CASE STUDY

Option Overload - Implementing AHP Decision Making at Millenni-X Transportation & Logistics

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Table of Contents

Introduction **4**

Industry Overview **4**

Overview of the Company **6**

Operations and the Role of Information Technology **7**

Possible Technology Solutions **10**

Solution A: Reconfiguring & Enhancing Sleipnir 10

Solution B: Upgrading to a More Robust System 11

Solution C: Building a Proof-of-Concept to Create Business Case 12

The Proposal **14**

What is the Analytical Hierarchy Process? **14**

Robustness of the Proposed AHP Process 15

Limitations of AHP 15

Validation & Accuracy of AHP 16

Sensitivity (What-If) Analysis with Millenni-X 17

The Decision **19**

Case Study Questions **20**

Case Study Deliverables & Submission **20**

References **21**

Appendices **24**

Exhibit A - Determination of Criteria Grading 24

Exhibit B - List of Requirements 24

Exhibit C - Product Cost & Pricing Structure 24

Exhibit D - AHP Survey to All Actors 25

Exhibit E - Survey Responses from All Actors 28

Exhibit F - CFS Lookahead Report 38

Exhibit G - Drayage Cost Tracker 39

Exhibit H - Container Tracker 40

Exhibit I - Entity-Relationship Diagram 41

Exhibit J - Millenni-X Operations As-Is Process 42

Introduction

"We're late, and we're falling behind!" John overheard her exclamation echoing through the office hallway. He put down his morning coffee and peeked around his office door. There, his star employee, Emma, who is typically calm and collected, looked flustered. It was March 16, 2023—a typical Thursday—when container cargo comes in and goes out. But why today, of all days, was Emma so frustrated?

As it turns out, the spreadsheet to track all container cargo transactions had become corrupted after being manually handled back and forth over email. Emma had to rework the spreadsheet since the beginning of the week. John wasn't aware of the additional rework and offered to help backtrack.

The entire spreadsheet was recovered by the end of the day on Friday. However, that distracted John and Emma from their other duties as they restored the spreadsheet with updated and verified data. John wondered if there were any possibilities to increase the reliability of the tools and documents pertinent to their operations. Another disaster like this could cost the company a substantial sum of money.

On Monday, after his morning coffee ritual, John set his sights on looking for an IT solution more robust than their current reliance on spreadsheets. John remembered an IT friend—he picked up his phone and gave him a call.

"Hello, Dave! Are you free for lunch today?"

Industry Overview

By the 21st century, the container shipping industry has experienced substantial and progressive growth and transformation, disrupting and inspiring new global trade dynamics. Characterized by the pursuit of optimized transportation of goods in standardized containers, this industry is the backbone of international commerce. Factors contributing to this include globalization (Crowley, 2008), technological advancements (Salah et al., 2020), logistical innovations (Panayides & Song, 2013), economic significance (Routley, 2018), market dynamics (Mordor Intelligence, n.d.), environmental consciousness (International Maritime Organization, n.d.), and overall challenges and opportunities (Saxon & Stone, 2017). As these

drivers continue to evolve, the container shipping industry will too. Therefore, the evolution of the industry will demand only the best in transportation and logistics operations.

Fairview Container Terminals, located in Prince Rupert, British Columbia, is described as "the most reliable container trade corridor on the West Coast... providing a high-velocity gateway for transpacific container trade" (Prince Rupert Port Authority [PRPA], n.d.-a). The initial feasibility study began in 2011, with the project starting in the spring of 2018 and completing in the summer of 2022 (PRPA, n.d.-a).

With the new connector road directly linking Fairview Container Terminals with Ridley Island, where many current logistics partners are located, PRPA CEO Shawn Stevenson states that the Port of Prince Rupert will "enable greater efficiencies and competitiveness at the Prince Rupert Gateway and generate new economic opportunities on local, regional, and national levels" (PRPA, n.d.-a; Association of Consulting Engineering Companies British Columbia, n.d.).

As the demand for international trade increases, the need for novel solutions for the delivery and receipt of unique goods becomes apparent. It is clear that the supply chain heavily relies on all players being able to deliver their services at an exemplary level. Without this, a bottleneck can occur in the supply chain, potentially leading to the breaking of a critical link in the process. While port operators such as Fairview Container Terminals are crucial to the overall supply chain, logistics companies play a key role in the receipt and delivery of consumer and industrial goods.

In the supply chain, many logistics providers focus on delivering a key service from origin to destination. Therefore, not all logistics providers are created equal – handoffs in the supply chain exist whereby goods are transferred from one logistics provider to the next. This results in a multi-node supply chain where second-party logistics partners hand off to third-party logistics partners, and so on, all the way to the nth-party logistics provider.

Enter Millenni-X Transportation & Logistics, a Canadian company based in Prince Rupert, British Columbia, aiming to satisfy the logistical needs of today's consumer, commercial, and industrial goods.

Overview of the Company

Millenni-X Transportation & Logistics (Millenni-X) is a Canadian logistics company and a key supply chain partner for numerous projects within British Columbia and beyond. Millenni-X's global footprint and over 200 years of industry experience enable them to possess foundational and robust expertise in the Canadian supply chain.

In Prince Rupert, the organization has fostered a strong partnership with the container port. They have been instrumental in offering services, including expertise in container drayage[1], container stuffing and destuffing[2], transloading to track[3], lift-on and lift-off services[4], and satellite container storage[5]. Millenni-X is committed to innovation, sustainability, and growth as it aims to acquire additional value-added services such as bonded warehousing and transloading directly to rail.

Although their main function in Prince Rupert, BC, is to serve as a container freight station facility, their strategic partnerships and global network through other international business units allow the organization to be responsive and adaptive. Their resilience enhances their competitiveness as a logistics player, making Millenni-X a trusted and preferred logistics partner for businesses. Millenni-X significantly adds value by navigating the complexities within the supply chain.

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[1] Container drayage is the terminology used to describe the movement of container freight over short distances between ports, facilities, rail yards and other shipping hubs. Drayage transportation is typically handled by trucks.

[2] Container stuffing is the process where goods are loaded into a container to be shipped. Container destuffing is the process where the goods are unloaded from a container.

[3] Transloading to track refers to the service offering whereby container units are unloaded from trucks and onto railcars to be transported by train.

[4] Lift-on services refers to the movement of non-containerized goods or commodities to be loaded on to a flatbed of a truck for long-haul truck transportation. Lift-off services refers to the movement of non-containerized goods or commodities to be unloaded off a flatbed of a truck.

