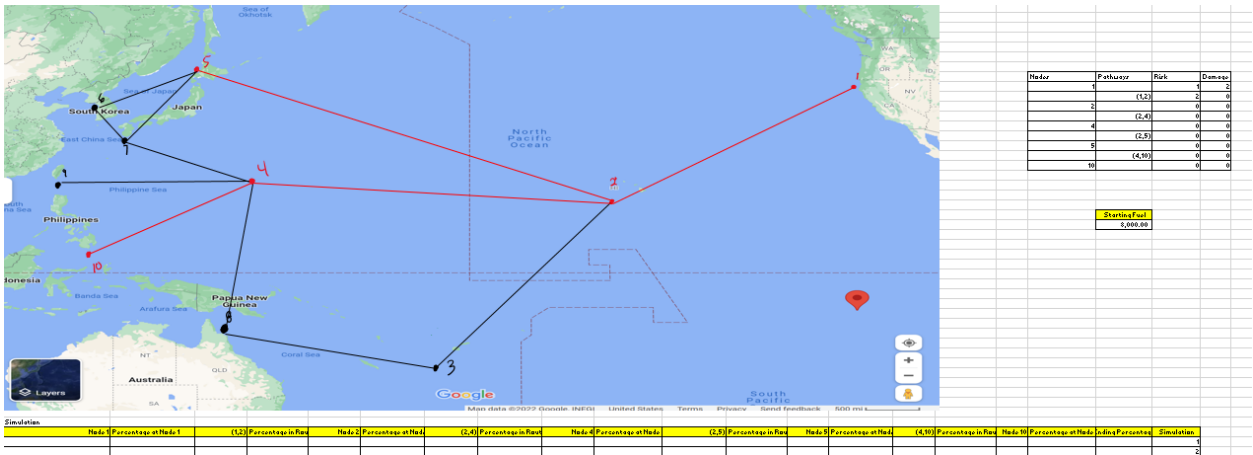
Figure 42.   MVP 4 Iteration

1.   Change #1: Create an Interface that Would Allow the User the Option to Completely Randomize or Manually Input Values in a Simulation

Figure 43 shows the user-interface format that will serve as the foundation for future iterations.

Random	Nodes	Pathways	Risk	Damage
Safe	1		1	1
Safe		(1,2)	1	1
Attacked	2		0	0
Attacked		(2,4)	0	0
Safe	4		0	0
Safe		(2,5)	0	0
Safe	5		0	0
Attacked		(4,10)	0	0
Attacked	10		0	0
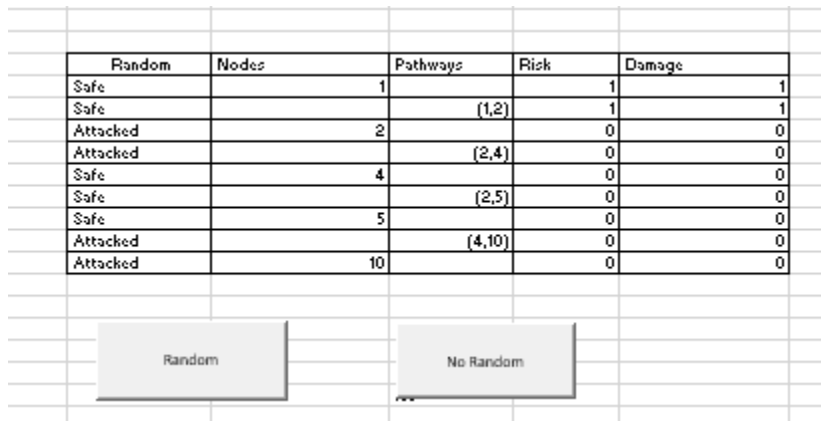
Figure 43.   User Interface with Randomized Conditions

As seen in Figure 44, by selecting the Random button, all the values for the nodes and pathways in the column labeled Random would be assigned a value of either Attacked or Safe. This would require the use of a macro that would paste the following equation: =CHOOSE(RANDBETWEEN(1,2),"Safe","Attacked") in each of the rows of the column labeled Random and then pressing F4.

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Figure 44.   User Interface with Manually Assigned Conditions

2.   Change #2: Add Functionally to the Run 1 and Run 10 Buttons

Creating the Run 1 and Run 10 buttons, a macro was used that would run the simulation once in the In Gallons table and then copy and paste the results in the Simulation table as seen in Figure 45.

Figure 45.   Example Simulation Run

This process would be repeated a number of times based on the button it was assigned to. For example, if the macro was assigned to the button Run 10, the macro would run 10 times.

Note: The Run 100 button does not function during this MVP as we were waiting to see if the sponsor would approve of this table output and simulation generation method.

F.   MINIMUM VIABLE PRODUCT 5

The information for MVP 5 will be presented in the following manner: First, the product outcome will be displayed, followed by feedback, and labeled in the order it was

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received from the sponsor, and a response will be placed under each feedback. The culmination of this effort is shown in Figure 46.

Figure 46.   MVP 5 Iteration

1.   Change #1: Improve the User Interface

A Control Panel was created to localize all the action buttons as seen in Figure 47.

Figure 47.   Control Panel for MVP 5

2.   Change #2: Remove Unused Features

The Run 1, Run 10, and Run 100 buttons were removed as they no longer served a purpose as they were only created to test equations and build the tables to record simulation runs.

3. Change #3: Create the Capability to Run 1000 Simulations

A macro similar to the ones created for the Run 1, Run 10, and Run 100 buttons was used to develop the following buttons: Run 1–250, Run 251–500, Run 501 to 750, and Run 751–1000 buttons.

Note: Excel had its limitations, as I could only run about 357 lines of the macro before it would result in a compiling error. Therefore, due to this limitation of Excel, 1000 scenarios had to be broken down into runs of 250 blocks.

G. MINIMUM VIABLE PRODUCT 6
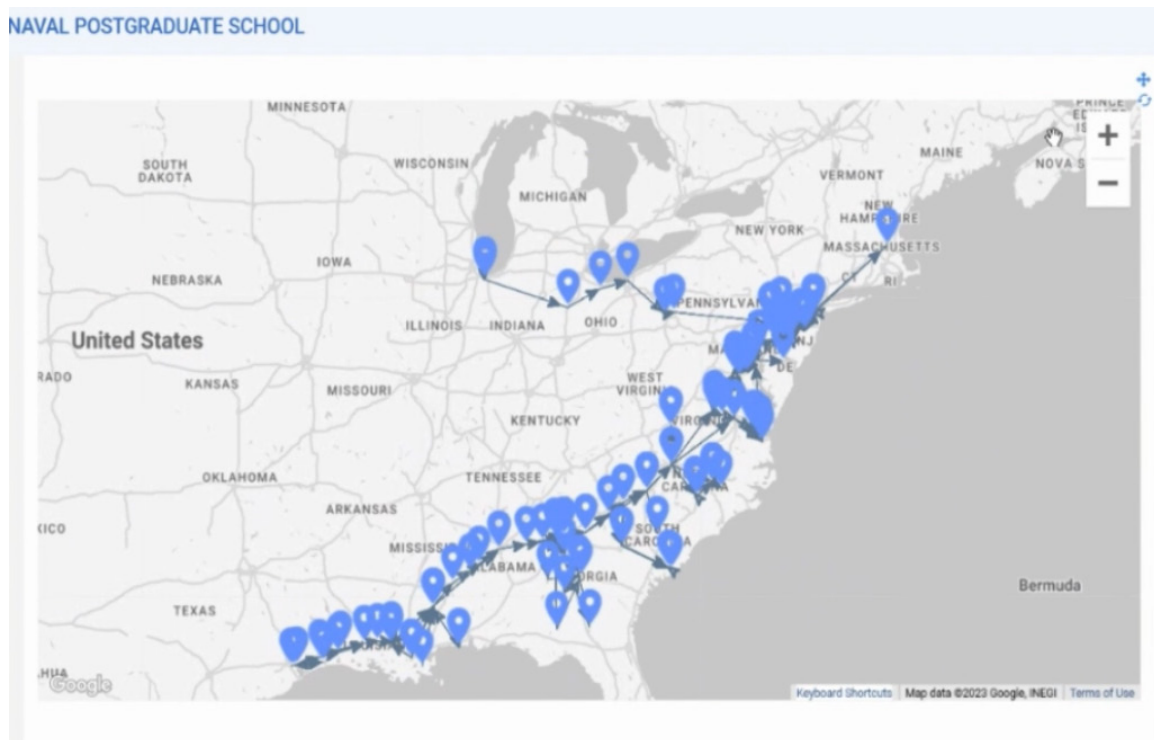
Figure 48.   MVP 6 Iteration

During the development of MVP 6, the team made the decision to transition from using Microsoft Excel to Resilinc. A step-by-step guide how this simulation was created can be found in attachment 2 while the guide on how to input the data into Resilinc can be found in attachment 3.

APPENDIX B. RESILINC—SCENARIO CREATION GUIDE

A.   WEBSITE

URL: https://www.resilinc.com/
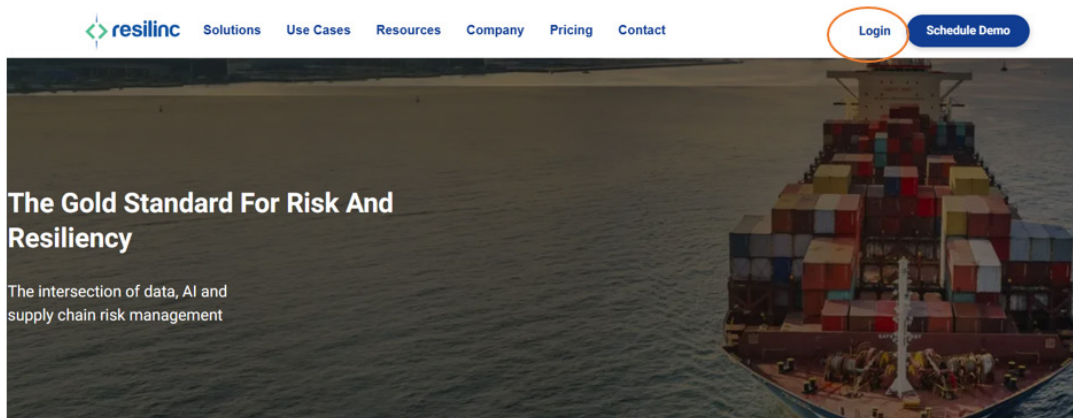
Figure 49.   Resilinc Home Page
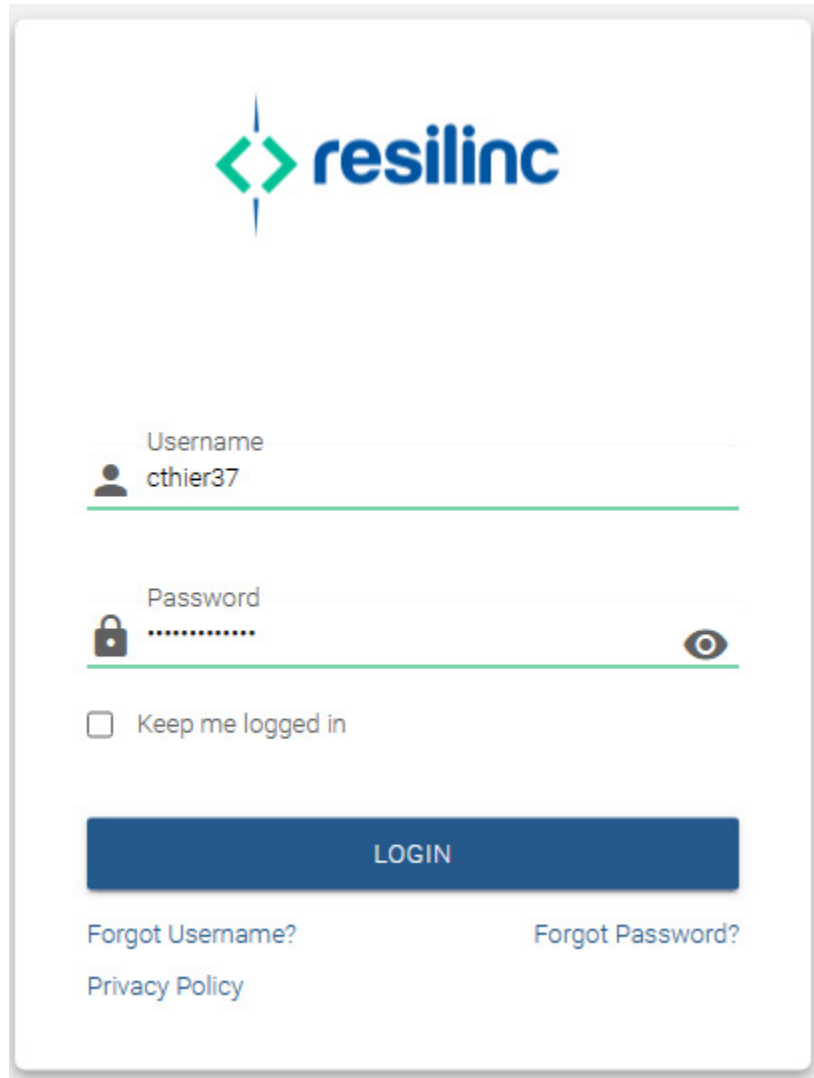
Figure 50.   Resilinc Log-in Screen

B.   LOCATING CURRENT DATA/UPLOADING NEW DATA

1.   Locating Current Data

Step 1: Look for the hourglass image on the left-hand side of the screen.

Step 2: Select the load data arrow.

Step 3: Select the load data option.
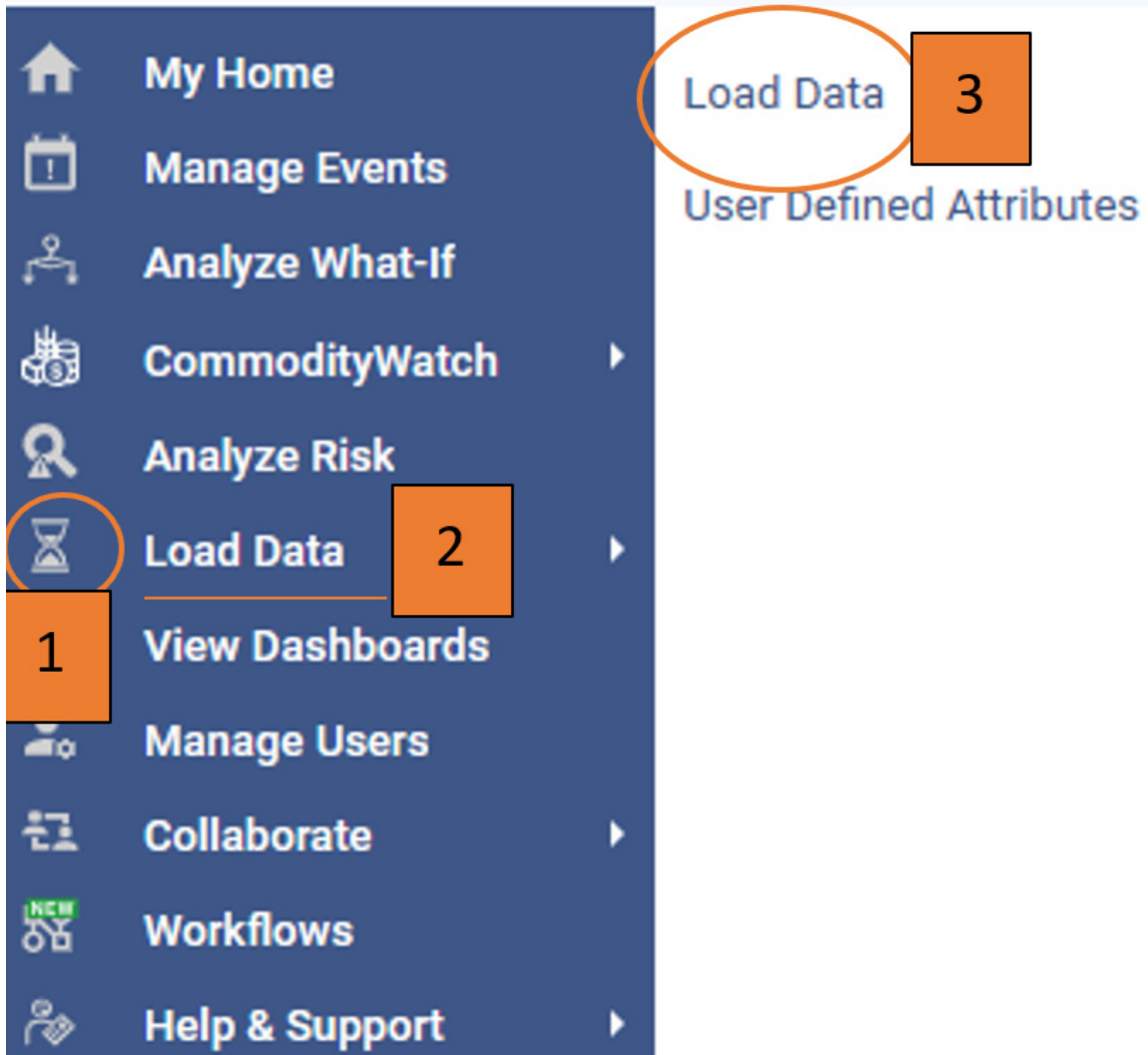
Figure 51.　Data Dashboard

Step 4: Select the download button.

Figure 52. Downloading Current Data

2. Uploading New Data

Step 1: Selecting the down arrow will allow you to download the most current version of the excel spreadsheet.