[5] Satellite container storage is an area of the facility where overflowing inventory of containers at the Port can be stored for a period until the port requests for their return. This service was heavily utilized between the Port and Millenni-X during the COVID-19 pandemic when the port container yard was exceeding 120% utilization. The satellite container storage provides short term relief to enable container yard fluidity.

Operations and the Role of Information Technology

A typical day of operations at Millenni-X begins with Emma dispatching tasks to the facility operators, which include reach stacker operators and forklift drivers. Emma closely collaborates with the Truck-Gate Operations at Fairview Container Terminals, initiating the gate appointment process with them shortly after assigning tasks to her team. Although the instructions are usually communicated through pen and paper, they can also be conveyed verbally via a VHF two-way radio system.

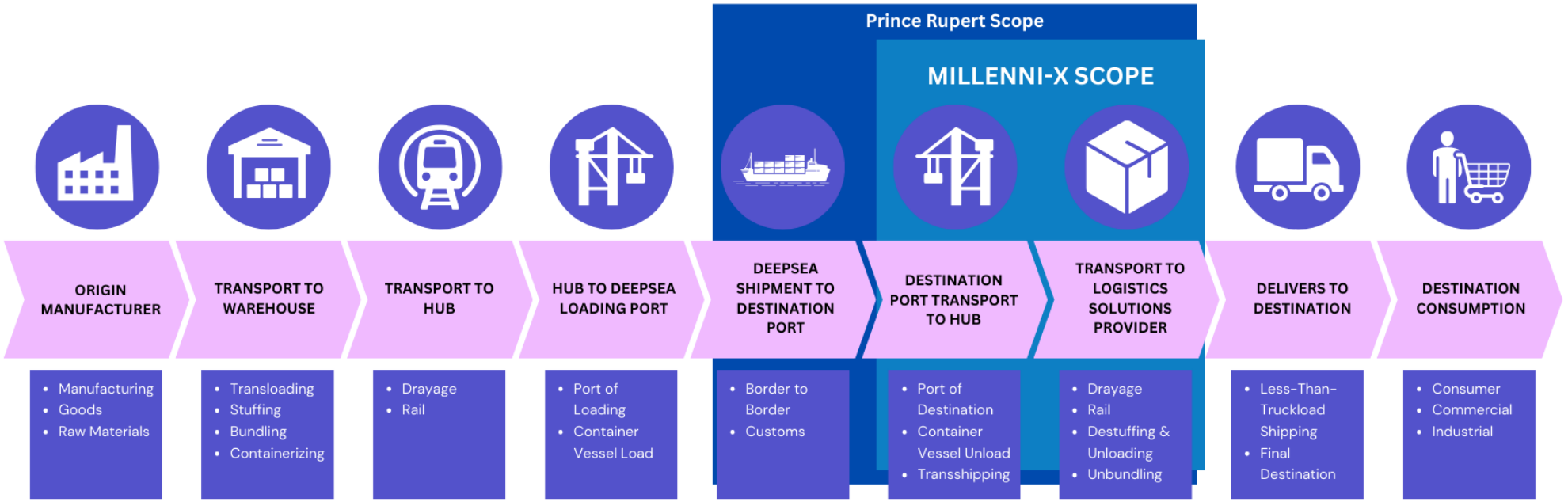
Based on the demand forecast from the previous workday, local trucking companies are informed of the number of contracted truck drivers required to transport cargo to and from the Millenni-X facility. On the morning of operations, Emma receives a roster from the trucking company detailing who has been dispatched to them for the day. With this information, she interacts with the container port's online Gate Appointment System to schedule gate appointments for containers being picked up and dropped off. These appointments require the following information:

1. The truck driver's port pass number
2. The truck driver's truck asset number and license plate
3. The container(s) to be dropped off
4. The container(s) to be picked up

If there are containers to be dropped off, the equipment operators are provided with work instructions to load the trucks with containers for delivery. Similarly, if a truck is arriving at Millenni-X, the operators are instructed to unload the truck's cargo. Truck trips are optimized whenever possible; Emma and her team aim to ensure no empty trucks enter or leave the terminal, maximizing efficiency and productivity.

Upon arrival, trucks are issued a terminal interchange receipt, which provides the driver with information about the containers they are dropping off and picking up at the terminal. This receipt also serves as a record-keeping tool for Emma when updating Millenni-X's operating system, codenamed **Sleipnir Intelligence** (Sleipnir). This system is implemented across all Millenni-X's business units in Canada and acts as a standardized platform for the organization's various units. This situation presents a challenge for the Millenni-X facility in Prince Rupert, BC, because:

High-Level Supply Chain Scope



1. The local trucking community is a unionized, pooled workforce servicing all port operators, not just Millenni-X.
2. The local trucking companies are paid an hourly wage but are guaranteed 8 hours of pay whenever they are dispatched.
3. Even though 8-hour shifts are guaranteed, the trucking communities allow dispatched trucks to be shared among their customers as long as there is demand.
    a. For example, if there were two port operators working that day and Millenni-X only needed to pick up and drop off a container (two transactions in total, spanning 1 hour) and the other port operator had 30 transactions, then Millenni-X would share the cost of the first hour, while the second port operator would cover the remaining seven hours of cost.
4. These variabilities are not logically supported in Sleipnir, as this environment does not exist anywhere else within Canada.

The uniqueness of the situation necessitated a workaround. To address this, Emma and John developed three key spreadsheets to monitor transactions and the ordering of trucks. These are detailed in **Exhibit F - CFS Lookahead Report, Exhibit G - Drayage Cost Tracker, and Exhibit H - Container Tracker**. These spreadsheets served as a bridge between the operations of Sleipnir and Millenni-X, but they are viewed as a short-term, temporary solution that is not scalable. Moreover, the spreadsheets are in a free-form format without any data validation or restrictions. Without any structure, the integrity, reliability, and validity of the data may become questionable. Fortunately, John can rely on Emma to perform well, yet everyone is susceptible to errors. A visual process flow chart is available in **Exhibit I - Millenni-X Operations As-Is Process.**

Furthermore, the spreadsheets are distributed among Millenni-X staff through email. However, this led to a breakdown in operations as Emma became disengaged from managing the daily operations, focusing instead on administrative duties within the spreadsheets. Besides overseeing the operations, communicating work instructions, and distributing terminal interchange receipts, she also had to manually enter data into three separate spreadsheets. The data in these spreadsheets are not always mutually exclusive, so Emma might end up updating the same information across three different platforms. This raises concerns about data consistency and the risk of relying on a key person if Emma were absent; who else could maintain the same level of consistency using Emma's nomenclature?