Step 2: When you have made the required changes select the delete and load option.

Step 3: Upload an updated excel file.

Step 4: Wait for confirmation on the data load status (delete and load)
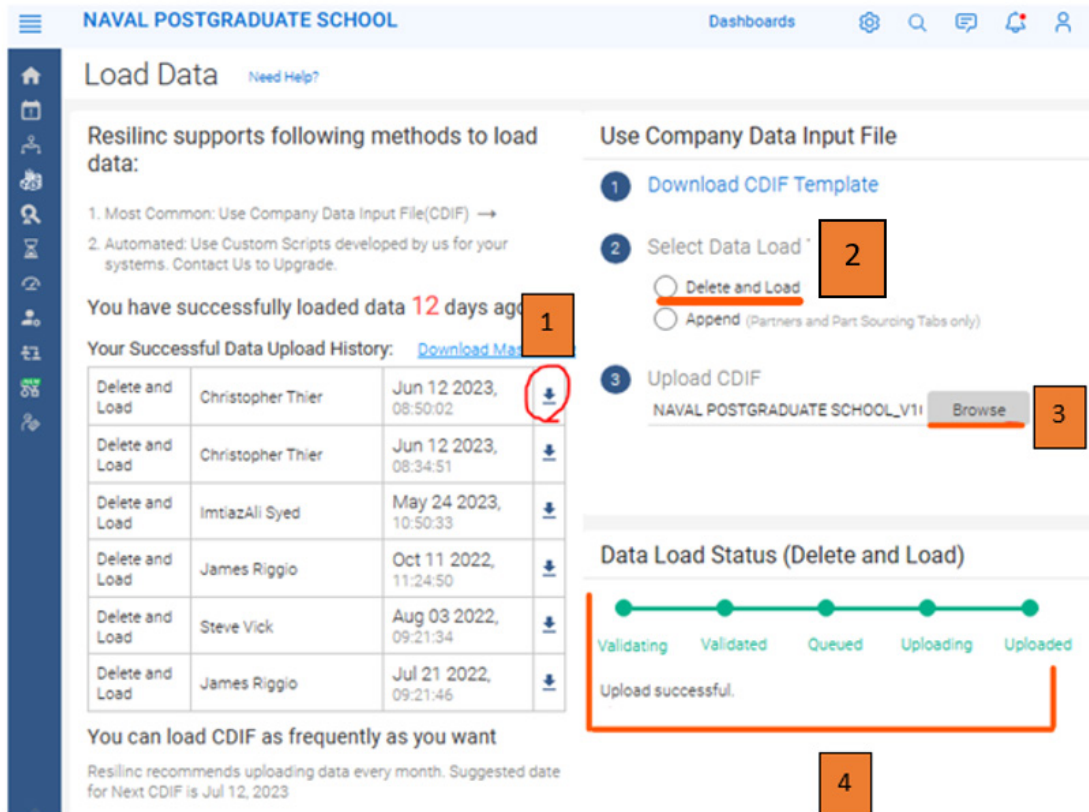
Figure 53.   Uploading New Data

C.   FILTERING SUPPLIERS

Step 1: Go to settings option (gear image) at the top right corner of the screen.
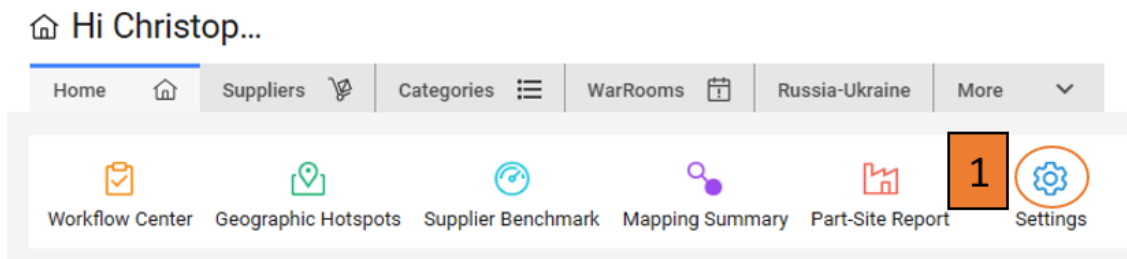
Figure 54.   Settings Option

Step 2: Filter by the supplier's name

Step 3: Once the filter is completed click the save button (highlighted dark blue).
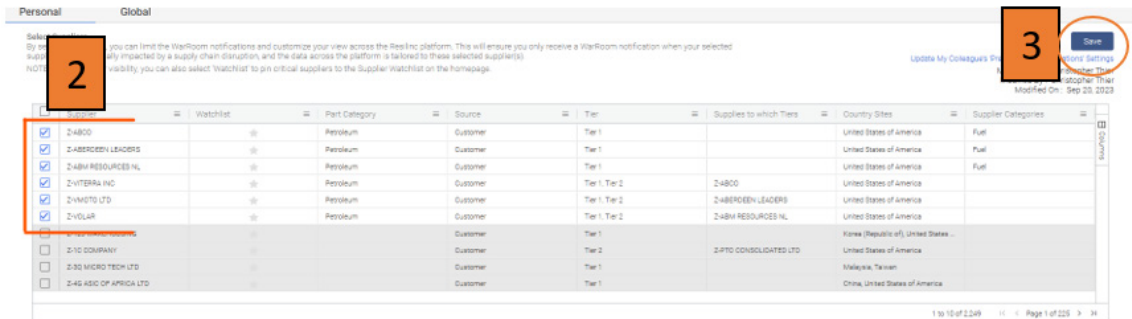
Figure 55.   Filtering Feature

Step 4: Once the filter has been saved the save button will turn gray.
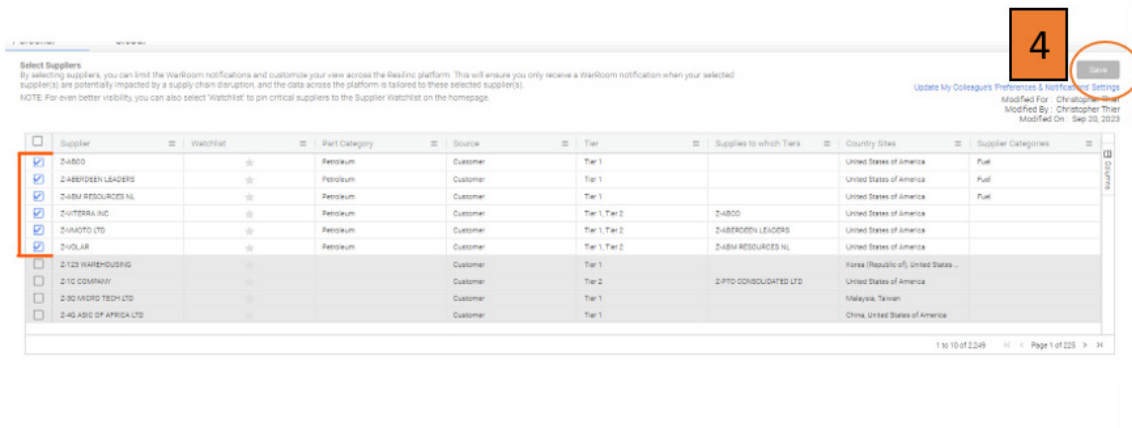
Figure 56.   Saving the Filter Criteria

Step 5: Back at the home screen, you will only see the vendors you filtered in the supplier watchlist on the right side of the screen.

Step 6: To make sure that the filter is correct select the view all link.
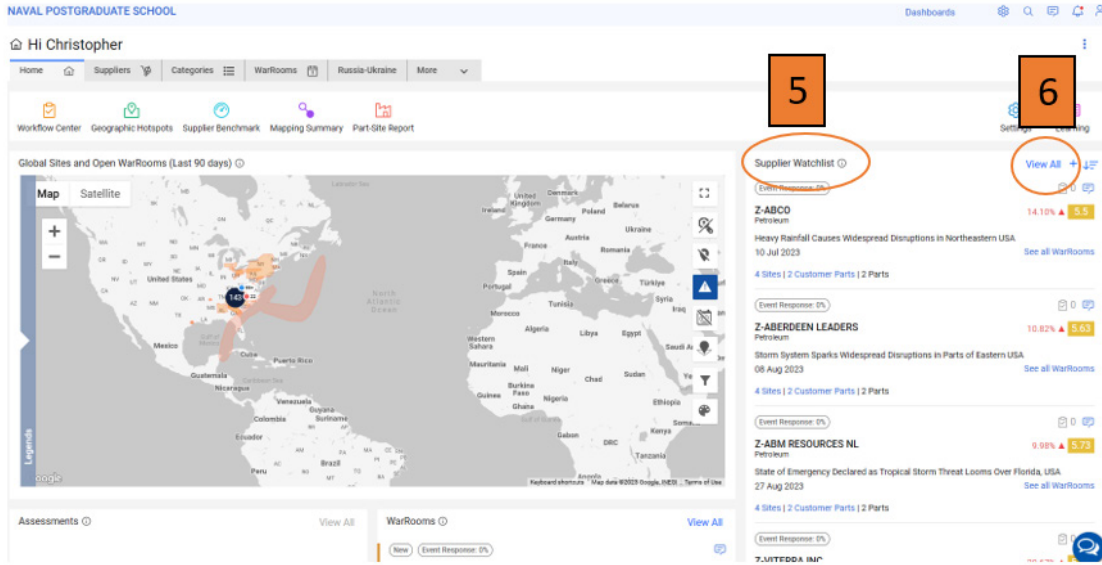
Figure 57.   View Filtered Criteria

Step 7: Review the filtered companies.
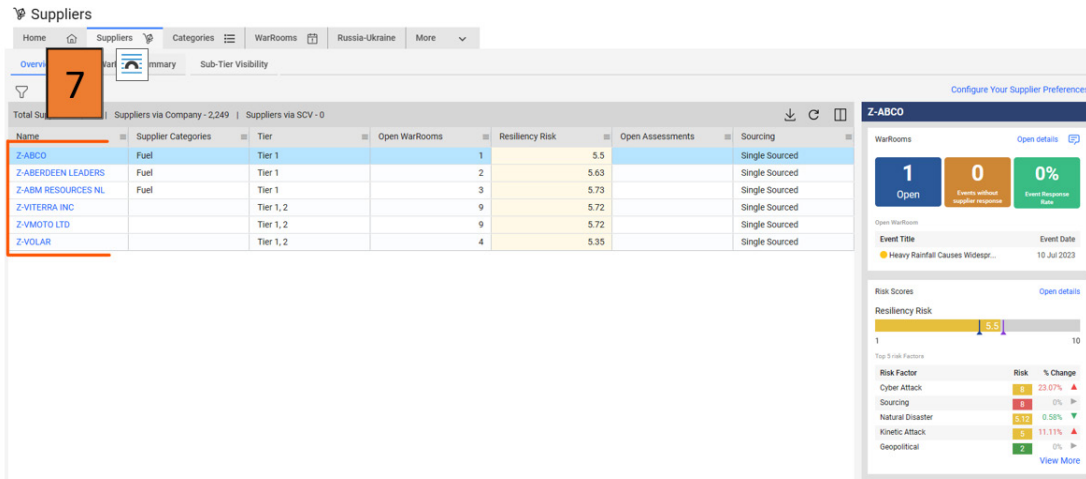
Figure 58.   Supplier Dashboard

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D. CREATING A DASHBOARD FAVORITES LIST

Step 1: Located the page you would like to favorite.

Step 2: Select the star image to add the page to your favorites.

Step 3: The favorite tab can be found by selecting the dashboards option at the top left corner of the screen.

Step 4: The page will now appear under the favorites tab.
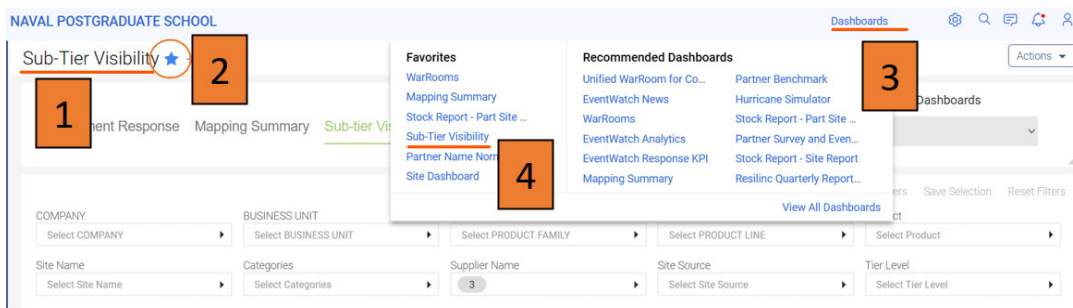
Figure 59.   Favorites List

E. VIEW THE SPIDER MAPPING

Step 1: Go to the mapping summary icon.
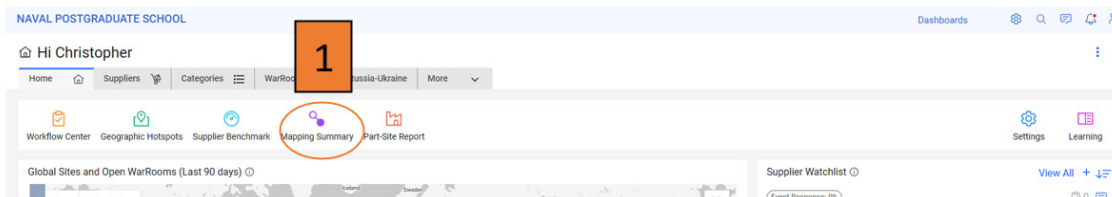
Figure 60.   Mapping Summary Feature

Step 2: Select the sub-tier visibility.

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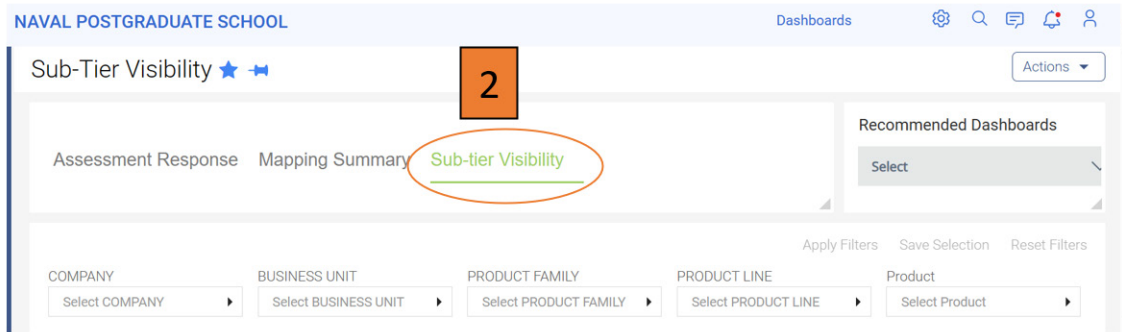
Figure 61.   Sub-Tier Visibility Feature

Step 3: Scroll down to the multi-tier supply chain.
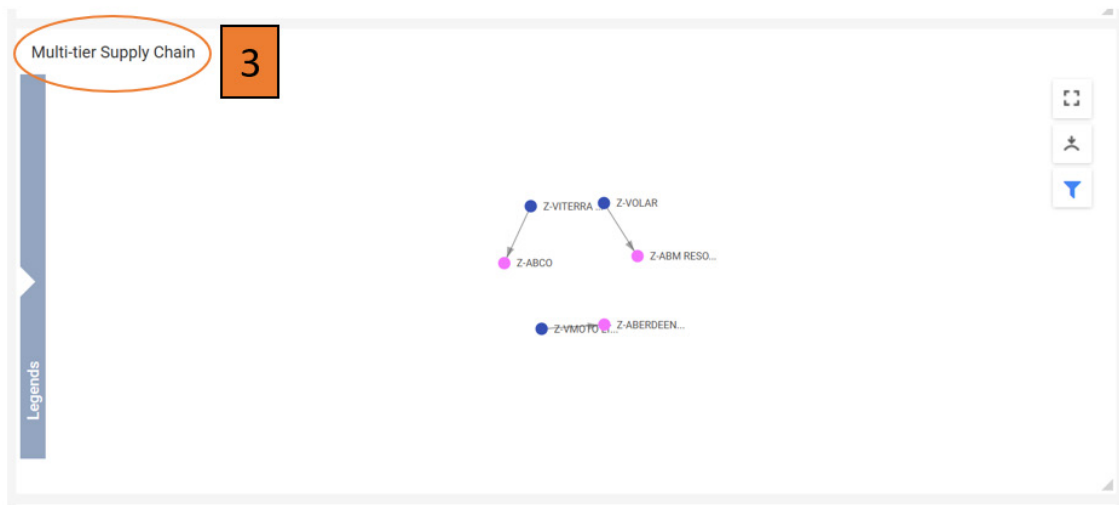
Figure 62.   Multi-Tier Supply Chain