An option to move the spreadsheets into cloud technologies is possible as Millenni-X does have licenses for Microsoft OneDrive, Teams and SharePoint. However, while this addresses the accessibility issues of the spreadsheets it does not accomplish the requirements for data consistency and structure.

Emma warmly welcomed Dave when she learned he was looking to develop an application to replace the spreadsheets. The first spreadsheet, the “Container Freight Station (CFS) Lookahead Report,” tracks all shipments to Millenni-X, associating them with relevant metadata and monitoring the containerized cargo arrivals and their return. It also keeps tabs on whether they have been completed and paid for.

The second spreadsheet, the “Drayage Cost Tracker,” primarily logs the bookings, the trucking companies hired for transport between Fairview Container Terminals and Millenni-X, the number of trucks hired, total hours worked, and the hourly cost. This spreadsheet lacks an aggregation of information, such as total cost per entry and cost per container.

Finally, the third spreadsheet, the “Container Tracker,” records each container's estimated time of arrival at the port, its entry into Millenni-X’s facility, and its return to the container port. It also tracks the trucking companies hired for receiving and delivering to and from Millenni-X, without adding any other value-added information.

Possible Technology Solutions

Solution A: Reconfiguring & Enhancing Sleipnir

Solution A would be to reconfigure and enhance Sleipnir to address their specific and unique needs. While Sleipnir is a project management software used by many logistics companies, it is currently incapable of fulfilling the requirements needed to streamline Millenni-X’s operations. It does offer functionality such as task management, resource allocation, and work instruction scheduling, which Millenni-X uses when necessary. So far, the software has allowed Millenni-X and other logistics firms alike to efficiently coordinate their shipment, warehousing, and distribution operations.

Another great feature going for Sleipnir is its transparency for stakeholders. It allows external users to have clear visibility on their cargos’ progress and can generally assist in

identifying potential bottlenecks in the overall supply chain. This creates a distinct advantage for Sleipnir, as it builds the trust of Millenni-X's stakeholders while also providing peace of mind through its robust tools. These tools and additional functionalities include seamless communication and knowledge sharing among team members. In turn, it enhances operational coordination and decision-making internally, which can then potentially create value-add for the customers.

Overall, Sleipnir has been utilized by Millenni-X initially due to its consistent ability to optimize operations, increase customer satisfaction, and drive the growth of the organization within the competitive industry. To reiterate, Sleipnir has some limitations in its current iteration due to the uniqueness of the Prince Rupert environment. It would take significant development and enhancements to create what John and his team need. In Sleipnir's favour, the development and implementation cost is under the threshold to require a formal Authorization for Expenditure (AFE) request to Cindy DeLyon, Director of Finance of Millenni-X Head Office. The current timeframe was quoted to be a 16-month development cycle, with 4 months of it dedicated to information gathering and understanding exactly what Millenni-X needs.

Pros	Cons
- No new training required. - Data is preserved; no migration needed. - The current application is preserved; no changes for users and stakeholders. - Low risk of implementation. - The enhancement has a high level of integration with the currently existing database. - AFE not required. - No additional user licenses required.	- 4-months for information and requirements gathering. - 12-month development cycle. - $10,000 development and implementation fee. - Older software is outdated. - Future upgrades may cause incompatibilities with the proposed enhancement. - Physical servers are not scalable. - Additional hardware may be required.

Solution B: Upgrading to a More Robust System

Solution B involves implementing a new enterprise system, codenamed **TransGlobal Management System** (TransGlobal). Similar to Sleipnir, TransGlobal is a renowned logistics software with a trustworthy brand name for logistics companies. It aims to meet the complex needs of the industry. TransGlobal encompasses many of Sleipnir's functionalities, plus additional essential management tools for freight forwarding and obtaining customs clearance.

TransGlobal offers modules for automating laborious tasks to enhance efficiency and reduce operational costs. It also allows for the definition of key performance indicators. Once set up, the system generates scorecards that reflect operational excellence. For John and his team, TransGlobal represents a significant upgrade from Sleipnir due to its scalable and customizable nature. John believes that this system, with its robust reporting and analytics capabilities, will enable Millenni-X to gain valuable insights into their operations, identify trends, and make informed decisions, thereby addressing their current inefficiencies and volatility.

Should John and his team decide to pursue this option, they would need to submit an AFE request to Cindy DeLyon, who would start the approval process. This process takes at least two months. The development and implementation period for Millenni-X would last about 12 months, followed by an additional migration and training phase lasting four months. John is also aware that without a solid business case, there's a high chance Cindy would reject the AFE request.

Pros	Cons
- New, modern software. - Entirely customizable to Millenni-X's needs. - Full visibility of information for Millenni-X's users. - Cloud-based solution, ensuring high availability and redundancy.	- AFE required. - $50,000 development and implementation cost. - AFE approval process requires a minimum of 2 months. - 12-month implementation and development period. - 4-month migration and training period. - New software entails a learning curve. - Training and communication processes necessary for end-users and stakeholders. - High risk of implementation due to inability to run on the current database. - New user licenses required with variable costs per user.

Solution C: Building a Proof-of-Concept to Create Business Case

John and Dave were having lunch at a local restaurant when John brought up his issues with the spreadsheets. After a candid conversation between the two, Dave offered to build a proof-of-concept application for John and his team. John liked the idea and invited Dave to see the operations at Millenni-X. The meeting concluded, and John authorized the distribution of

these files for Dave to review on his own. Later that evening, Dave sent an email to John and Emma stating that the development time for the application to implement the logic of these spreadsheets would be eight months. Dave's proposed solution would provide structure in their tracking and recordkeeping by storing this information in a relational database. To interface with this database, a web application would be built on top, allowing any Millenni-X staff to perform these duties. Lastly, the web application would be capable of ensuring data consistency by implementing front-end and back-end validations with form controls. An entity-relationship diagram of the database can be referenced in **Exhibit I - Entity-Relationship Diagram.**

Dave also said that the application would be provided to Millenni-X as a proof-of-concept. This is to help build John's business case to present to Cindy and the Executive Team, and Dave will not be charging any fees unless the company decides to move forward with the solution in whatever capacity. Dave also disclosed that the application would be standalone, meaning there will be zero integration with any other applications or software being utilized by Millenni-X.