F.   WHAT IF ANALYSIS: CREATING AN EVENT

Step 1. Select the what if analysis icon.
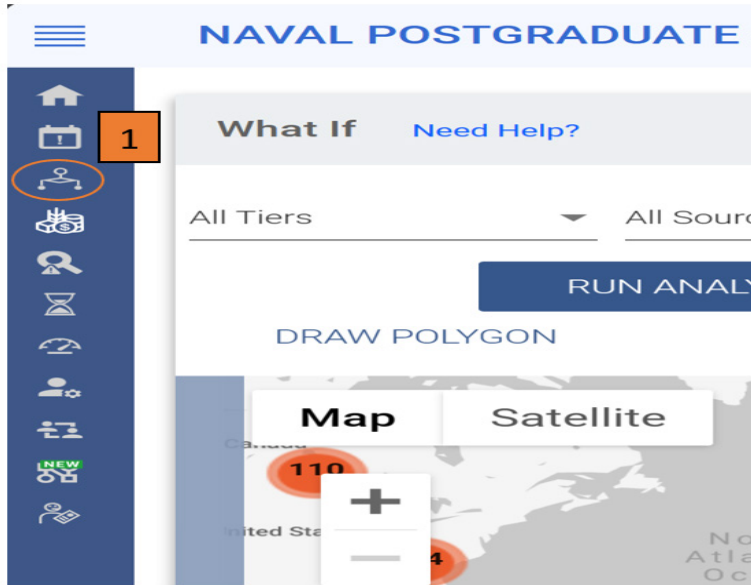
Figure 63.   What-If Feature

Step 2: Then select the analyze what-if option
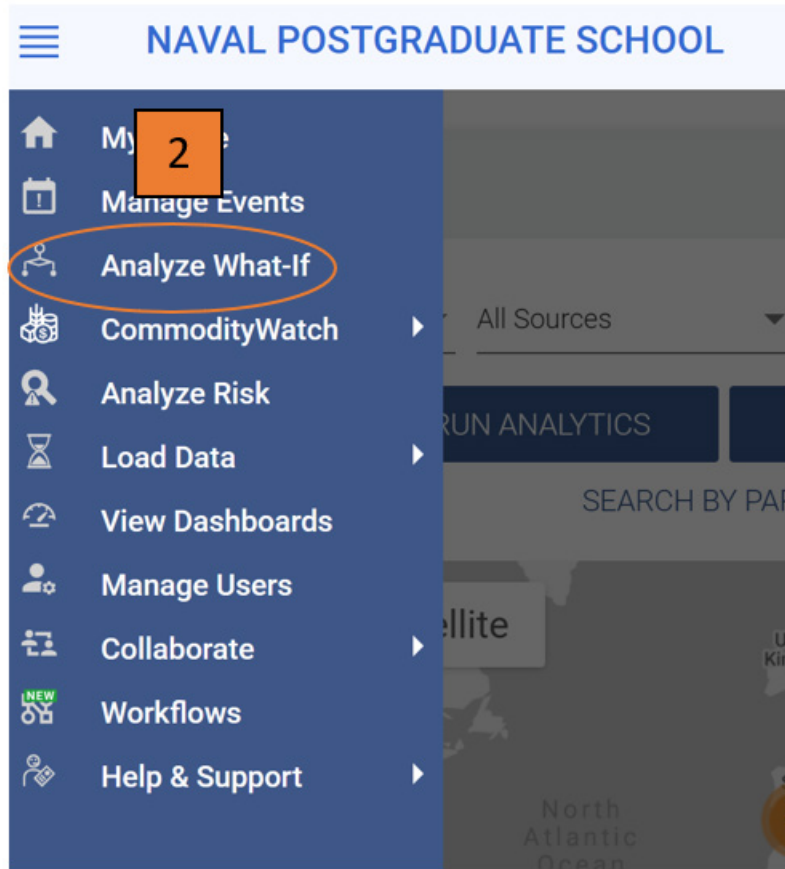
Figure 64.　What-If Analysis Feature

Step 3: Select draw a polygon.
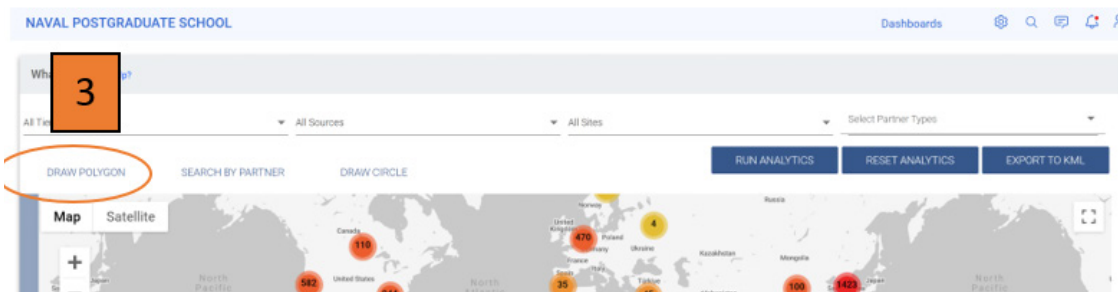
Figure 65.　Creating Event Location

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Step 4: Add a polygon over that area you would like to see impacted by a simulated event.
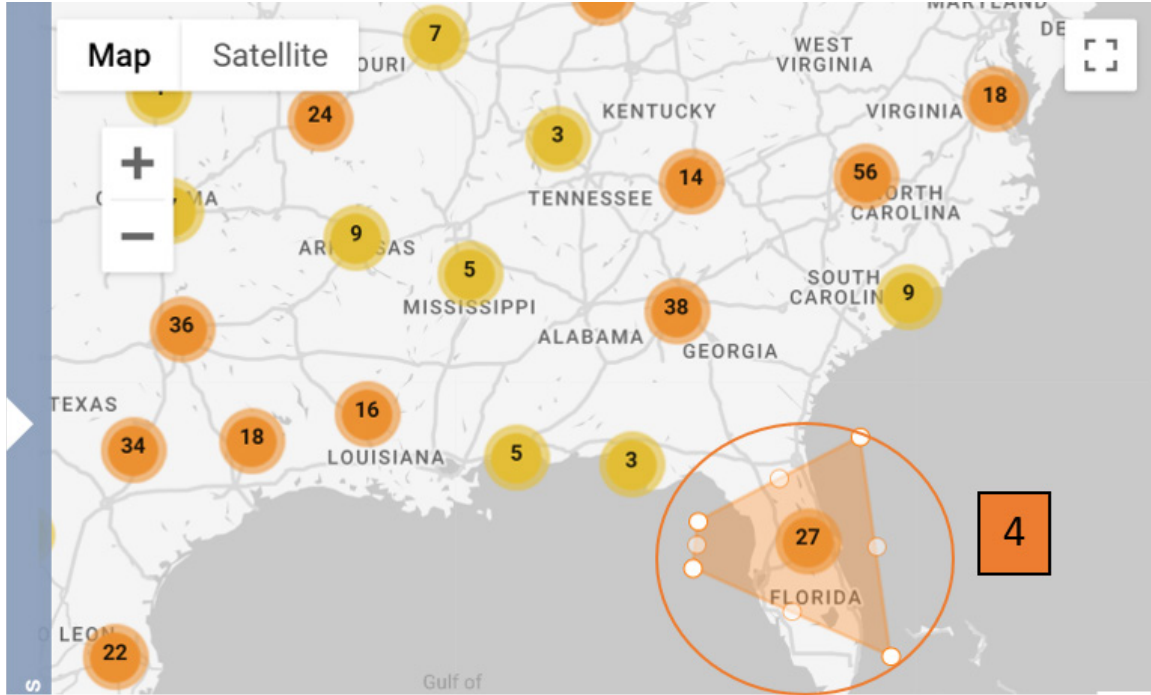
Figure 66.   Drawing Out the Event Location

Step 5: If you would like to have another area impacted then select add new polygon.

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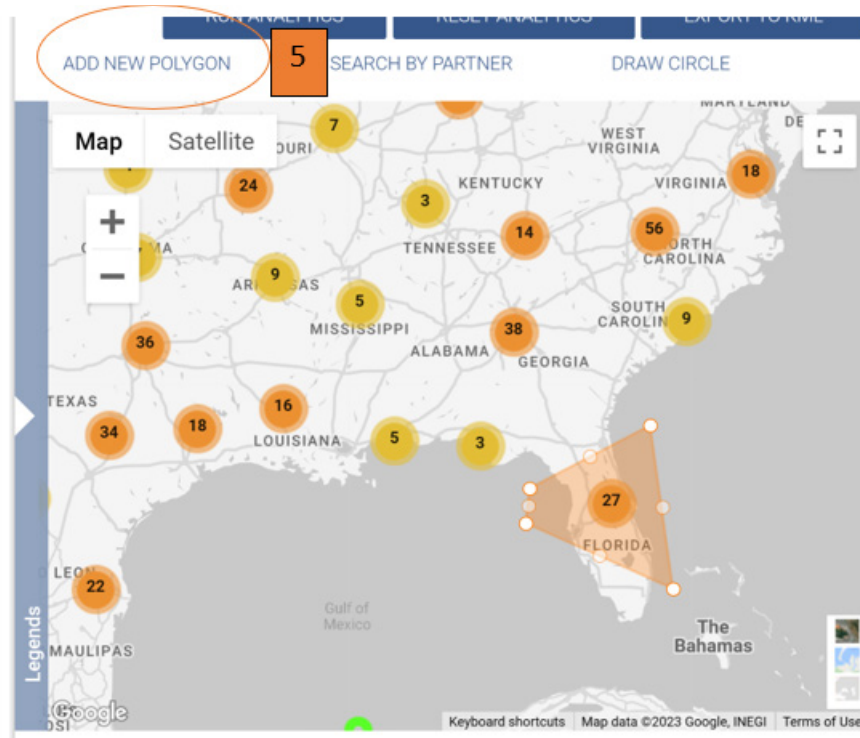
Figure 67. Creating a Second Event

Step 6: Place a second polygon over another impacted area.
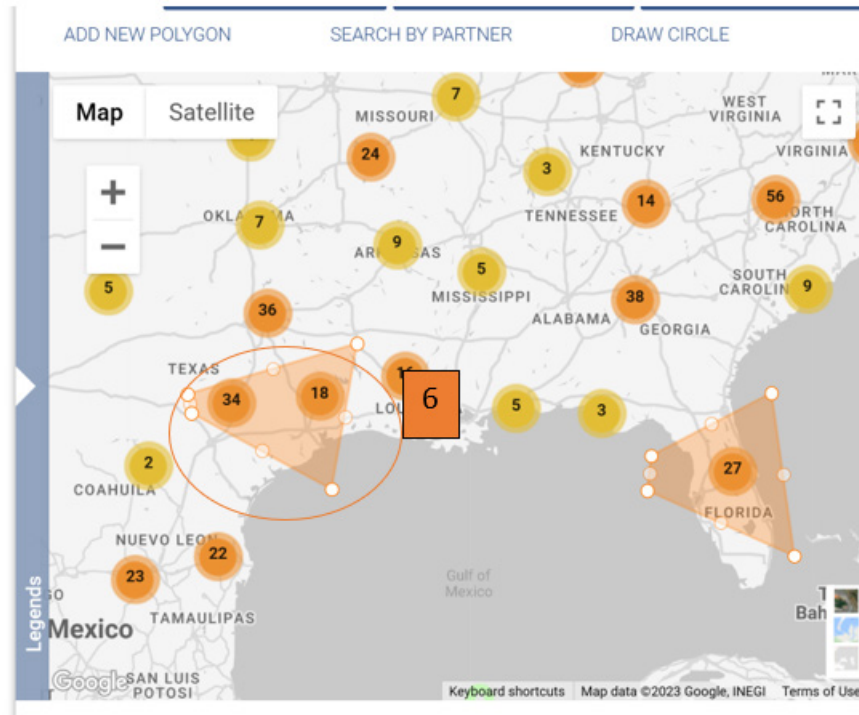
Figure 68.   Drawing out the Second Event Location

Step 7: Select run analytics.

Step 8: Select create event.
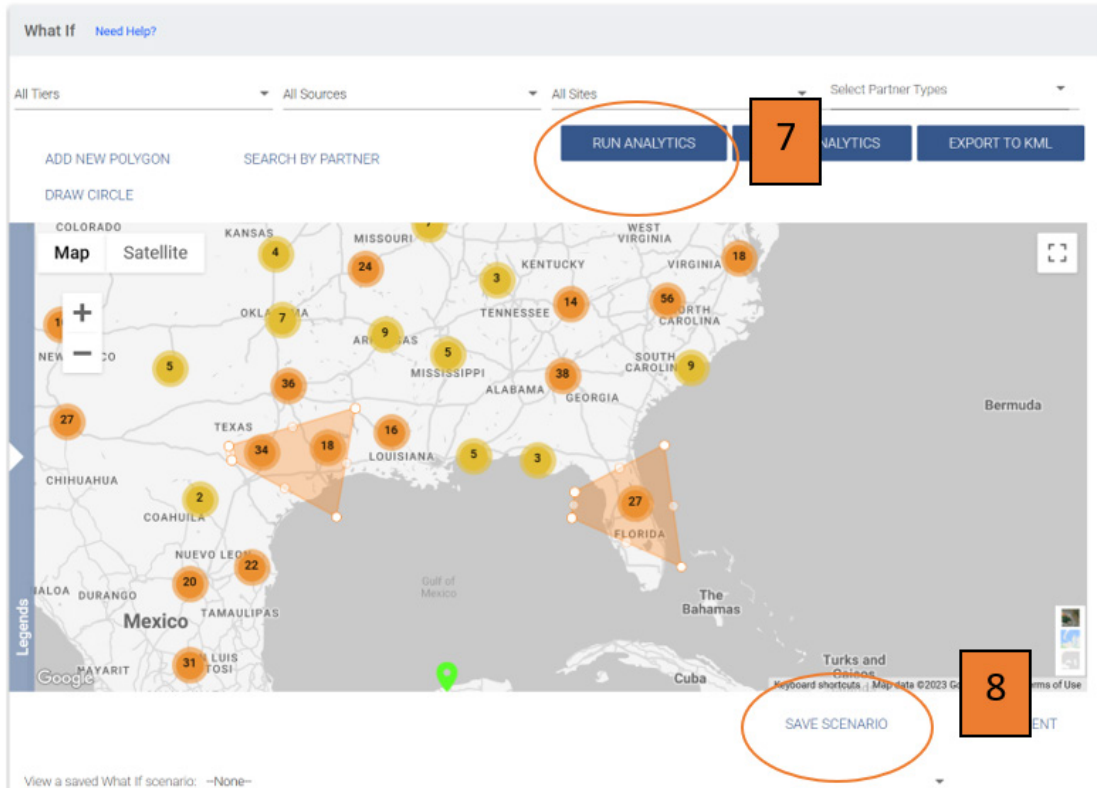
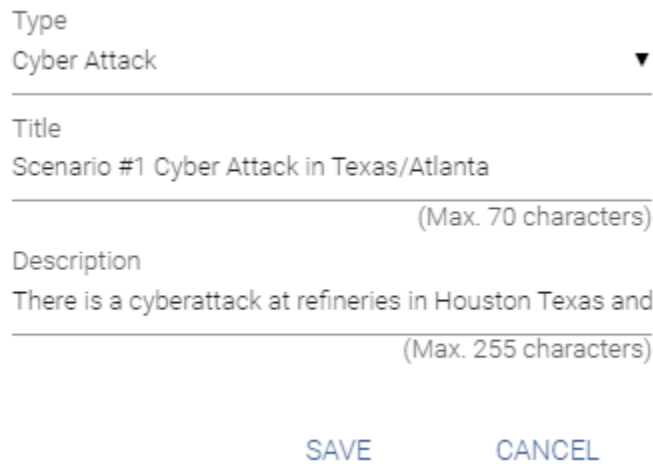Figure 69.   Creating the Scenario

Step 9: Provide the following information:

Example:

Type: Cyber Attack

Note: When naming the event that has no impact on the risk assigned to the supplier, it is just a title.

Title: NPS Simulation—Cyber-Attack—Exercise #2

Description: This is an exercise to simulate a cyber-attack.