The solution does present a risk whereby the proof-of-concept is deployed in production without proper user acceptance testing of the system. Because the solution is not a replacement product, the risk of an insufficient testing period may result in duplication of data between the current Sleipnir database and the new proof-of-concept database. The challenge would be to determine which system would have the source of truth if one record must be entered into two separate systems that are not synchronized with each other.

Pros	Cons
- Precisely tailored to address the three key spreadsheets. - Zero risk of implementation. - Utilizes new, modern software and code technologies. - Offers a Proof-of-Concept that can be used in conjunction with Sleipnir or Solution B. - No operational process changes required. - No process changes for end-users or stakeholders. - AFE is not required. - No variable cost per user, and no licenses are required.	- Not a finished product. - Requires some training for users. - Not integrated with any existing applications. - Ambiguous source of truth. - Two distinct, unsynchronized, and mutually exclusive systems. - Deploying a potentially incomplete system into production without sufficient user acceptance testing - Proof-of-concept is not a proven product compared to its alternatives.

The Proposal

To assist John in making decisions, Dave suggested employing the Analytical Hierarchy Process (AHP) as a framework. Dave clarified that AHP provides an objective, quantitative method for making decisions by ranking essential criteria and evaluating the performance of each product against these criteria. Dave was able to share a preliminary mockup of the data collection and presented it to John (refer to **Exhibit D - AHP Survey to All Actors**). The framework also ensures that all key stakeholders – specifically, John, Emma, and Cindy – have conducted thorough due diligence before arriving at the recommended decision. John agrees that pursuing this strategic route is beneficial and has received support from both Emma and Cindy.

Dave initiates the data collection process. The responses to the survey are available in **Exhibit E - Survey Responses from All Actors**. A third-party consultant will conduct the AHP analysis.

What is the Analytical Hierarchy Process?

AHP is a decision-making methodology developed by Thomas L. Saaty in the 1970s for decisions involving multiple criteria and alternatives (Sharma, 2018; Russo, 2015). Various forms of AHP are widely used across fields such as business, engineering, healthcare, and environmental management (Oubahman et al., 2024; Gacu et al., 2023; Russo & Camanho, 2015; Yuksel et al., 2023).

At its core, AHP breaks down a complex problem into a hierarchical structure of criteria and alternatives (Oubahman et al., 2024; Yuksel et al., 2023). It evaluates the relative importance, or weight, of these elements through pairwise comparisons. At this stage, each criterion is compared with every other to determine its weight and ranking (Russo & Camanho, 2015; Gacu et al., 2023). These comparisons are made on a numerical scale, often between 1 and 9, where 1 indicates equal importance and 9 indicates extreme importance (Sharma, 2018). This process is illustrated in **Exhibit D - AHP Survey to All Actors.**

Once the pairwise comparisons are completed, AHP uses mathematical calculations to determine the weights of each criterion (Sharma, 2018; Russo & Camanho, 2015; Gacu et al., 2023). These weights are the relative values of each variable to achieve the objective (Sharma, 2018; Russo & Camanho, 2015). Finally, the framework synthesizes the weights to rank the

alternatives, providing the decision-maker with a recommendation on the optimal solution (Gacu et al., 2023; Yuksel et al., 2023).

AHP enhances decision quality by systematically structuring decision problems, capturing subjective preferences, and quantifying decision criteria. This exercise increases transparency and fosters consensus among stakeholders (Oubahman et al., 2024; Gacu et al., 2023; Yuksel et al., 2023; Russo & Camanho, 2015; Sharma, 2018). Overall, AHP is a structured approach to decision-making that enables users to navigate complex multi-criteria decision-making (MCDM) processes with objectivity and clarity (Sharma, 2018).

Robustness of the Proposed AHP Process

While the existing literature supports the strengths and usefulness of AHP and its framework, it is not immune to some shortcomings. Further review explores the practicality of the framework using literature that highlights the apparent weaknesses and limitations of AHP.

Limitations of AHP

As structured and objective as the AHP may be, its accuracy is contingent upon the quality of the inputs. This is due to the fact that the ranking and grading of criteria and solutions rely on the judgments of the participants (Karthikeyan et al., 2016). Concerns such as bias and emotions can directly influence the respondents' answers, depending on time, place, and surroundings (Karthikeyan et al., 2016). Therefore, the framework presupposes that all participants are in a stable state of mind and that there are no biases during data collection. In this context, bias may also pertain to the participants' expertise on the topic, which means that two equally rational users with differing experiences in criteria or solutions could potentially rank and grade differently (Karthikeyan et al., 2016).

Karthikeyan et al. (2016) have described AHP as "exceptionally delicate" (p. 13) and noted that removing any criteria or alternatives would disrupt the framework, as the pairwise comparisons would no longer be preserved. Furthermore, the framework's method of collecting information through a comparison of two criteria or alternatives against each other has been criticized as "defective" due to its oversimplification of ranking two items on a linear scale and the excessive repetition of this process (Karthikeyan et al., 2016). The larger the selection of criteria and alternatives, the more cumbersome the framework becomes.

Munier and Hontoria (2021) address the assumption that the criteria formulated within the framework are independent. However, this assumption leads to the question: what if the criteria were indeed related? For instance, consider the criteria of road safety and road speed (Munier & Hontoria, 2021, p. 62). Other experts also echo this criticism, with some arguing that the independence of criteria is critical when modeling the decision-making process and that "it is absurd to pretend that it exists" (Munier & Hontoria, 2021, p. 62). Ultimately, the framework's optimal recommendation may or may not be correctly derived from the listed objectives and trade-offs (Munier & Hontoria, 2021, p. 62).

Validation & Accuracy of AHP

Based on the previous discussion of AHP limitations, supported by evidence from numerous authors and compilations, the topic shifts to exploring the framework's accuracy and its ability to validate the process, especially during the criteria selection process where the framework has proven most sensitive (Karthikeyan et al., 2016; Munier & Hontoria, 2021).

Firstly, Saaty implemented the use of the Eigenvector Method (EVM). For the purposes of this case study, the technicalities and mathematical rationale behind eigenvectors and eigenvalues are omitted and considered out-of-scope. However, many authors agree with this justification but identify another limitation: EVM only provides precise values for up to three alternatives (Munier & Hontoria, 2021). This raises the question of what happens when there are more than three alternatives. If the decision-maker decides to reduce multiple alternatives down to three, are they potentially omitting the optimal solution by prematurely removing them based on their intuition? Beyond three alternatives, therefore, EVM will not provide exact values, which challenges the accuracy of the AHP framework.