When the information has been enter select the save button

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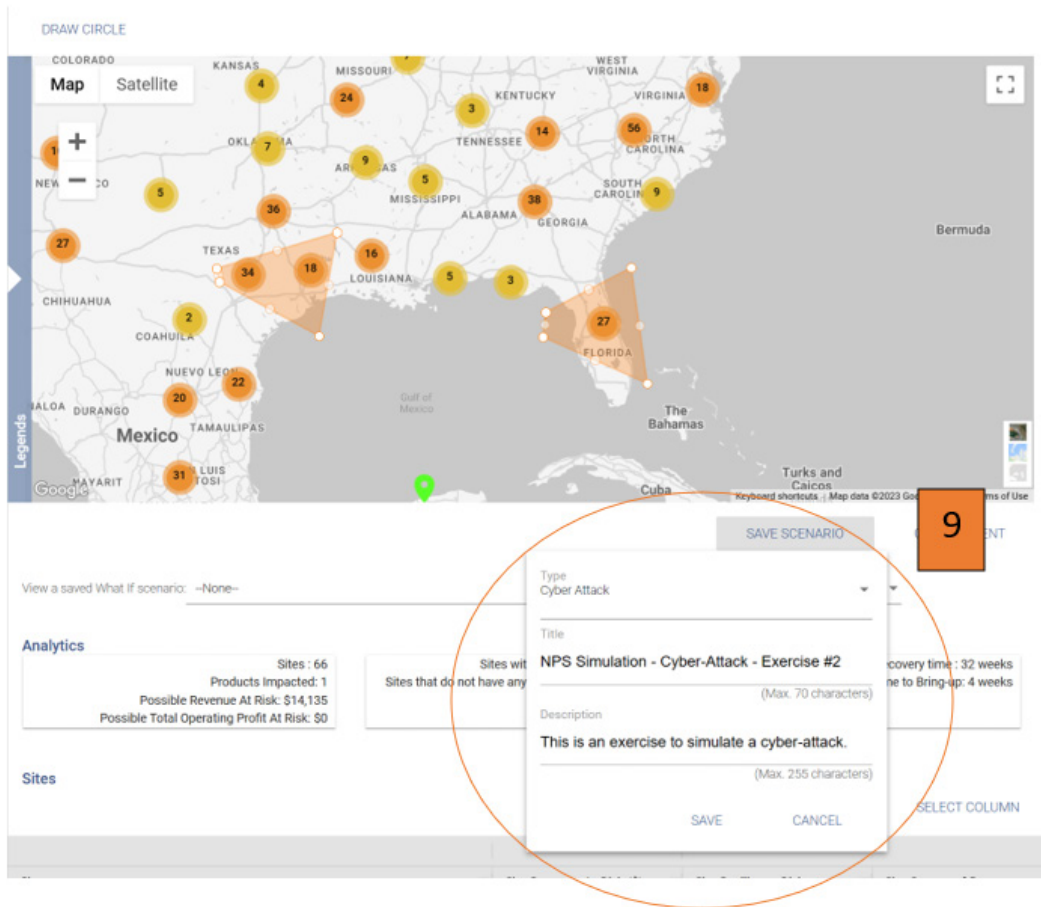
Figure 70.   Naming the Scenario

Step 10: Refresh the page to see your event(s) appear in the view a saved what if scenario drop down menu.
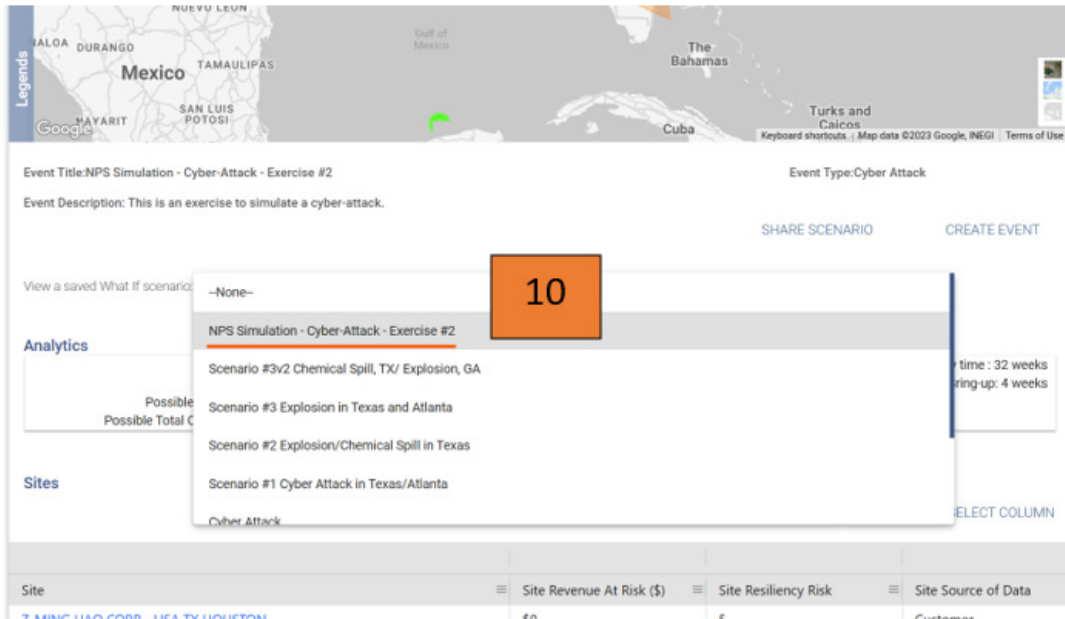
Figure 71.   Saving the scenario

G.   CREATE SCENARIO #1

Cyber Attacks at Houston, Texas, and Atlanta, Georgia.

Step 1: First select the areas affected by the cyber-attack.

Step 2: Select Houston, Texas:

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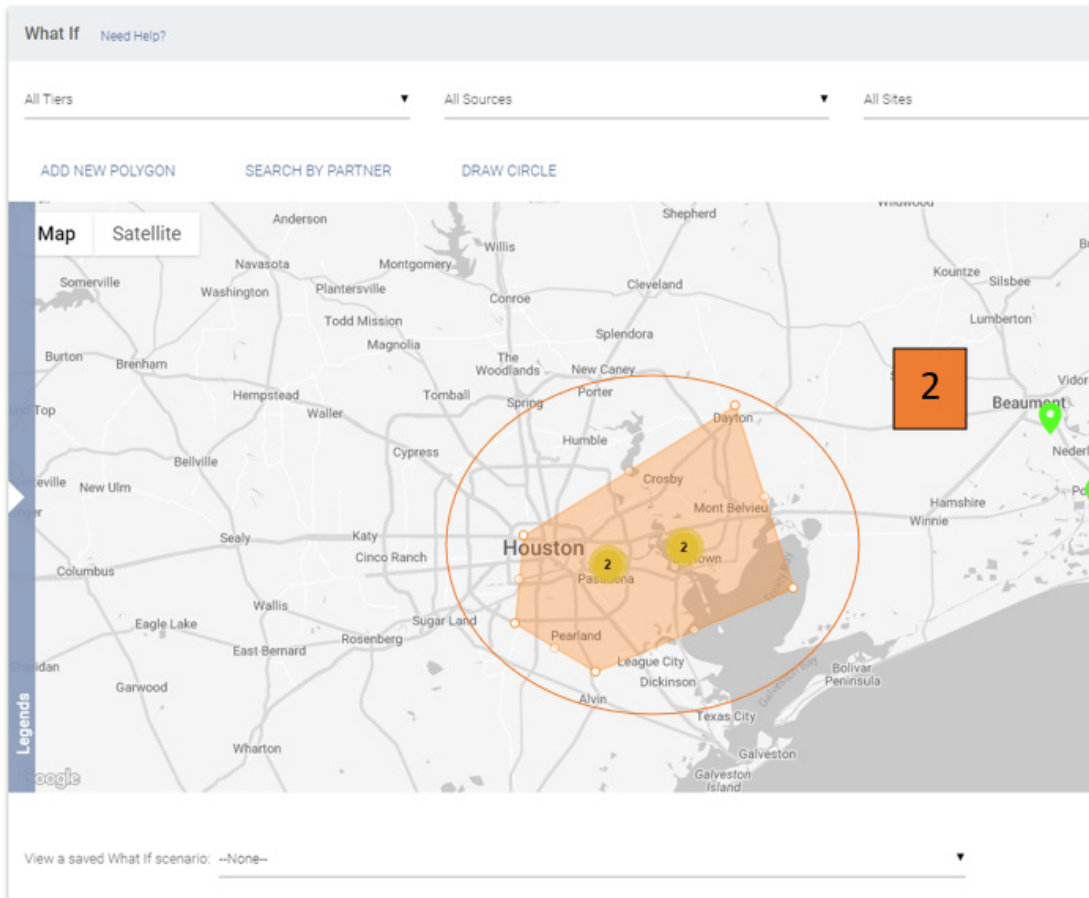
Figure 72.   Cyber Attack Event at Houston Texas

Step 3: Select Atlanta, Georgia
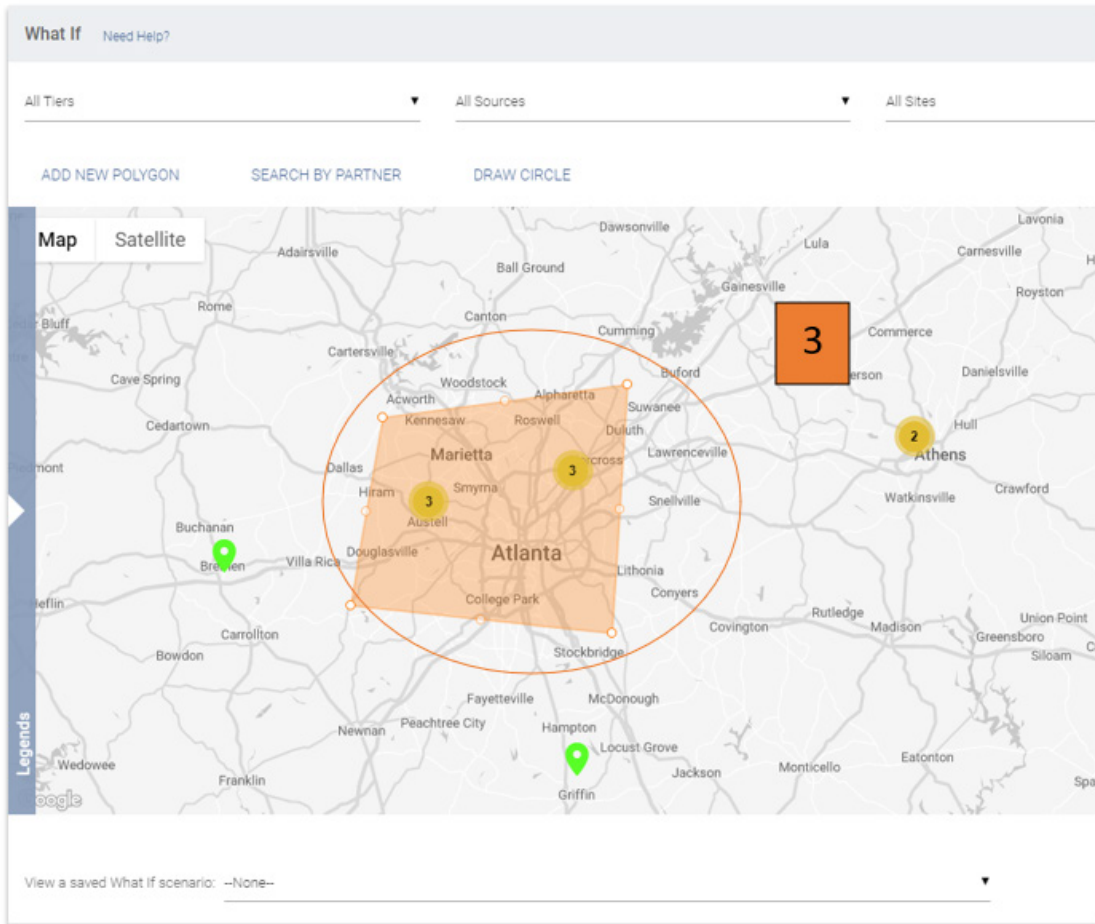
Figure 73.　Cyber Attack in Atlanta Georgia

Step 4: Select run analytics.

Step 5: Save the scenario.

Step 6: Provide the following information:

Example:

Type: Cyber Attack

Note: When naming the event that has no impact on the risk assigned to the supplier, it is just a title.

Title: Scenario #1 Cyber Attack in Texas/Atlanta

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Description: There is a cyberattack at refineries in Houston, Texas and Atlanta, Georgia.

When the information has been entered select the save button.

Figure 74.   Saving the Cyber Attack Scenario

H.   CREATE SCENARIO #2

Simulate an explosion at the Houston refineries with a subsequent chemical/oil spill.

Step 1: Locate the area affected.

Step 2: Select draw circle.

Step 3: The provide the address.

Step 4: Provide the radius

Step 5: Select draw circle
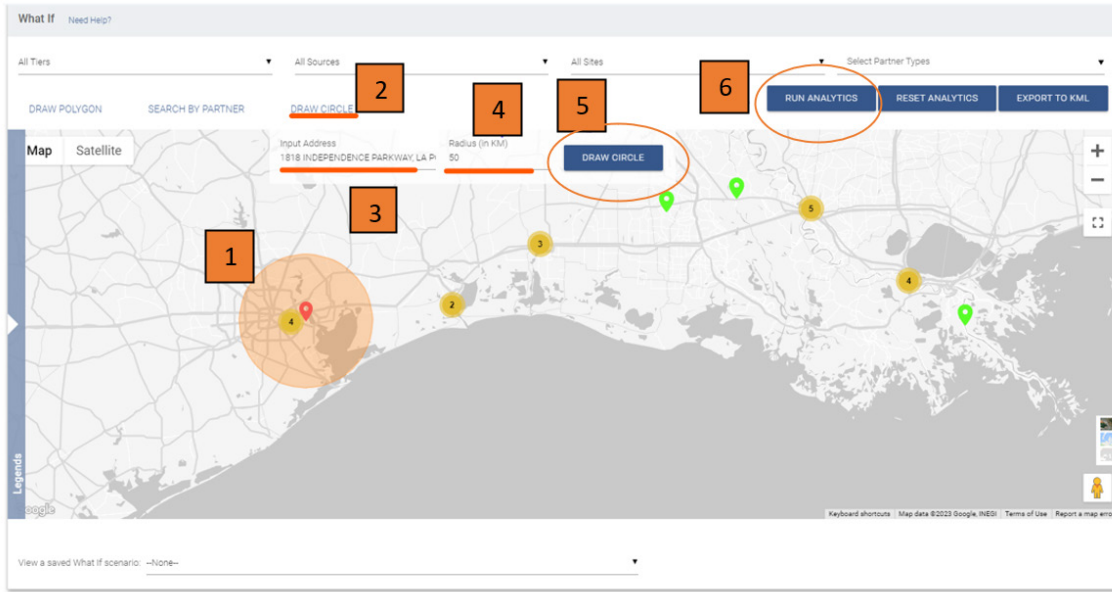
Step 6: Then select run analytics

Figure 75.   Chemical Spill in Houston Texas

Step 7: Save the scenario

Figure 76.   Saving the Chemical Spill Scenario

I.   CREATE SCENARIO #3

Step 1: Select the locations affected by the event.

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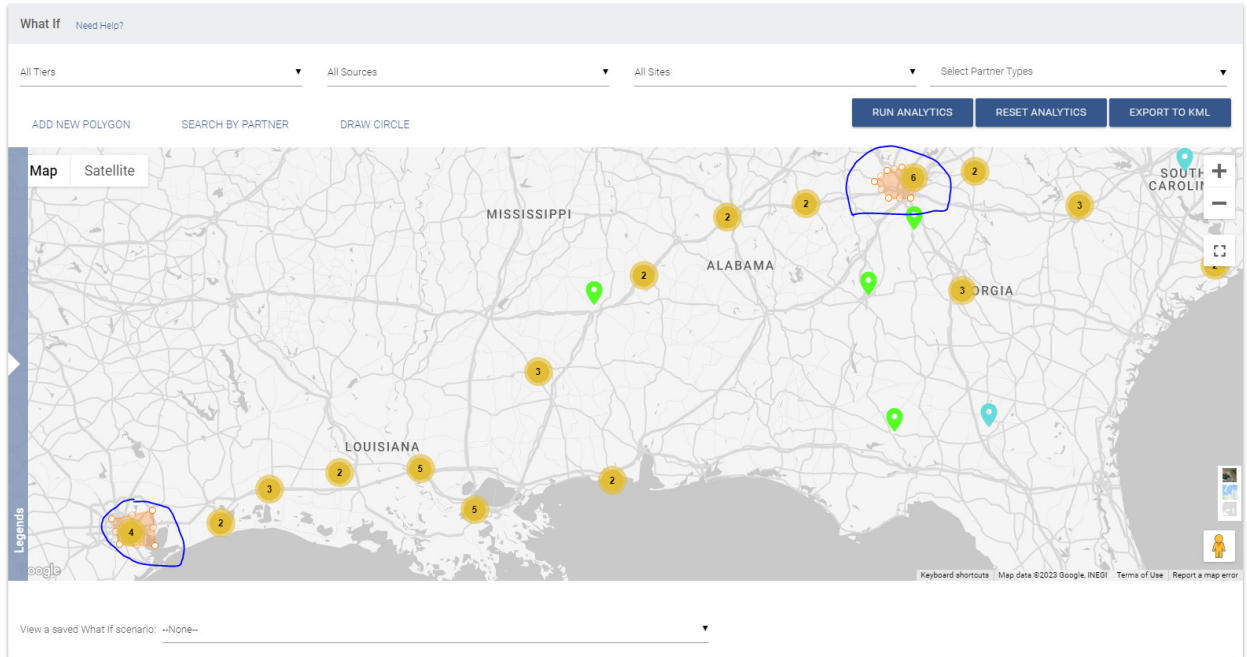
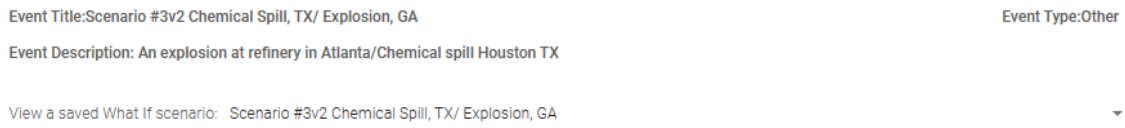Figure 77. Explosion at Texas and Georgia Refineries

Step 2: Save the scenario

Event Title:Scenario #3v2 Chemical Spill, TX/ Explosion, GA   Event Type:Other

Event Description: An explosion at refinery in Atlanta/Chemical spill Houston TX

View a saved What If scenario: Scenario #3v2 Chemical Spill, TX/ Explosion, GA   ▼

Figure 78. Saving Scenario #3

J.   VIEWING RISK SCORES

Step 1: Select a site you have in the scenario.

Figure 79.　Selecting a Site and Partner for Risk Resilience

Step 2: Select risk score

Figure 80.　Selecting Risk Score

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Figure 81. Site Risk Scores

K. SCENARIO COMPARISON

1. Impact of Selecting a Different Scenario (Cyber Attack Versus Chemical Spill)

Example 1: Cyber Attack Exercise
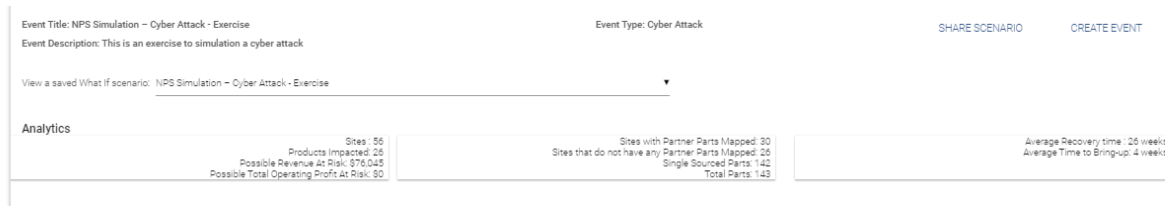
Figure 82. Cyber Attack: Scenario #1

Example 2: Chemical Spill Exercise
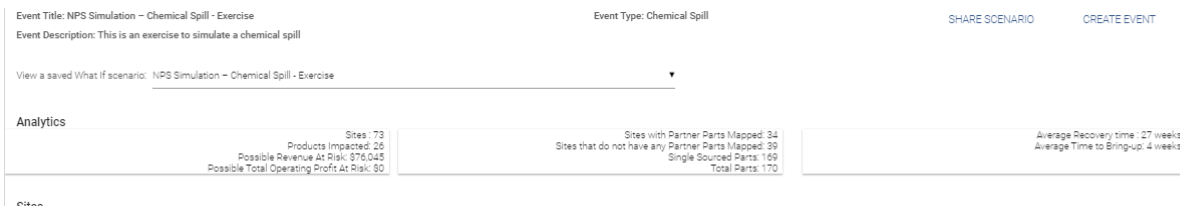
Figure 83. Chemical Spill Scenario

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2. Exporting Results to Excel

Once you have the list of vendors impacted by the scenario click the export to excel option.

Figure 84.   Exporting Result to Excel

L. LINKS TO WAR ROOMS

NPS Simulation—Cyber Attack—Exercise

https://home.resilinc.com/#/warroom/17103677?tab=overview

M. ADJUSTING THE RISK

Step 1: Customer risk can be found in Tab 1—partner list

Step 2: There are in Columns U, V, W, X, Y

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Figure 85.   Customer Risk

Step 3: Add the desires risk values.

Note: Do not alter the column headers

Step 4: Assign a risk score to the respective suppler (row)

Step 5: Upload the data to Resilinc

Step 6: Once the upload is completed, go to Resilinc and go to setting icon (in the dashboard)
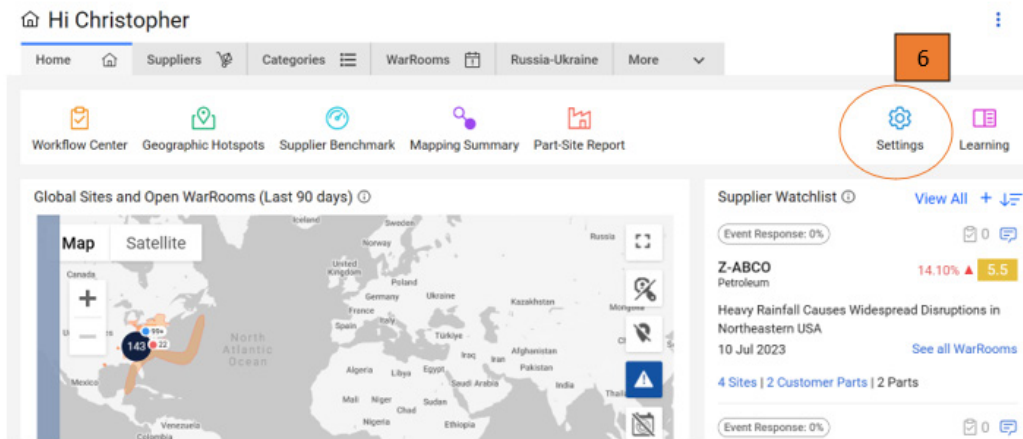
Figure 85

Figure 86.   Setting Icon

Step 8: Select the risk tab.

Step 9: Select add new.

Step 10: Add the data related to

- Name
- Source
- Level
- Type
- Mapped to CDIF (this will align with the customer risk score column in the spreadsheet)

Note: The weights column should add up to 100.

Figure 87.   Adding A New Risk

Below is an example of the risks kinetic attack and cyber-attack being added:

Figure 88.   Adding the Risk: Physical Attack

Step 11: Review the data in the supplier risk dashboard.
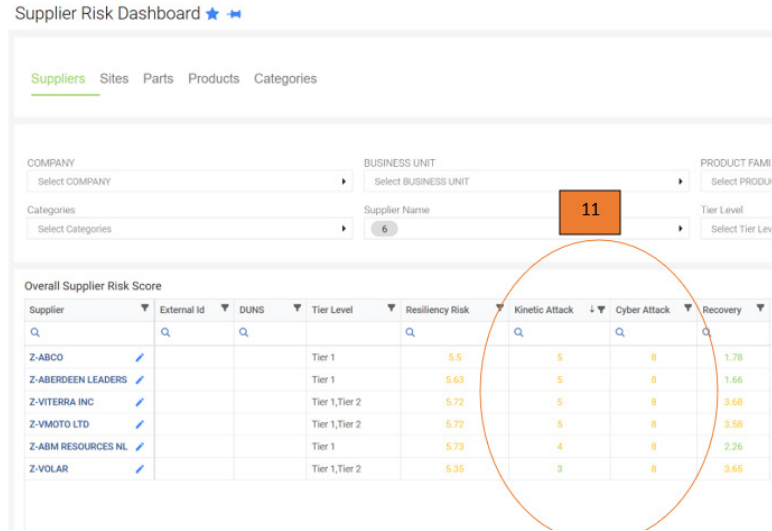
Figure 89.   Verifying the physical attack risk was added

N.   OVERRIDE SCORE (MANUAL ENTRY OF THE RISK)

Step 1: Go to the supplier risk dashboard.

Step 2: Select the supplier.
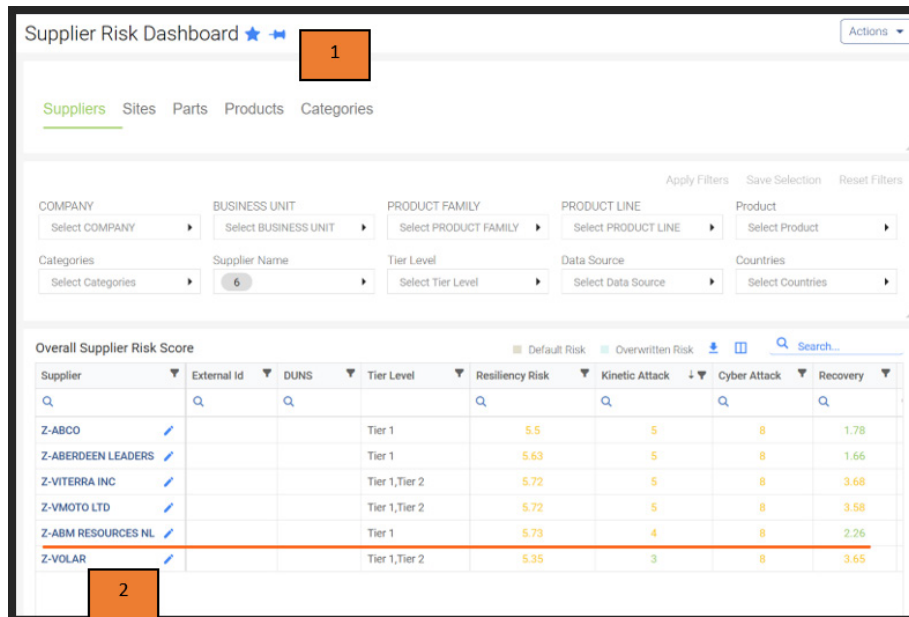
Figure 90.   Supplier Risk Dashboard

Step 3: Go to overwrite scores under the quick links section.
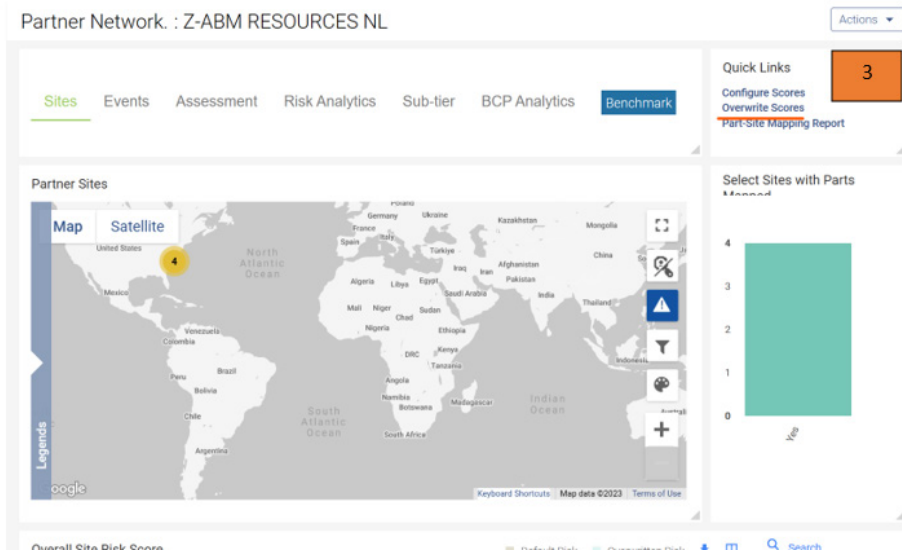
Figure 91.   Overwrite Current Risk Score

APPENDIX C. RESILINC DATA ENTRY GUIDE

A. TAB RELATIONSHIPS/LINKS

Below are key terms that link each spreadsheet.
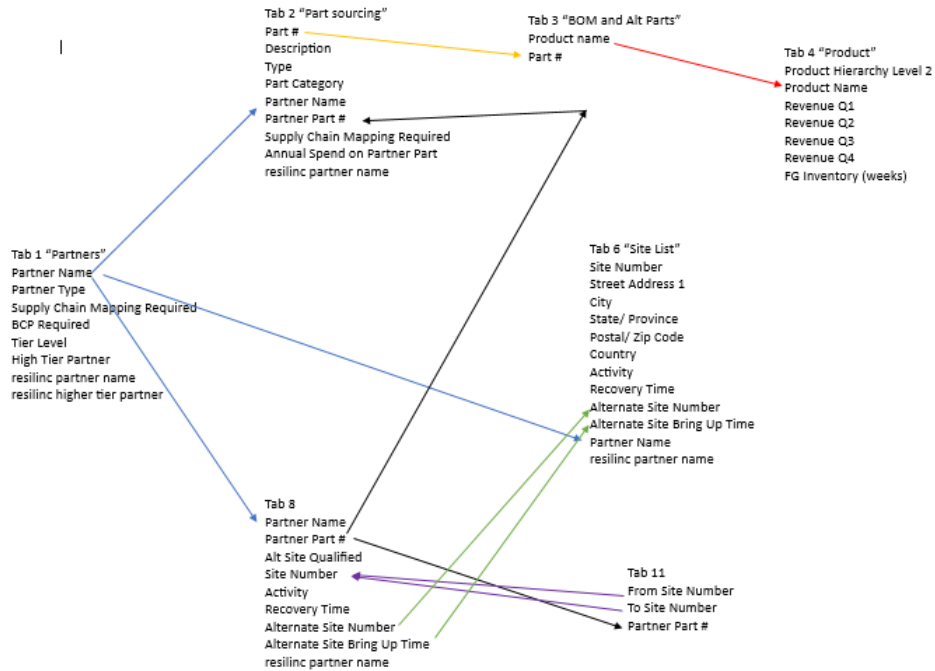
Figure 92.   Tab Relationships

B. TAB 1: PARTNERS—CREATING THE TIER 1 AND 2 RELATIONSHIPS

Step 1: Select the partner name for your Tier 1 and Tier 2 suppliers.

Step 2: You will need to enter the following information:

Table 7.   Columns for Data Entry in Tab 1—Partners

Column Name	Column	Optional/Required
Partner Name	A	Required
Partner Type	C	Optional
Supply Chain Mapping Required	K	Required (Yes)
BCP Required	L	Required (Yes)
Partner Custom Defined Risk Score (1)	U	Optional
Partner Custom Defined Risk Score (2)	V	Optional
Partner Custom Defined Risk Score (3)	W	Optional
Partner Custom Defined Risk Score (4)	X	Optional
Partner Custom Defined Risk Score (5)	Y	Optional
Tier Level	AG	Required
Higher Tier Partner	AH	Required
resilinc partner name	AI	Required
resilinc higher tier partner	AJ	Required

Step 3: Once you have determined the information that will be placed in Columns A, C, K, L, and AI, you will have to define the relationship between the partners in Columns AG and AH.

The relationship between the Tiers works as follows:

Tier 1 <- Tier 2 <- Tier 3 <- Tier 4 … <- Tier 10

Tier 1 being the highest and Tier 10 being the lowest.

To create a spider map between the sites in Reslinic, there must be more than one tier.

See the example below for linking Tier 1 and Tier 2 suppliers:

Table 8.   Creating Tier 1 and Tier 2 Supplier Relationships

Column A	Column C	Column AG	Column AH	Column AI	Column AJ
Partner Name	Partner Type	Tier Level	Higher Tier Partner	resilinc partner name	resilinc higher tier partner
Z-ABCO	Other	1		Z-ABCO	
Z-ABERDEEN LEADERS	Other	1		Z-ABERDEEN LEADERS	
Z-ABM RESOURCES NL	Other	1		Z-ABM RESOURCES NL	
Z-VITERRA INC	Other	2	Z-ABCO	Z-VITERRA INC	Z-ABCO
Z-VMOTO LTD	Other	2	Z-ABERDEEN LEADERS	Z-VMOTO LTD	Z-ABERDEEN LEADERS
Z-VOLAR	Other	2	Z-ABM RESOURCES NL	Z-VOLAR	Z-ABM RESOURCES NL

In Column A, the Partner Name contains Z-ABCO, Z-ABERDEEN LEADERS, and Z- ABM RESOURCES NL which are Tier 1 suppliers, while Z-VITERRA INC, Z-VMOTO LTD, and Z-VOLAR are Tier 2 suppliers.

The Tier 2 Suppliers are linked to the Tier 1 Suppliers with a Column AH—Higher Tier Partner and Column AJ—resilinc higher tier partner.

1.   Risk Assessment Modification

Step 1. Enter the data in Columns U, V, W, X, Y

Table 9.   Adding Additional Risk Factors

Column A	Column U	Column V	Column W
Partner Name	Partner Custom Defined Risk Score (1)	Partner Custom Defined Risk Score (2)	Partner Custom Defined Risk Score (3)
Z-ABCO	8		5
Z-ABERDEEN LEADERS	8		5
Z-ABM RESOURCES NL	8		4
Z-VITERRA INC	8		5
Z-VMOTO LTD	8		5
Z-VOLAR	8		3

Column U—represents the cyber-attack risk.

Column W—represents the physical attack risk.

2.   Resilinc Program

This information will be found in the Hierarchical Multi-Tier Table

Step 1: Go to the home page.

Step 2: Select the Suppliers.

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Figure 93.   Location of Tier 1 and Tier 2 Relationship within Resilinc

Plantation Pipeline

Tab 1. Z-VITERRA INC (Tier 2) is a sub tier of Z-ABCO (Tier 1)

Colonial Pipeline

Tab 1. Z-VMOTO LTD (Tier 2) is a sub tier of Z-ABERDEEN LEADERS (Tier 1)

Buckeye Pipeline

Tab 1. Z-VOLAR (Tier 2) is a sub tier of Z-ABM RESOURCES NL (Tier 1)

C.   **TAB 2: PART SOURCING—CREATING PARTS FOR THE SUPPLY CHAIN**

Step 1: Define the names of the parts you will need in your supply chain.

For example,

CP12345678: This Part # will represent the fuel that is moving through the Colonial Pipeline.

PP12345678: This Part # will represent the fuel that is moving through the Plantation pipeline.

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BP12345678: This Part # will represent the fuel that is moving through the Buckeye pipeline.

Step 2: You will need to enter the following information:

Table 10. Columns for Data Entry in The Part Sourcing Tab

Column Name	Column	Optional/Required
Part #	A	Required
Description	B	Optional
Part Category	D	Optional
Partner Name	E	Required
Partner #	F	Required
Supply Chain Mapping	T	Required (Yes)
Annual Spend	W	Optional
reslinic partner name	X	Required

Step 3: Now that the Part # has been created, it can be linked to the Partner Name via Tab 2 Column E—Partner Name to Tab 1 Column A—Partner Name

Table 11. Assigning a Partner Name to a Part #

Part #	Description	Type	Part Category	Partner Name	Partner Part #	Supply Chain Mapping Required	Annual Spend on Partner	Rrsilinc partner name
PP12345678	Fuel PP	Part	Petroleum	Z-ABCO	PP12345678	Y	10,000	Z-ABCO
CP12345678	Fuel CP	Part	Petroleum	Z-ABERDEEN LEADERS	CP12345678	Y	10,000	Z-ABERDEEN LEADERS
BP12345678	Fuel BP	Part	Petroleum	Z-ABM RESOURCES NL	BP12345678	Y	10,000	Z-ABM RESOURCES NL
PP12345678	Fuel PP	Part	Petroleum	Z-VITERRA INC	PP12345678	Y		Z-VITERRA INC
CP12345678	Fuel CP	Part	Petroleum	Z-VMOTO LTD	CP12345678	Y		Z-VMOTO LTD
BP12345678	Fuel BP	Part	Petroleum	Z-VOLAR	BP12345678	Y		Z-VOLAR

Looking at Column A—Part # -> PP12345678, this part is described with Fuel PP (which is the fuel is flowing through the Plantation Pipeline) is assigned to Z-ABCO and Z-VITERRA INC. Since the Tier relationship was created in Tab 1, Resilinc created a spider map that will have Z-VITERRA INC. as the Tier 2 supplier providing Part # PP12345678 to the Z-ABCO the Tier 1 supplier. Therefore, the flow of Part #— PP12345678 will start with Z-VITERRA INC and end at Z-ABCO.