Next, there is a discussion on validating the responses in the data collection process. To begin, Saaty's framework checks the consistency of answers by calculating the Consistency Index and dividing it by the Randomness Index. The resulting value is the Consistency Ratio, and ideally, a pairwise comparison matrix from a respondent is considered consistent if the Consistency Ratio is less than 0.1. There are some concerns with this approach:

1. How is it possible to ensure that the respondents are providing consistent answers when the data collection is conducted manually, such as with pen and paper?
2. Assuming no agents are present during the data collection process, what does the decision-maker do upon realizing that the answers are inconsistent?

3. From where does the benchmark constant of 0.1, used to compare against the Consistency Ratio, originate?

To address Point 1, a robust software solution capable of modeling the MCDM exercise and being responsive to the user is a plausible option. Here, responsiveness is akin to front-end form validation, signaling to the user when the data entry is invalid or unacceptable. For an AHP software, providing real-time feedback on inconsistent answers may be significant in bridging the consistency gap.

Regarding Point 2, the AHP analyst or decision-maker could retain the right to modify the answers to achieve consistency. However, Munier and Hontoria (2021), along with other authors, note that changing inconsistent answers to consistent ones may trigger cascading effects on the sensitivity of the criteria and solutions' ranking and grading, respectively. While the decision maker may accept and acknowledge this, it leads to the next topic: the inconsistency ratio benchmark.

The allowable inconsistency ratio, defined as 0.1 or less by Bozóki and Rapcsák (2008), serves as a guideline. Munier and Hontoria (2021) recognize this aligns with Saaty's intuition but also emphasize the statistical reasoning behind it, as noted by Vargas (1982). This raises concerns about relying on subjective, intuitive parameters within the framework. Does a matrix with a consistency ratio of 0.12 invalidate itself for not meeting the allowable inconsistency threshold of 0.1 or less? Returning to Point 2, if the decision maker adjusts the values to meet the consistency ratio criteria, to what extent does this affect the overall framework in that specific scenario modeling?

Sensitivity (What-If) Analysis with Millenni-X

To illustrate the limitations, concerns about accuracy, and validity of the Analytic Hierarchy Process (AHP), a sensitivity analysis was conducted using the Millenni-X scenario. For this purpose, an AHP software called SpiceLogic AHP was employed to provide a secondary assessment of the decision-making evaluation and to offer advanced features, such as Individual Sensitivity Analyses. All actor responses from **Exhibit E - Survey Responses from All Actors** were transposed

The findings indicated that each respondent, including DeLyon's revised responses, exhibited a 0% sensitivity for all criteria and variables. This result is surprising but can be attributed to the fact that the software allows the analyst to choose whether to enforce the

transitivity rule. The transitivity rule ensures that the comparisons of each criterion are relative to each other based on a multiplicative value. An example provided by the software illustrates that:

1. If Person A prefers an apple twice more than an orange, and;
2. If Person A prefers an orange three times more than a banana, then;
3. Person A should prefer an apple six times more than a banana.

In this case, it was revealed that some variables were sensitive to change with respect to the user. A summarizing table can be referenced below:

Respondent	Criteria	Sensitive Variable	Sensitivity %
Cindy DeLyon	Cost	Solution A vs. Solution C (Survey Question 24)	12.5%
John Ramblings	Functionality	Solution A vs. Solution C (Survey Question 12)	57.5%
John Ramblings	Functionality vs. Timeframe	Survey Question 3	18.75%

Interestingly, enforcing the transitivity rule on DeLyon's revised (and purposely made inconsistent) survey responses did not appear to immediately affect the sensitivity of variables. Based on these findings, adjustments were made to each sensitive variable, and the results are reported below:

Respondent	Question #	Change From	Change To	Total Change*	Observed Changes
Cindy DeLyon	Q24	5 for Solution C	1 for Solution A and C	4 points	Q18 and Q23 now become sensitive
John Ramblings	Q12	5 for Solution C	3 for Solution C	2 points	Q11 and Q23 now become sensitive
John Ramblings	Q3	9 for Functionality	1 for Functionality	8 points	Q11 and Q21 now becomes sensitive

** Note: Total Change is calculated based on the change importance from one criteria to another. However, rather than calculating the individual nodes, the value is calculated based on the weight traversing from left (negative) to right (positive) and vice-versa, ignoring zero as a value; the absolute value is taken from this delta value.*

What is also interesting is the change in sensitivity of other variables based on adjustments to the initially identified sensitive variables. Findings from SpiceLogic AHP related to Millenni-X's scenario can be made available upon request. It is recommended that analysts experiment with altering the sensitive variables to visually understand their impact using SpiceLogic AHP software.

Ultimately, it is crucial for the AHP analyst to grasp the implications of the framework's robustness and its internal dependencies. If Ramblings and DeLyon were to alter their responses to the identified sensitive variables, it would not be surprising to see a different solution recommendation from the framework than the one currently proposed. Thus, altering a sensitive variable can have a cascading effect, making other variables, previously considered insensitive, sensitive enough to influence the determination of the optimal solution.

The Decision

Emma and John arrived at the office the day after their productive meeting with Dave. After getting his morning coffee, John sat down, opened his emails, and saw Dave's proposal. John faced a decision. What was the most sensible option for him and his team at the moment? More importantly, how could he make this decision objectively without being influenced by his friend? He knew that presenting his case as it stood to Cindy and the executives would be akin to facing a committee of fire-breathing dragons.

John took another sip of his coffee. He realized he needed to find a way to mitigate the risks associated with his current operational processes, and he needed to make that decision soon.

Case Study Questions

1. Determine the weights of each criteria based on John's, Emma's and Cindy's responses to the survey.
    a. What criteria is weighted the most?
    b. What criteria is weighted the least?
2. Determine the grading of each solution based on the assessments from John, Emma and Cindy.
    a. Are each of the participants consistent with their grading?
3. Using AHP, out of the three proposed solutions which one does the framework recommend John and his team to move forward with?
    a. Do you agree with the recommendation provided by the AHP framework? Why or why not?
    b. What other concerns do you have based on these findings?
4. Cindy decided to revise her survey response and have submitted a new set of criteria ranking and solution grading.
    a. What are the implications of Cindy's revised submission?
    b. Does it change the AHP's recommendation?
5. Write a follow-up email to John to describe your AHP findings. Ensure that you incorporate your qualitative findings as well.

Case Study Deliverables & Submission

1. The spreadsheet containing both the initial and revised AHP frameworks. Although students may use different formulas, their results should match within a 0.5% margin (attributable to rounding errors).
2. A Word document that addresses the Case Study questions and includes an email follow-up, formatted as though it were being sent as an actual email.