Annual spend (tab 2) is not the same as revenue at risk (on tab 4).

Revenue at risk is only based on the data provided on tab 4, and how to link that data on tables 1, 2, and 3.

1.   **Result**

Plantation Pipeline

Tab 1. Z-VITERRA INC (Tier 2) is a sub tier of Z-ABCO (Tier 1)

Tab 2. Both have been assigned Part # and Partner Part # PP123456789

Tab 2. Z-ABCO has been assigned an annual revenue of $10,000.

Colonial Pipeline

Tab 1. Z-VMOTO LTD (Tier 2) is a sub tier of Z-ABERDEEN LEADERS (Tier 1)

Tab 2. Both have been assigned Part # and Partner Part # CP123456789

Tab 2. Z-ABERDEEN LEADERS has been assigned an annual revenue of $10,000.

Buckeye Pipeline

Tab 1. Z-VOLAR (Tier 2) is a sub tier of Z-ABM RESOURCES NL (Tier 1)

Tab 2. Both have been assigned Part # and Partner Part # BP123456789

Tab 2. Z-ABM RESOURCES NL has been assigned an annual revenue of $10,000.

2.   **Resilinc Program**

This information can be found in the part dashboard.

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Step 1: Select the Dashboard at the top right of the screen.

Step 2: Select view all dashboards.
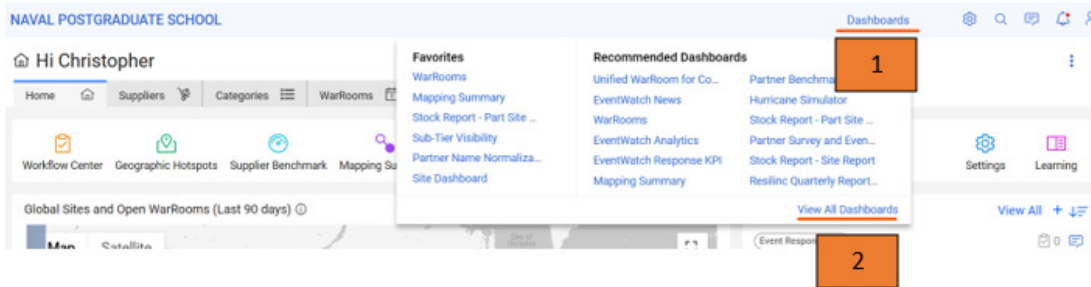
Figure 94.   Viewing the Dashboard Page

Step 3: Search for parts dashboard
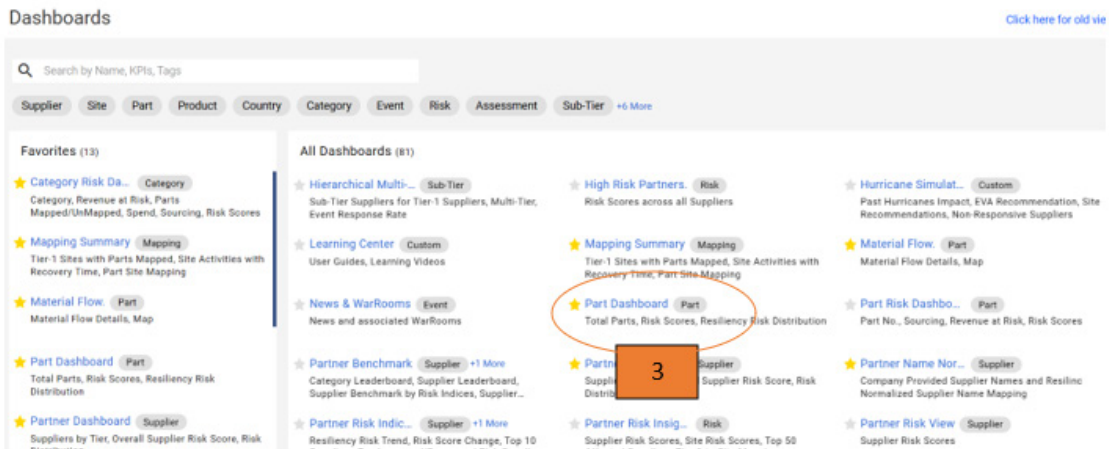
Figure 95.   Selecting the Parts Dashboard

Step 4: Select the parts tab

Step 5: Set product to select all -> Fuel PP, CP, BP

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Step 6: Set partner name to select all -> Z-ABCO, Z-ABERDEEN, Z-ABM RESOURCES NL, VITERRA INC, Z-VMOTO LTD, AND Z-VOLAR

Step 7: Set the categories to Petroleum.
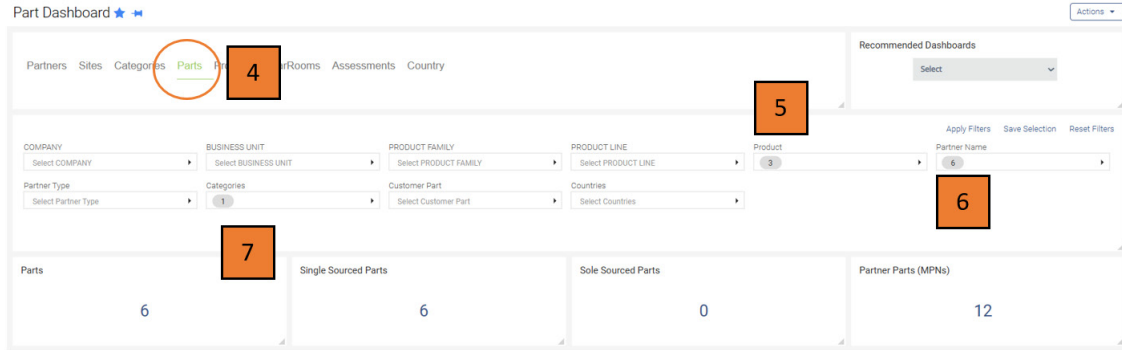
Figure 96.   Filtering the Suppliers

D.   TAB 3: BOM AND ALT PARTS—ASSIGNING A PRODUCT NAME TO A PART

Step 1: Make sure that the product name is linked to part #.

Step 2: You will need to provide the following information.

Table 12.   Columns for Data Entry in the BOM and ALT PARTS Tab

Column Name	Column	Optional/Required
Product Name	A	Required
Part #	B	Required

Step 3: Below is an example of how the relationship between product name and part # is established.

Table 13.   Connecting Product name and Part #

Column A	Column B
Product name	Part #
Fuel PP	PP12345678
Fuel CP	CP12345678
Fuel BP	BP12345678

In this example, the product name (fuel pp) is connected to part # (PP12345678)

With this tab completed the product name is now matched with the partner name through the following:

Tab 3 Column B—Part # and Tab 2 Column A—Part #

Tab 2 Column E Partner Name and Tab 1 Column A Partner Name

1.   Result

Plantation Pipeline

Tab 1. Z-VITERRA INC (Tier 2) is a sub tier of Z-ABCO (Tier 1)

Tab 2. Both have been assigned Part # and Partner Part # PP123456789

Tab 2. Z-ABCO has been assigned an annual revenue of $10,000

Tab 3. Product name Fuel PP has connected to Part # PP123456789

Colonial Pipeline

Tab 1. Z-VMOTO LTD (Tier 2) is a sub tier of Z-ABERDEEN LEADERS (Tier 1)

Tab 2. Both have been assigned Part # and Partner Part # CP123456789

Tab 2. Z-ABERDEEN LEADERS has been assigned an annual revenue of $10,000

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Tab 3. Product name Fuel CP has connected to Part # CP123456789

Buckeye Pipeline

Tab 1. Z-VOLAR (Tier 2) is a sub tier of Z-ABM RESOURCES NL (Tier 1)

Tab 2. Both have been assigned Part # and Partner Part # BP123456789

Tab 2. Z-ABM RESOURCES NL has been assigned an annual revenue of $10,000

Tab 3. Product name Fuel BP has connected to Part # BP123456789

2.   Resilinc Program

This information can be found in the Product Country Origin Dashboard

Step 1: Select the dashboard at the top right of the screen.

Step 2: Select view all dashboards.

Step 3: Select the product country origin.

Step 4: Review the data to make sure that it matches the spreadsheet.

Product	Part	Description	Category	Activity	Country	Partner Part	Partner
Fuel CP	CP12345678	Fuel CP	Petroleum	Distribution/Hub	United States of America	CP12345678	Z-VMOTO LTD
Fuel PP	PP12345678	Fuel BP	Petroleum	Distribution/Hub	United States of America	PP12345678	Z-VITERRA IN
Fuel BP	BP12345678	Fuel PP	Petroleum	Distribution/Hub	United States of America	BP12345678	Z-VOLAR
Fuel BP	BP12345678	Fuel PP	Petroleum	Distribution/Hub	United States of America	BP12345678	Z-ABM RESOU
Fuel PP	PP12345678	Fuel BP	Petroleum	Distribution/Hub	United States of America	PP12345678	Z-ABCO
Fuel CP	CP12345678	Fuel CP	Petroleum	Distribution/Hub	United States of America	CP12345678	Z-ABERDEEN

Figure 97.   Matching Resilinc to Tab 3: BOM AND ALT PARTS

E.   TAB 4: PRODUCT—ASSIGNING A DOLLAR VALUE TO A PRODUCT.

Step 1: The next step is to determine the dollar amount that will act as a proxy for the gallons of gas. Since the platform tracks the flow of supplies through dollar value, this will act as a proxy for simulating the impact of a fuel supply disruption.

Step 2: You will need to provide the following information:

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Table 14. Columns for Data Entry for Tab 4

Column Name	Column	Optional/Required
Product Hierarchy Level 2	B	Optional
Product Name	G	Required
Product Description	H	Optional
Revenue Q1	I	Optional
Revenue Q2	J	Optional
Revenue Q3	K	Optional
Revenue Q4	L	Optional
FG Inventory (weeks)	M	Optional

Product name and description can be found at the following product risk dashboard.
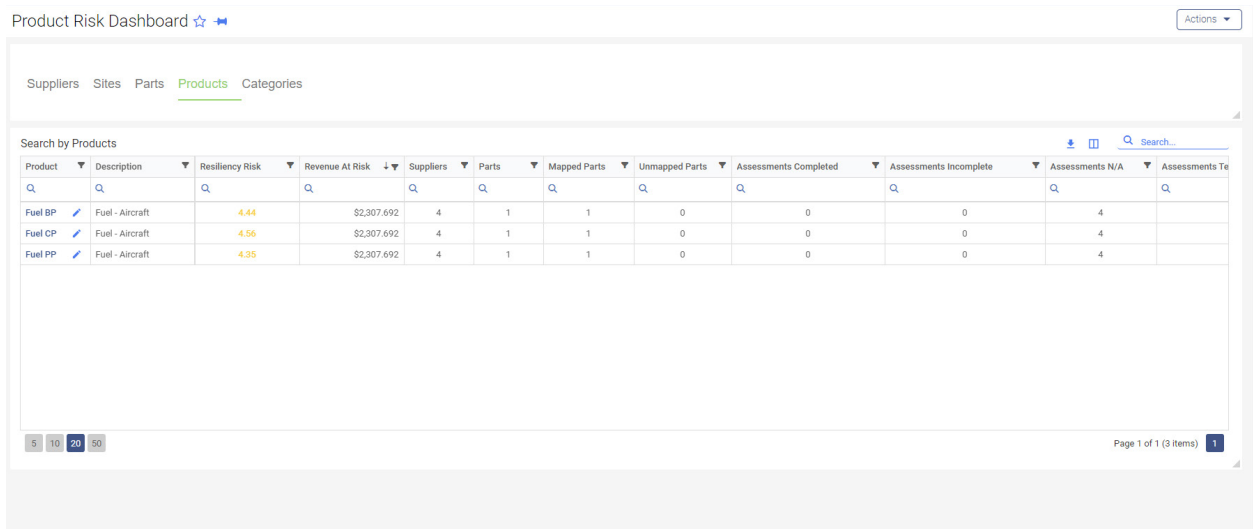
Figure 98. Product Risk Dashboard

Product hierarchy level 1 and 2 can be found on the site risk dashboard.
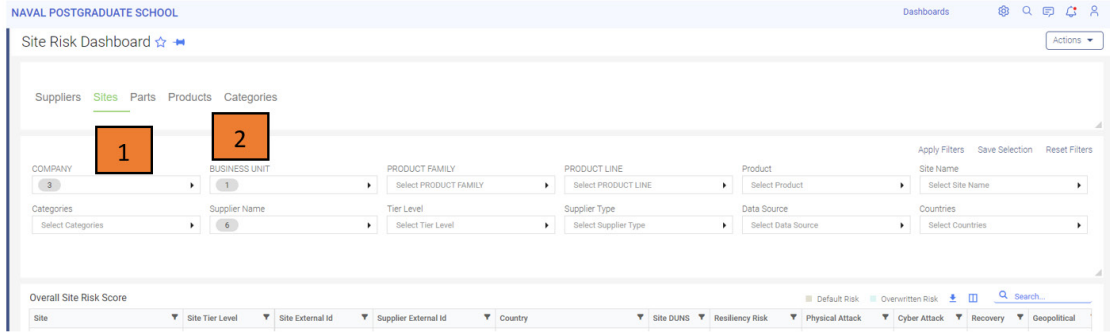
Figure 99.   Site Risk Dashboard

This tab will assign a dollar value to the product name that was listed in tab 3 Column A.

Table 15.   Assigning Dollar Value to Product name

Column B	Column G	Column I	Column J	Column K	Column L	Column M
Product Hierarchy Level 2	Product Name	Revenue Q1	Revenue Q2	Revenue Q3	Revenue Q4	FG Inventory (weeks)
Fuel	Fuel BP	$2,500.00	$2,500.00	$2,500.00	$2,500.00	40
Fuel	Fuel CP	$2,500.00	$2,500.00	$2,500.00	$2,500.00	40
Fuel	Fuel PP	$2,500.00	$2,500.00	$2,500.00	$2,500.00	40

Having a connect between the Product Name and the Revenue at Risk, now that links between the tabs can be made.

For example, with now know that Fuel PP (Tab 4 Column G) has a total revenue at risk of 10,000 dollars (Sum of Column I J K L).

The Revenue at risk is linked to the Part # via Tab 4 Column G—Product Name and Tab 3 Column A—Product name.

The Product name has been associated with partner name in Tab 2

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This now means that Z-ABCO and Z-VITERRA INC have a total revenue at risk of $10, 000.

1.   **Result**

Plantation Pipeline

Tab 1. Z-VITERRA INC (Tier 2) is a sub tier of Z-ABCO (Tier 1)

Tab 2. Both have been assigned Part # and Partner Part # PP123456789

Tab 2. Z-ABCO has been assigned an annual revenue of $10,000.

Tab 3. Product name Fuel PP has connected to Part # PP123456789

Tab 4. The annual revenue is tied to the Product name (Fuel PP) has been broken into Q1, Q2, Q3. Q4 each valued at $2,500 each.

Colonial Pipeline

Tab 1. Z-VMOTO LTD (Tier 2) is a sub tier of Z-ABERDEEN LEADERS (Tier 1)

Tab 2. Both have been assigned Part # and Partner Part # CP123456789

Tab 2. Z-ABERDEEN LEADERS has been assigned an annual revenue of $10,000.

Tab 3. Product name Fuel CP has connected to Part # CP123456789

Tab 4. The annual revenue is tied to the Product name (Fuel CP) has been broken into Q1, Q2, Q3. Q4 each valued at $2,500 each.

Buckeye Pipeline

Tab 1. Z-VOLAR (Tier 2) is a sub tier of Z-ABM RESOURCES NL (Tier 1)

Tab 2. Both have been assigned Part # and Partner Part # BP123456789

Tab 2. Z-ABM RESOURCES NL has been assigned an annual revenue of $10,000.

Tab 3. Product name Fuel BP has connected to Part # BP123456789

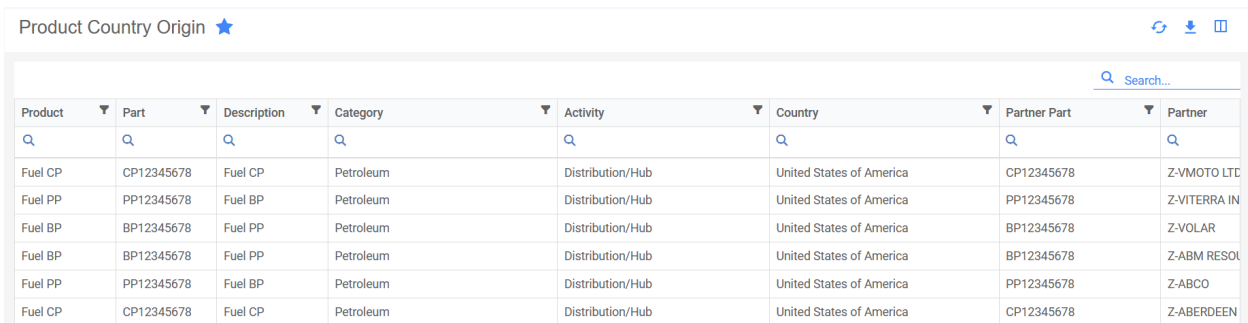Tab 4. The annual revenue is tied to the Product name (Fuel BP) has been broken into Q1, Q2, Q3. Q4 each valued at $2,500 each.