References

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Appendices

Exhibit A - Determination of Criteria Grading

A follow-up meeting with Millenni-X and Dave resulted in finalizing these five criteria for grading each of the software solutions.

1. **Functionality** - the overall capabilities of the solution and its ability to fulfill the replacement needs of the three key spreadsheets
2. **Accessibility** - the ease of use, navigation and straightforwardness of the solution
3. **Risk of Implementation** - the potential adverse impacts to Millenni-X operations
4. **Timeframe** - the proposed timeline for requirements gathering, development and implementation, training and communication for any of the proposed projects
5. **Cost** - the fixed and variable costs of each solution (refer to **Exhibit C - Product Cost & Pricing Structure**)

Exhibit B - List of Requirements

See supplementary spreadsheet of requirements from Millenni-X.

Exhibit C - Product Cost & Pricing Structure

Option	Fixed Cost	Variable Cost
Solution A	$10,000USD implementation and development	Pre-existing. No additional costs.
Solution B	$50,000USD implementation and development	$880USD monthly subscription ($10,560USD annual fee, recurring).
Solution C	$0 for proof-of-concept application	$0 per user, no monthly or annual subscription.

Exhibit D - AHP Survey to All Actors

To help with the AHP data collection process, the criteria derived from **Exhibit A - Determination of Criteria Grading** were used to format Part 1 of the survey. Part 2 of the survey was formatted using the information from section **Possible Technology Solutions** and **Exhibit A - Determination of Criteria Grading**. The survey has been truncated to display the data collection from John, Emma and Cindy.

2-Way Likert Scale for AHP				
1	3	5	7	9
Equal Importance	Moderate Importance	Strong Importance	Very Strong Importance	Extreme Importance

Part 1 - Criteria Ranking to Evaluate Solutions

Question 1 - Weighted Importance: Functionality versus Accessibility										
	9	7	5	3	1	3	5	7	9	
Functionality	☐	☐	☐	☐	☐	☐	☐	☐	☐	Accessibility

Question 2 - Weighted Importance: Functionality versus Risk of Implementation										
	9	7	5	3	1	3	5	7	9	
Functionality	☐	☐	☐	☐	☐	☐	☐	☐	☐	Risk of Implementation

Question 3 - Weighted Importance: Functionality versus Timeframe										
	9	7	5	3	1	3	5	7	9	
Functionality	☐	☐	☐	☐	☐	☐	☐	☐	☐	Timeframe

Question 4 - Weighted Importance: Functionality versus Cost										
	9	7	5	3	1	3	5	7	9	
Functionality	☐	☐	☐	☐	☐	☐	☐	☐	☐	Cost

Question 5 - Weighted Importance: Accessibility versus Risk of Implementation										
	9	7	5	3	1	3	5	7	9	
Accessibility	☐	☐	☐	☐	☐	☐	☐	☐	☐	Risk of Implementation

Question 6 - Weighted Importance: Accessibility versus Timeframe										
	9	7	5	3	1	3	5	7	9	
Accessibility	☐	☐	☐	☐	☐	☐	☐	☐	☐	Timeframe

Question 7 - Weighted Importance: Accessibility versus Cost										
	9	7	5	3	1	3	5	7	9	
Accessibility	☐	☐	☐	☐	☐	☐	☐	☐	☐	Cost

Question 8 - Weighted Importance: Risk of Implementation versus Timeframe										
	9	7	5	3	1	3	5	7	9	
Risk of Implementation	☐	☐	☐	☐	☐	☐	☐	☐	☐	Timeframe

Question 9 - Weighted Importance: Risk of Implementation versus Cost										
	9	7	5	3	1	3	5	7	9	
Risk of Implementation	☐	☐	☐	☐	☐	☐	☐	☐	☐	Cost

Question 10 - Weighted Importance: Timeframe versus Cost										
	9	7	5	3	1	3	5	7	9	
Timeframe	☐	☐	☐	☐	☐	☐	☐	☐	☐	Cost

Part 2 - Product Grading

Question 11 - Grading the Product Performance: Functionality										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☐	☐	☐	☐	Solution B

Question 12 - Grading the Product Performance: Functionality										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☐	☐	☐	☐	Solution C

Question 13 - Grading the Product Performance: Functionality										
	9	7	5	3	1	3	5	7	9	
Solution B	☐	☐	☐	☐	☐	☐	☐	☐	☐	Solution C

Question 14 - Grading the Product Performance: Accessibility										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☐	☐	☐	☐	Solution B

Question 15 - Grading the Product Performance: Accessibility										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☐	☐	☐	☐	Solution C

Question 16 - Grading the Product Performance: Accessibility										
	9	7	5	3	1	3	5	7	9	
Solution B	☐	☐	☐	☐	☐	☐	☐	☐	☐	Solution C

Question 17 - Grading the Product Performance: Risk of Implementation										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☐	☐	☐	☐	Solution B

Question 18 - Grading the Product Performance: Risk of Implementation										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☐	☐	☐	☐	Solution C

Question 19 - Grading the Product Performance: Risk of Implementation										
	9	7	5	3	1	3	5	7	9	
Solution B	☐	☐	☐	☐	☐	☐	☐	☐	☐	Solution C

Question 20 - Grading the Product Performance: Timeframe										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☐	☐	☐	☐	Solution B

Question 21 - Grading the Product Performance: Timeframe										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☐	☐	☐	☐	Solution C

Question 22 - Grading the Product Performance: Timeframe										
	9	7	5	3	1	3	5	7	9	
Solution B	☐	☐	☐	☐	☐	☐	☐	☐	☐	Solution C

Question 23 - Grading the Product Performance: Cost										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☐	☐	☐	☐	Solution B

Question 24 - Grading the Product Performance: Cost										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☐	☐	☐	☐	Solution C

Question 25 - Grading the Product Performance: Cost										
	9	7	5	3	1	3	5	7	9	
Solution B	☐	☐	☐	☐	☐	☐	☐	☐	☐	Solution C

Exhibit E - Survey Responses from All Actors

John Ramblings - Part 1 - Criteria Ranking to Evaluate Solutions

Question 1 - Weighted Importance: Functionality versus Accessibility										
	9	7	5	3	1	3	5	7	9	
Functionality	☐	☐	☐	☑	☐	☐	☐	☐	☐	Accessibility