2. Resilinc Program

This information can be found at the Category Risk Dashboard

Step 1: Select the dashboard at the top right of the screen.

Step 2: Select view all dashboards.

Step 3: Select the category risk dashboard.
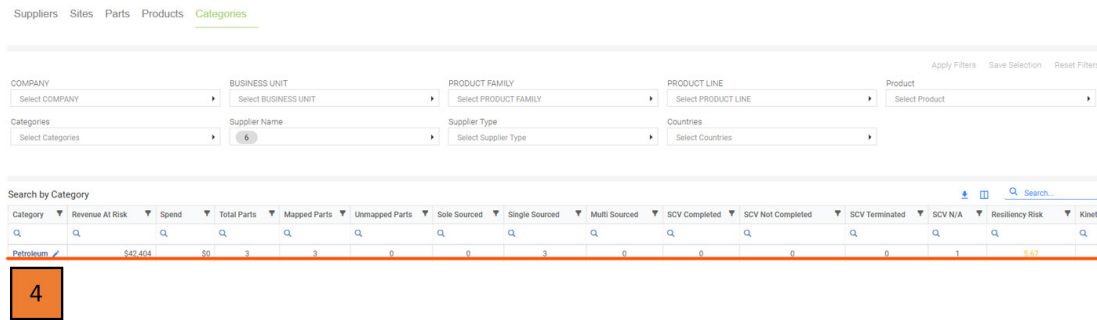
Figure 100. Location of Assigned Dollar in Resilinc

Step 4: Click on the category

Step 5: Scroll down to part recovery and risk intelligence

Figure 101. Part Recovery and Risk Intelligence

F. TAB 5: EXECUTIONAL DETAILS—NOT APPLICABLE

G. TAB 6: SITE LIST—MAPPING THE SUPPLY CHAIN

Step 1: Locate the points that you would like to be part of the supply chain.

Step 2: You will need to locate the following information:

Table 16.   Columns for Data Entry in Tab 6

Column Name	Column	Optional/Required
Site Number	A	Required
Street Address 1	B	Required
Street Address 2	C	Optional
City	D	Required
State	E	Required
Postal Zip Code	F	Optional
Country	G	Required
Activity	I	Optional
Recovery Time	J	Optional
Alternate Site Number	K	Optional
Alternate Site Bring Up Time	L	Optional
Partner Name	M	Required
Resilinc Partner Name	S	Required

Step 3: Assigning Site Numbers

Note: Each location must have a unique site number (Column A). meaning that two or more sites cannot have the same site number.

The addressed should be unique as well.

Step 4: Creating alternate sites.

Select a site in step 3 for which you would like to have an alternate site.

Then you will need to locate the same information found in Step 2 for the alternate site.

Once you have that information, you will assign a site number (Column A).

That site number will then be placed in alternate site number (Column K) for any site (not considered an alternate site).

Then you will assign a Recovery Time in Weeks (Column J) and an Alternate Site Bring Up Time in Weeks (Column L)

Note: The Recovery Time (Column J) must be less than the Alternate Site Bring Up Time (Column L)

Below is an example:

Table 17.   Data Entry for Simulated Site—Part 1

Column A	Column B	Column D	Column E	Column F	Column G
Site Number	Street Address 1	City	State/ Province	Postal/ Zip Code	Country
7012	250 Chevron Way	Pascagoula	Mississippi	39581	US
7013	3329 Scenic Highway	Baton Rouge	Louisiana	70805	US
7014	1940 LA-1	Port Allen	Louisiana	70767	US

Table 18.   Data Entry for Simulated Site—Part 2

Column I	Column J	Column K	Column L	Column M	Column N	Column S
Activity	Recovery Time	Alternate Site Number	Alternate Site Bring Up Time	Partner Name	Subcontractor Name	resilinc partner name
Distribution/ Hub	15	7119	14	Z-VITERRA INC	Plantation Pipeline	Z-VITERRA INC
Distribution/ Hub	15	7120	10	Z-VITERRA INC	Plantation Pipeline	Z-VITERRA INC
Distribution/ Hub	25			Z-VITERRA INC	Plantation Pipeline	Z-VITERRA INC

Now that the connection has been made between the Site Number in Column A and the Partner Name in Column M, the companies can be matched to the physical address of their sites.

Site Numbers is linked to the Partner Name via Tab 1 Column A—Partner Name and Tab 6 Column M—Partner Name.

1. **Result**

Plantation Pipeline

Tab 1. Z-VITERRA INC (Tier 2) is a sub tier of Z-ABCO (Tier 1)

Tab 2. Both have been assigned Part # and Partner Part # PP123456789

Tab 2. Z-ABCO has been assigned an annual revenue of $10,000.

Tab 3. Product name Fuel PP has connected to Part # PP123456789

Tab 4. The annual revenue is tied to the Product name (Fuel PP) has been broken into Q1, Q2, Q3. Q4 each valued at $2,500 each.

Tab 6. Z-ABCO has been linked to sites: 7000,7001, 7005, 7006

Tab 6. Z-VITERRA INC has been linked to sites: 7012–7049, 7119–7120

Colonial Pipeline

Tab 1. Z-VMOTO LTD (Tier 2) is a sub tier of Z-ABERDEEN LEADERS (Tier 1)

Tab 2. Both have been assigned Part # and Partner Part # CP123456789

Tab 2. Z-ABERDEEN LEADERS has been assigned an annual revenue of $10,000.

Tab 3. Product name Fuel CP has connected to Part # CP123456789

Tab 4. The annual revenue is tied to the Product name (Fuel CP) has been broken into Q1, Q2, Q3. Q4 each valued at $2,500 each.

Tab 6. Z-ABERDEEN LEADERS has been linked to sites:7002,7003, 7004, 7007

Tab 6. Z-VMOTO LTD has been linked to sites: 7050–7103

Buckeye Pipeline

Tab 1. Z-VOLAR (Tier 2) is a sub tier of Z-ABM RESOURCES NL (Tier 1)

Tab 2. Both have been assigned Part # and Partner Part # BP123456789

Tab 2. Z-ABM RESOURCES NL has been assigned an annual revenue of $10,000.

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Tab 3. Product name Fuel BP has connected to Part # BP123456789

Tab 4. The annual revenue is tied to the Product name (Fuel BP) has been broken into Q1, Q2, Q3. Q4 each valued at $2,500 each.

Tab 6. Z-ABM RESOURCES NL has been linked to sites:7008,7009,7010,7011

Tab 6. Z-VOLAR has been linked to sites: 7014–7118

2. Resilinc Program

This information can be found in individual supplier.

Step 1: Go to the main page (your username will be displayed).

Step 2: Select the suppliers tab.
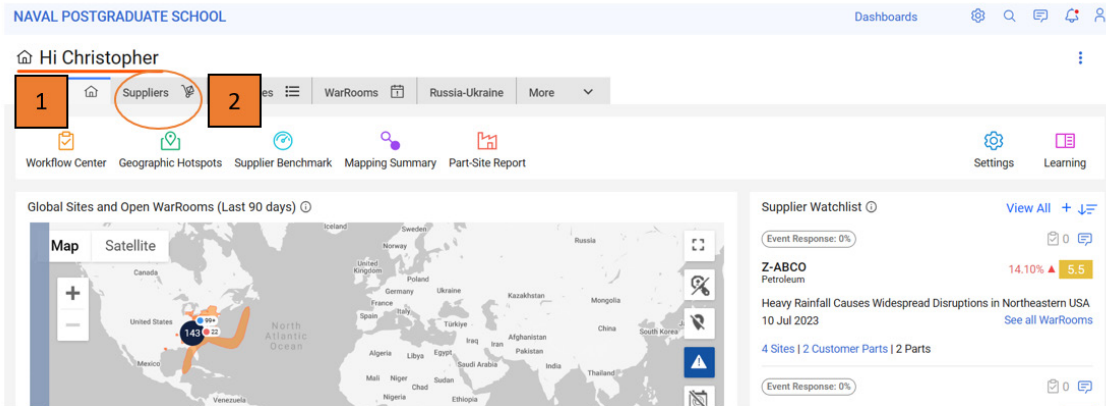
Figure 102.   Accessing the Supplier Dashboard

Step 3: Pick a supplier.
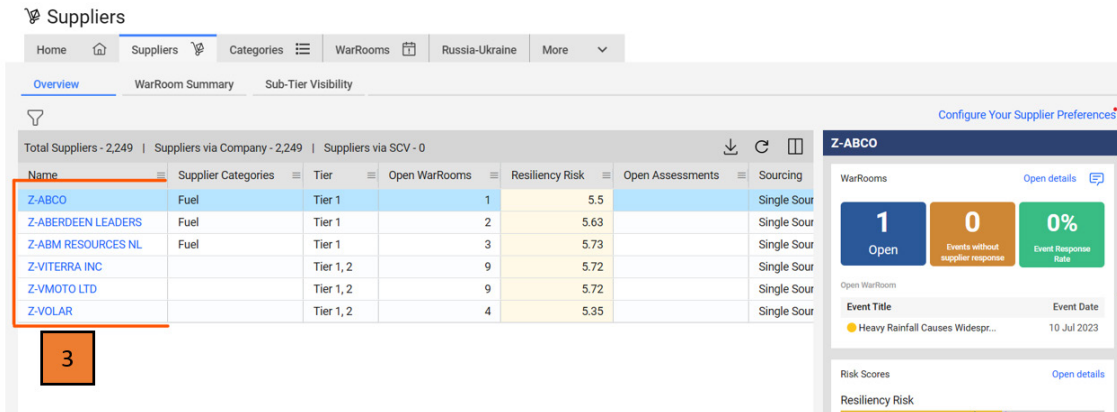
Figure 103.   Supplier List

Step 4: Once you have selected the partner, then select the sites tab
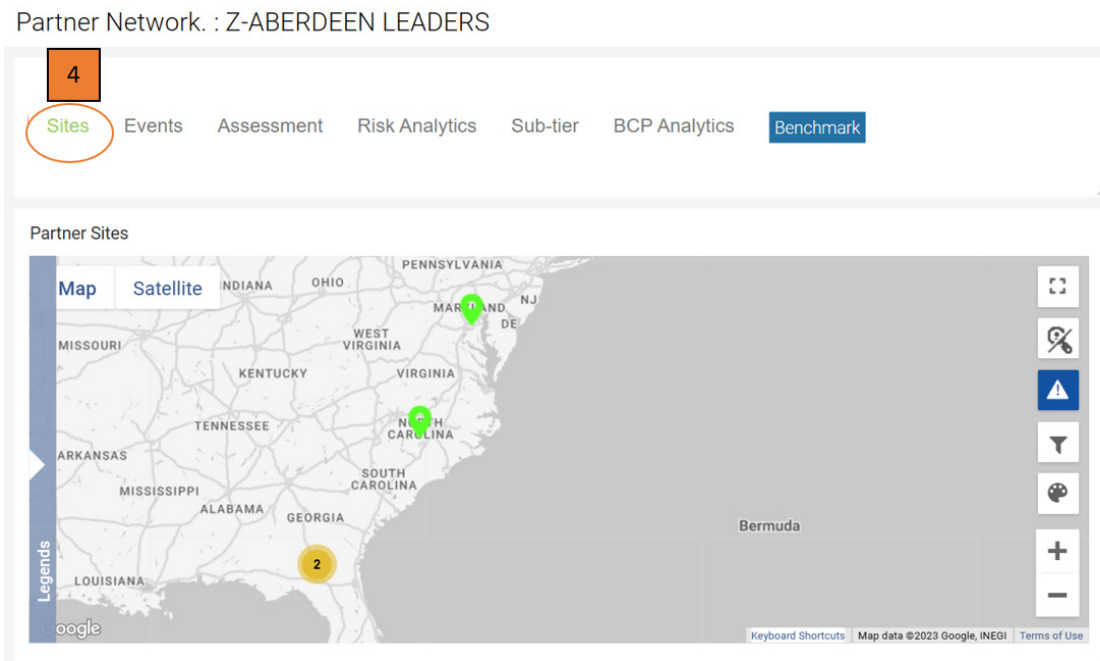
Figure 104.   Suppler Locations

Step 5: Scroll down to the overall site risk score

Step 6: Review to ensure that the nodes on Resilinc match the ones on the spreadsheet.

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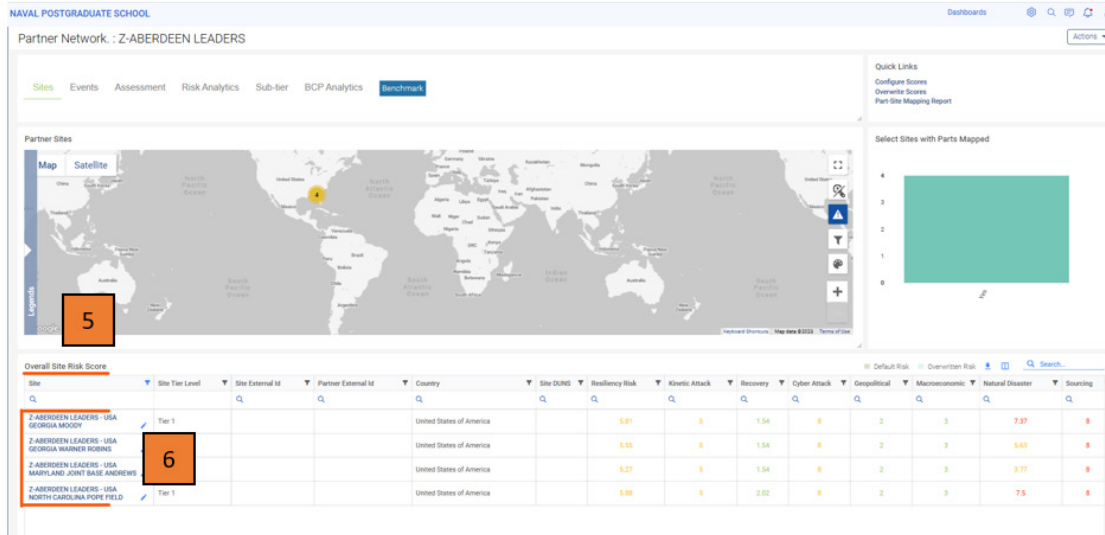
Figure 105.   Overall Risk Score for Affected Sites

H.   TAB 7: NOT APPLICABLE

I.   TAB 8: PART—SITE MAP—MAPPING A FUEL TO SITES

Step 1: Determine which site will be assigned to the fuel that will flow through the Colonial Pipeline, Plantation Pipeline and Buckeye Pipeline

Step 2: You will need to locate the following information:

1.   Result

Plantation Pipeline

Tab 1. Z-VITERRA INC (Tier 2) is a sub tier of Z-ABCO (Tier 1)

Tab 2. Both have been assigned Part # and Partner Part # PP123456789

Tab 2. Z-ABCO has been assigned an annual revenue of $10,000.

Tab 3. Product name Fuel PP has connected to Part # PP123456789

Tab 4. The annual revenue is tied to the Product name (Fuel PP) has been broken into Q1, Q2, Q3. Q4 each valued at $2,500 each.

Tab 6. Z-ABCO has been linked to sites: 7000,7001, 7005, 7006

Tab 6. Z-VITERRA INC has been linked to sites: 7012–7049, 7119–7120

Tab 8. Partner Part # PP12345678 is connected to the Z-ABCO and the Z-VITERRA Sites

Colonial Pipeline

Tab 1. Z-VMOTO LTD (Tier 2) is a sub tier of Z-ABERDEEN LEADERS (Tier 1)

Tab 2. Both have been assigned Part # and Partner Part # CP123456789

Tab 2. Z-ABERDEEN LEADERS has been assigned an annual revenue of $10,000.

Tab 3. Product name Fuel CP has connected to Part # CP123456789

Tab 4. The annual revenue is tied to the Product name (Fuel CP) has been broken into Q1, Q2, Q3. Q4 each valued at $2,500 each.

Tab 6. Z-ABERDEEN LEADERS has been linked to sites:7002,7003, 7004, 7007

Tab 6. Z-VMOTO LTD has been linked to sites: 7050–7103

Tab 8. Partner Part # CP12345678 is connected to the Z-ABERDEEN LEADERS and the Z--VMOTO LTD Sites

Buckeye Pipeline

Tab 1. Z-VOLAR (Tier 2) is a sub tier of Z-ABM RESOURCES NL (Tier 1)

Tab 2. Both have been assigned Part # and Partner Part # BP123456789

Tab 2. Z-ABM RESOURCES NL has been assigned an annual revenue of $10,000.

Tab 3. Product name Fuel BP has connected to Part # BP123456789

Tab 4. The annual revenue is tied to the Product name (Fuel BP) has been broken into Q1, Q2, Q3. Q4 each valued at $2,500 each.