Question 2 - Weighted Importance: Functionality versus Risk of Implementation										
	9	7	5	3	1	3	5	7	9	
Functionality	☐	☑	☐	☐	☐	☐	☐	☐	☐	Risk of Implementation

Question 3 - Weighted Importance: Functionality versus Timeframe										
	9	7	5	3	1	3	5	7	9	
Functionality	☑	☐	☐	☐	☐	☐	☐	☐	☐	Timeframe

Question 4 - Weighted Importance: Functionality versus Cost										
	9	7	5	3	1	3	5	7	9	
Functionality	☐	☐	☐	☑	☐	☐	☐	☐	☐	Cost

Question 5 - Weighted Importance: Accessibility versus Risk of Implementation										
	9	7	5	3	1	3	5	7	9	
Accessibility	☐	☐	☐	☐	☑	☐	☐	☐	☐	Risk of Implementation

Question 6 - Weighted Importance: Accessibility versus Timeframe										
	9	7	5	3	1	3	5	7	9	
Accessibility	☐	☐	☐	☑	☐	☐	☐	☐	☐	Timeframe

Question 7 - Weighted Importance: Accessibility versus Cost										
	9	7	5	3	1	3	5	7	9	
Accessibility	☐	☐	☐	☐	☐	☑	☐	☐	☐	Cost

Question 8 - Weighted Importance: Risk of Implementation versus Timeframe										
	9	7	5	3	1	3	5	7	9	
Risk of Implementation	☐	☐	☐	☑	☐	☐	☐	☐	☐	Timeframe

Question 9 - Weighted Importance: Risk of Implementation versus Cost										
	9	7	5	3	1	3	5	7	9	
Risk of Implementation	☐	☐	☐	☐	☐	☐	☑	☐	☐	Cost

Question 10 - Weighted Importance: Timeframe versus Cost										
	9	7	5	3	1	3	5	7	9	
Timeframe	☐	☐	☐	☐	☐	☐	☑	☐	☐	Cost

John Ramblings - Part 2 - Product Grading

Question 11 - Grading the Product Performance: Functionality										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☑	☐	☐	☐	Solution B

Question 12 - Grading the Product Performance: Functionality										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☐	☑	☐	☐	Solution C

Question 13 - Grading the Product Performance: Functionality										
	9	7	5	3	1	3	5	7	9	
Solution B	☐	☐	☐	☐	☐	☑	☐	☐	☐	Solution C

Question 14 - Grading the Product Performance: Accessibility										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☑	☐	☐	☐	Solution B

Question 15 - Grading the Product Performance: Accessibility										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☐	☑	☐	☐	Solution C

Question 16 - Grading the Product Performance: Accessibility										
	9	7	5	3	1	3	5	7	9	
Solution B	☐	☐	☐	☐	☐	☑	☐	☐	☐	Solution C

Question 17 - Grading the Product Performance: Risk of Implementation										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☑	☐	☐	☐	Solution B

Question 18 - Grading the Product Performance: Risk of Implementation										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☐	☑	☐	☐	Solution C

Question 19 - Grading the Product Performance: Risk of Implementation										
	9	7	5	3	1	3	5	7	9	
Solution B	☐	☐	☐	☐	☐	☑	☐	☐	☐	Solution C

Question 20 - Grading the Product Performance: Timeframe										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☐	☑	☐	☐	Solution B

Question 21 - Grading the Product Performance: Timeframe										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☑	☐	☐	☐	Solution C

Question 22 - Grading the Product Performance: Timeframe										
	9	7	5	3	1	3	5	7	9	
Solution B	☐	☐	☐	☐	☑	☐	☐	☐	☐	Solution C

Question 23 - Grading the Product Performance: Cost										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☑	☐	☐	☐	☐	☐	Solution B

Question 24 - Grading the Product Performance: Cost										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☐	☑	☐	☐	Solution C

Question 25 - Grading the Product Performance: Cost										
	9	7	5	3	1	3	5	7	9	
Solution B	☐	☐	☐	☐	☐	☐	☐	☑	☐	Solution C

Emma Stoutheart - Part 1 - Criteria Ranking to Evaluate Solutions

Question 1 - Weighted Importance: Functionality versus Accessibility										
	9	7	5	3	1	3	5	7	9	
Functionality	☐	☐	☐	☐	☑	☐	☐	☐	☐	Accessibility

Question 2 - Weighted Importance: Functionality versus Risk of Implementation										
	9	7	5	3	1	3	5	7	9	
Functionality	☐	☑	☐	☐	☐	☐	☐	☐	☐	Risk of Implementation

Question 3 - Weighted Importance: Functionality versus Timeframe										
	9	7	5	3	1	3	5	7	9	
Functionality	☐	☑	☐	☐	☐	☐	☐	☐	☐	Timeframe

Question 4 - Weighted Importance: Functionality versus Cost										
	9	7	5	3	1	3	5	7	9	
Functionality	☐	☐	☐	☐	☑	☐	☐	☐	☐	Cost

Question 5 - Weighted Importance: Accessibility versus Risk of Implementation										
	9	7	5	3	1	3	5	7	9	
Accessibility	☐	☑	☐	☐	☐	☐	☐	☐	☐	Risk of Implementation

Question 6 - Weighted Importance: Accessibility versus Timeframe										
	9	7	5	3	1	3	5	7	9	
Accessibility	☐	☑	☐	☐	☐	☐	☐	☐	☐	Timeframe

Question 7 - Weighted Importance: Accessibility versus Cost										
	9	7	5	3	1	3	5	7	9	
Accessibility	☐	☐	☐	☐	☑	☐	☐	☐	☐	Cost

Question 8 - Weighted Importance: Risk of Implementation versus Timeframe										
	9	7	5	3	1	3	5	7	9	
Risk of Implementation	☐	☐	☐	☐	☑	☐	☐	☐	☐	Timeframe

Question 9 - Weighted Importance: Risk of Implementation versus Cost										
	9	7	5	3	1	3	5	7	9	
Risk of Implementation	☐	☐	☐	☐	☐	☐	☑	☐	☐	Cost

Question 10 - Weighted Importance: Timeframe versus Cost										
	9	7	5	3	1	3	5	7	9	
Timeframe	☐	☐	☐	☐	☐	☑	☐	☐	☐	Cost

Emma Stoutheart - Part 2 - Product Grading

Question 11 - Grading the Product Performance: Functionality										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☐	☑	☐	☐	Solution B

Question 12 - Grading the Product Performance: Functionality										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☐	☐	☐	☑	Solution C