Tab 6. Z-ABM RESOURCES NL has been linked to sites:7008,7009,7010,7011

Tab 6. Z-VOLAR has been linked to sites: 7014–7118

Tab 8. Partner Part # BP12345678 is connected to the Z-ABM RESOURCES NL and the Z-VOLAR Sites

2. Resilinc Program

Table 19. Columns for Data Entry for Tab 8

Column Name	Column	Optional/Required
Partner Name	A	Required
Partner Part #	B	Required
Alt Site Qualified	C	Optional
Site Number	D	Required
Activity	E	Required
Recovery Time	F	Required
Alternate Site Number	G	Optional
Alternate Site Bring Up time	H	Optional
resilinc partner name	I	Required

Below is an example:

Table 20. Data Entry for the Simulation—Part 1

Column A	Column B	Column C	Column D
Partner Name	Partner Part #	Alt Site Qualified?	Site Number
Z-ABERDEEN LEADERS	CP12345678	N	7002
Z-ABERDEEN LEADERS	CP12345678	N	7003
Z-ABERDEEN LEADERS	CP12345678	N	7004
Z-ABCO	PP12345678	N	7005
Z-ABCO	PP12345678	N	7006

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Column A	Column B	Column C	Column D
Partner Name	Partner Part #	Alt Site Qualified?	Site Number
Z-ABERDEEN LEADERS	CP12345678	N	7007
Z-ABM RESOURCES NL	BP12345678	N	7008
Z-ABM RESOURCES NL	BP12345678	N	7009
Z-ABM RESOURCES NL	BP12345678	N	7010
Z-ABM RESOURCES NL	BP12345678	N	7011
Z-VITERRA INC	PP12345678	Y	7012
Z-VITERRA INC	PP12345678	Y	7013

Table 21.   Data Entry for the Simulation—Part 2

Column E	Column F	Column G	Column H	Column I
Activity	Recovery Time	Alternate Site Number	Alternate Site Bring Up Time	resilinc partner name
Logistics	1			Z-ABERDEEN LEADERS
Logistics	1			Z-ABERDEEN LEADERS
Logistics	1			Z-ABERDEEN LEADERS
Logistics	1			Z-ABCO

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Column E	Column F	Column G	Column H	Column I
Activity	Recovery Time	Alternate Site Number	Alternate Site Bring Up Time	resilinc partner name
Logistics	1			Z-ABCO
Logistics	1			Z-ABERDEEN LEADERS
Logistics	1			Z-ABM RESOURCES NL
Logistics	1			Z-ABM RESOURCES NL
Logistics	1			Z-ABM RESOURCES NL
Logistics	1			Z-ABM RESOURCES NL
Distribution/ Hub	15	7119	14	Z-VITERRA INC
Distribution/ Hub	15	7120	10	Z-VITERRA INC

This will make the connection between the Partner Part # in Column B to the Partner Name in Column A and the Site Number in Column D and the Alternative Site Number in Column G and the Alternate Site Bring Up Time in Column H.

J.   TAB 9: NOT APPLICABLE

K.   TAB 10: NOT APPLICABLE

L.   TAB 11: SITE TO SITE MAPPING–CREATING THE FUEL NETWORK

Step 1: Now that the Fuel has been assigned to site the next step is to connect those sites to simulate the flow of fuel.

Step 2: You will need to locate the following information:

Table 22.　　Columns for Data Entry for Tab 11

Column Name	Column	Optional/Required
Form Site Number	A	Required
To Site Number	B	Required
Partner Part #	C	Optional
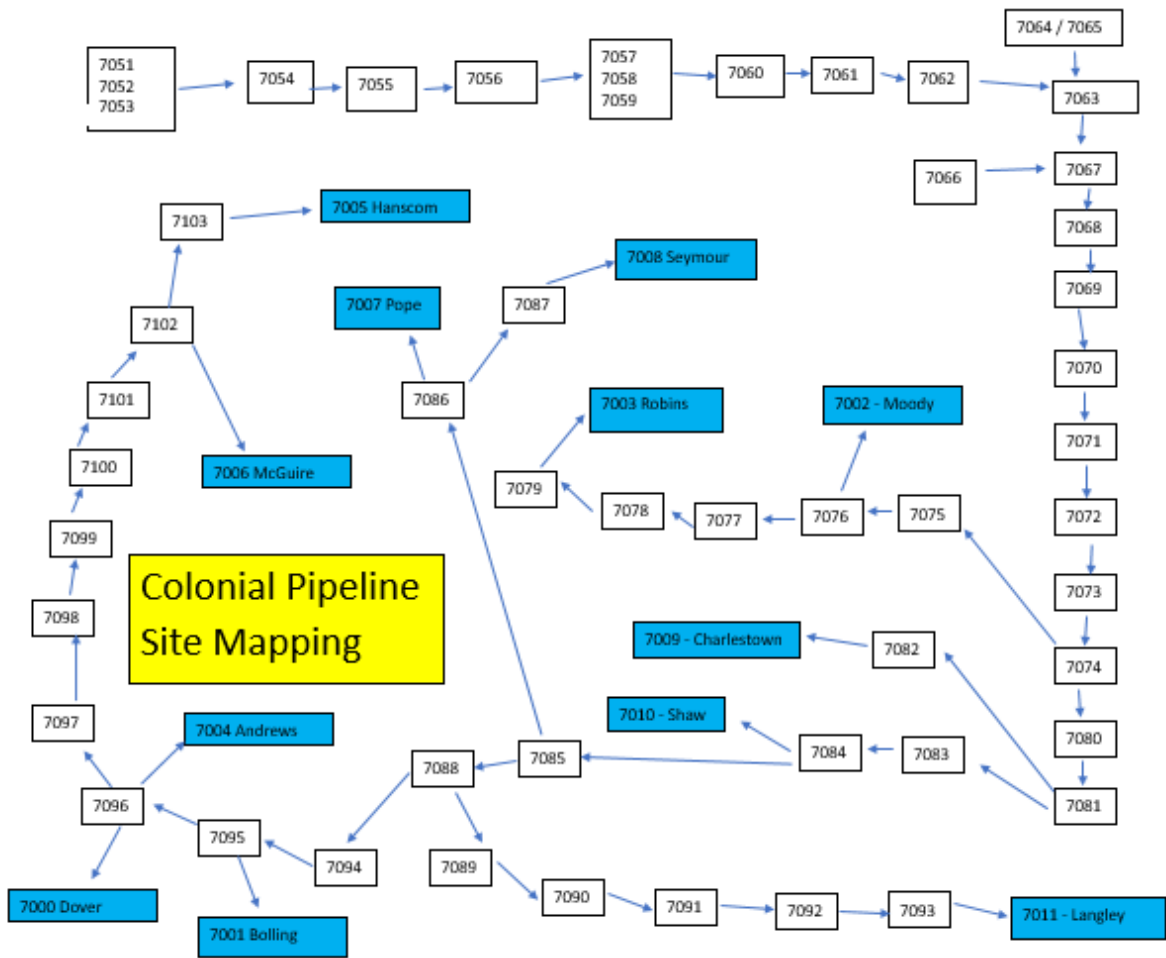
Figure 106.　Site to Sote Mapping for the Colonial Pipeline

Figure 107. Site to Site for the Plantation Pipeline

Figure 108.   Site to Site Mapping for the Buckeye Pipeline

1.   Result

Plantation Pipeline

Tab 1. Z-VITERRA INC (Tier 2) is a sub tier of Z-ABCO (Tier 1)

Tab 2. Both have been assigned Part # and Partner Part # PP123456789

Tab 2. Z-ABCO has been assigned an annual revenue of $10,000.

Tab 3. Product name Fuel PP has connected to Part # PP123456789

Tab 4. The annual revenue is tied to the Product name (Fuel PP) has been broken into Q1, Q2, Q3. Q4 each valued at $2,500 each.

Tab 6. Z-ABCO has been linked to sites: 7000,7001, 7005, 7006

Tab 6. Z-VITERRA INC has been linked to sites: 7012–7049, 7119–7120

Tab 8. Partner Part # PP12345678 is connected to the Z-ABCO and the Z-VITERRA Sites

Tab 11. The flow of material starts with Z-VITERRA INC (Tier 2) and ends at Z-ABCO (Tier 1)

Colonial Pipeline

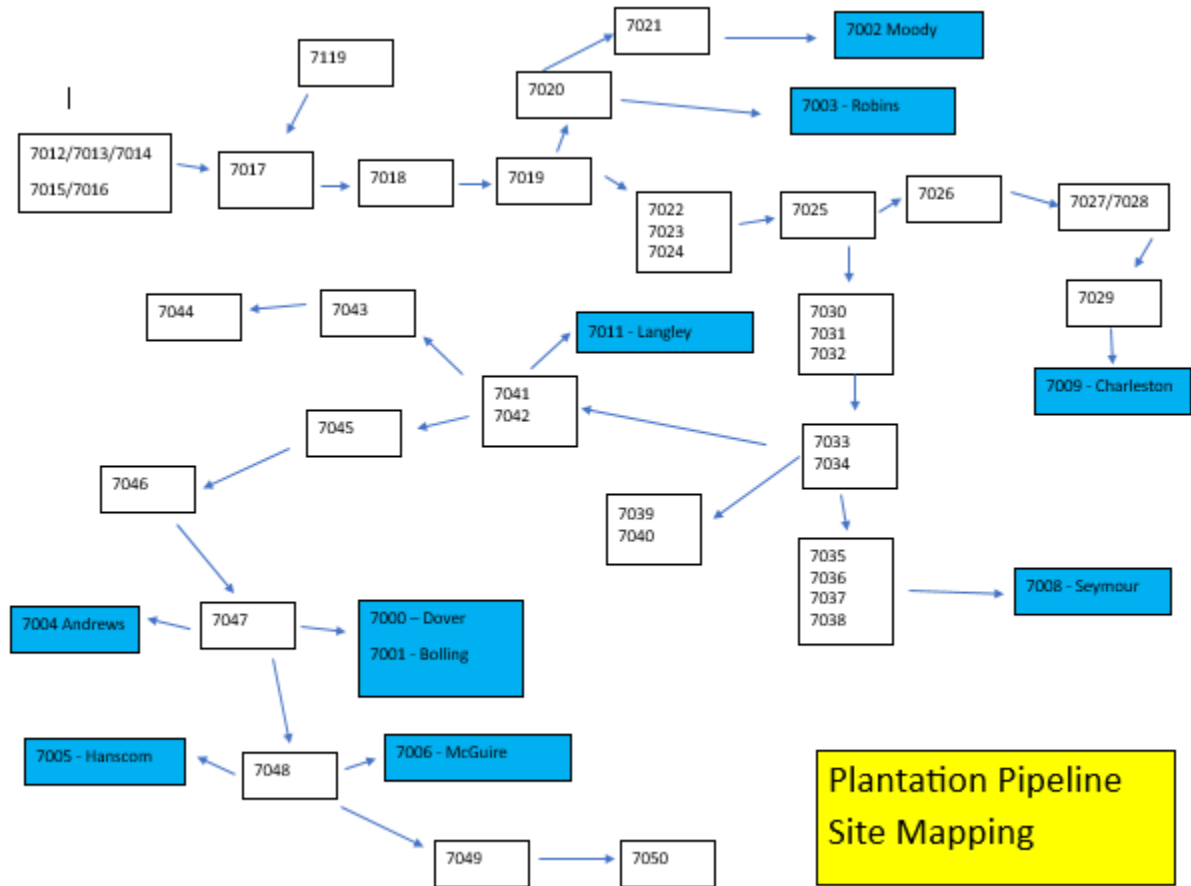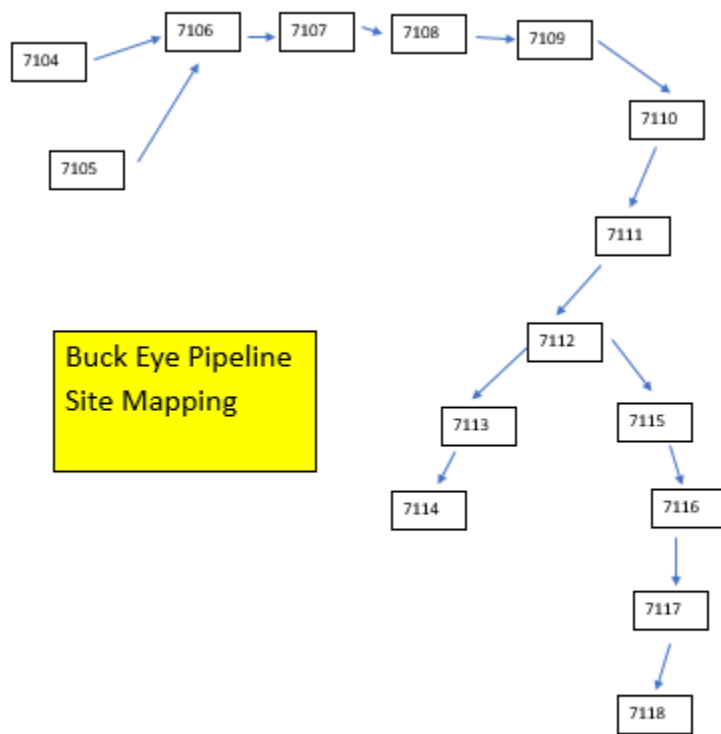Tab 1. Z-VMOTO LTD (Tier 2) is a sub tier of Z-ABERDEEN LEADERS (Tier 1)

Tab 2. Both have been assigned Part # and Partner Part # CP123456789

Tab 2. Z-ABERDEEN LEADERS has been assigned an annual revenue of $10,000.

Tab 3. Product name Fuel CP has connected to Part # CP123456789

Tab 4. The annual revenue is tied to the Product name (Fuel CP) has been broken into Q1, Q2, Q3. Q4 each valued at $2,500 each.

Tab 6. Z-ABERDEEN LEADERS has been linked to sites:7002,7003, 7004, 7007

Tab 6. Z-VMOTO LTD has been linked to sites: 7050–7103
Tab 8. Partner Part # CP12345678 is connected to the Z-ABERDEEN LEADERS and the Z--VMOTO LTD Sites

Tab 11. The flow of material starts with Z-VMOTO LTD (Tier 2) and ends at Z-ABERDEEN LEADERS (Tier 1)

Buckeye Pipeline

Tab 1. Z-VOLAR (Tier 2) is a sub tier of Z-ABM RESOURCES NL (Tier 1)

Tab 2. Both have been assigned Part # and Partner Part # BP123456789

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Tab 2. Z-ABM RESOURCES NL has been assigned an annual revenue of $10,000.

Tab 3. Product name Fuel BP has connected to Part # BP123456789

Tab 4. The annual revenue is tied to the Product name (Fuel BP) has been broken into Q1, Q2, Q3. Q4 each valued at $2,500 each.

Tab 6. Z-ABM RESOURCES NL has been linked to sites:7008,7009,7010,7011

Tab 6. Z-VOLAR has been linked to sites: 7014–7118

Tab 8. Partner Part # BP12345678 is connected to the Z-ABM RESOURCES NL and the Z-VOLAR Sites

Tab 11. The flow of material starts with Z-VOLAR (Tier 2) and ends at Z-ABM RESOURCES NL (Tier 1)

Step 2: Enter this information into Tab 11 Part—Site Map

Step 3—You will need to locate the following information:

Column Name	Column	Optional/Required
From Site Number	A	Required
To Site Number	B	Required
Partner Part #	C	Optional

2. Resilinc Program

This information can be found at the Material Flow Page

Step 1: Select the Dashboard at the top right of the screen

Step 2: Select View all Dashboards

Step 3: Select the Material Flow Dashboard

Step 4: Review the map to see the network that was created

Partners   Sites   Categories   Parts   Products   WarRooms   Assessments   Country

▼ FILTER MATERIAL FLOW:

Choose one or more filters from the panels below

✖ Clear All Filters

Filter by Partner

Filter by Site

🔍 Search...

Filter Material Flow by Event

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APPENDIX D. POST-EXERCISE EVALUATION QUESTIONS

For Questions 1 through 7 (rate each statement 1…7 with 1 being completely disagree and 7 being completely agree)

Question 1: The fuel simulation was realistic.

1: Completely Disagree

2: Disagree

3: Somewhat Disagree

4: Neither Agree nor Disagree

5: Somewhat Agree

6: Agree

7: Completely Agree

Question 2: The fuel simulation was informative.

1: Completely Disagree

2: Disagree

3: Somewhat Disagree

4: Neither Agree nor Disagree

5: Somewhat Agree

6: Agree

7: Completely Agree

Question 3: The fuel simulation was engaging.

1: Completely Disagree

2: Disagree

3: Somewhat Disagree

4: Neither Agree nor Disagree

5: Somewhat Agree

6: Agree

7: Completely Agree

Question 4: The fuel simulation scenarios were challenging.

1: Completely Disagree

2: Disagree

3: Somewhat Disagree

4: Neither Agree nor Disagree

5: Somewhat Agree

6: Agree

7: Completely Agree

Question 5: The fuel simulation provided a good understanding of the impact of external factors on the fuel supply chain.

1: Completely Disagree

2: Disagree

3: Somewhat Disagree

4: Neither Agree nor Disagree

5: Somewhat Agree

6: Agree

7: Completely Agree

Question 6: The fuel simulation provided enough information to help make informed decisions.

1: Completely Disagree

2: Disagree

3: Somewhat Disagree

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4: Neither Agree nor Disagree

5: Somewhat Agree

6: Agree

7: Completely Agree

Question 7: The fuel simulation was a valuable learning tool.

1: Completely Disagree

2: Disagree

3: Somewhat Disagree

4: Neither Agree nor Disagree

5: Somewhat Agree

6: Agree

7: Completely Agree

Please answer the following questions in written format. If you have no relevant feedback for each question simply state "none."

Provide a list of important facts or data points missing from the simulation that you expected to see.

Explain how the fuel simulation exercise enhanced understanding of the topic, if at all.

Explain any difficulties experienced during the fuel simulation, either with the subject or technical issues.

Please provide any suggestions on how to improve the fuel simulation exercise for future use.

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