Question 13 - Grading the Product Performance: Functionality										
	9	7	5	3	1	3	5	7	9	
Solution B	☐	☐	☐	☐	☐	☑	☐	☐	☐	Solution C

Question 14 - Grading the Product Performance: Accessibility										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☐	☑	☐	☐	Solution B

Question 15 - Grading the Product Performance: Accessibility										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☐	☐	☐	☑	Solution C

Question 16 - Grading the Product Performance: Accessibility										
	9	7	5	3	1	3	5	7	9	
Solution B	☐	☐	☐	☐	☐	☑	☐	☐	☐	Solution C

Question 17 - Grading the Product Performance: Risk of Implementation										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☑	☐	☐	☐	☐	☐	☐	Solution B

Question 18 - Grading the Product Performance: Risk of Implementation										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☑	☐	☐	☐	Solution C

Question 19 - Grading the Product Performance: Risk of Implementation										
	9	7	5	3	1	3	5	7	9	
Solution B	☐	☐	☐	☐	☐	☐	☐	☐	☑	Solution C

Question 20 - Grading the Product Performance: Timeframe										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☑	☐	☐	☐	☐	Solution B

Question 21 - Grading the Product Performance: Timeframe										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☑	☐	☐	☐	Solution C

Question 22 - Grading the Product Performance: Timeframe										
	9	7	5	3	1	3	5	7	9	
Solution B	☐	☐	☐	☐	☐	☑	☐	☐	☐	Solution C

Question 23 - Grading the Product Performance: Cost										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☑	☐	☐	☐	☐	☐	Solution B

Question 24 - Grading the Product Performance: Cost										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☐	☑	☐	☐	Solution C

Question 25 - Grading the Product Performance: Cost										
	9	7	5	3	1	3	5	7	9	
Solution B	☐	☐	☐	☐	☐	☐	☐	☐	☑	Solution C

Cindy DeLyon - Part 1 - Criteria Ranking to Evaluate Solutions

Question 1 - Weighted Importance: Functionality versus Accessibility										
	9	7	5	3	1	3	5	7	9	
Functionality	☐	☐	☐	☐	☑	☐	☐	☐	☐	Accessibility

Question 2 - Weighted Importance: Functionality versus Risk of Implementation										
	9	7	5	3	1	3	5	7	9	
Functionality	☐	☐	☐	☐	☐	☐	☑	☐	☐	Risk of Implementation

Question 3 - Weighted Importance: Functionality versus Timeframe										
	9	7	5	3	1	3	5	7	9	
Functionality	☐	☐	☐	☐	☐	☑	☐	☐	☐	Timeframe

Question 4 - Weighted Importance: Functionality versus Cost										
	9	7	5	3	1	3	5	7	9	
Functionality	☐	☐	☐	☐	☐	☐	☐	☐	☑	Cost

Question 5 - Weighted Importance: Accessibility versus Risk of Implementation										
	9	7	5	3	1	3	5	7	9	
Accessibility	☐	☐	☐	☐	☐	☐	☑	☐	☐	Risk of Implementation

Question 6 - Weighted Importance: Accessibility versus Timeframe										
	9	7	5	3	1	3	5	7	9	
Accessibility	☐	☐	☐	☐	☐	☑	☐	☐	☐	Timeframe

Question 7 - Weighted Importance: Accessibility versus Cost										
	9	7	5	3	1	3	5	7	9	
Accessibility	☐	☐	☐	☐	☐	☐	☐	☑	☐	Cost

Question 8 - Weighted Importance: Risk of Implementation versus Timeframe										
	9	7	5	3	1	3	5	7	9	
Risk of Implementation	☐	☐	☐	☐	☑	☐	☐	☐	☐	Timeframe

Question 9 - Weighted Importance: Risk of Implementation versus Cost										
	9	7	5	3	1	3	5	7	9	
Risk of Implementation	☐	☐	☐	☐	☐	☑	☐	☐	☐	Cost

Question 10 - Weighted Importance: Timeframe versus Cost										
	9	7	5	3	1	3	5	7	9	
Timeframe	☐	☐	☐	☐	☐	☑	☐	☐	☐	Cost

Cindy DeLyon - Part 2 - Product Grading

Question 11 - Grading the Product Performance: Functionality										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☑	☐	☐	☐	☐	Solution B

Question 12 - Grading the Product Performance: Functionality										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☑	☐	☐	☐	Solution C

Question 13 - Grading the Product Performance: Functionality										
	9	7	5	3	1	3	5	7	9	
Solution B	☐	☐	☐	☐	☐	☑	☐	☐	☐	Solution C

Question 14 - Grading the Product Performance: Accessibility										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☑	☐	☐	☐	☐	Solution B

Question 15 - Grading the Product Performance: Accessibility										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☑	☐	☐	☐	Solution C

Question 16 - Grading the Product Performance: Accessibility										
	9	7	5	3	1	3	5	7	9	
Solution B	☐	☐	☐	☐	☐	☑	☐	☐	☐	Solution C

Question 17 - Grading the Product Performance: Risk of Implementation										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☑	☐	☐	☐	☐	☐	Solution B

Question 18 - Grading the Product Performance: Risk of Implementation										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☐	☑	☐	☐	Solution C

Question 19 - Grading the Product Performance: Risk of Implementation										
	9	7	5	3	1	3	5	7	9	
Solution B	☐	☐	☐	☐	☐	☐	☐	☐	☑	Solution C

Question 20 - Grading the Product Performance: Timeframe										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☑	☐	☐	☐	☐	☐	Solution B

Question 21 - Grading the Product Performance: Timeframe										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☑	☐	☐	☐	Solution C

Question 22 - Grading the Product Performance: Timeframe										
	9	7	5	3	1	3	5	7	9	
Solution B	☐	☐	☐	☐	☐	☐	☑	☐	☐	Solution C

Question 23 - Grading the Product Performance: Cost										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☑	☐	☐	☐	☐	☐	Solution B

Question 24 - Grading the Product Performance: Cost										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☐	☑	☐	☐	Solution C

Question 25 - Grading the Product Performance: Cost										
	9	7	5	3	1	3	5	7	9	
Solution B	☐	☐	☐	☐	☐	☐	☐	☑	☐	Solution C

REVISED Cindy DeLyon - Part 1 - Criteria Ranking to Evaluate Solutions

Question 1 - Weighted Importance: Functionality versus Accessibility										
	9	7	5	3	1	3	5	7	9	
Functionality	☐	☐	☐	☑	☐	☐	☐	☐	☐	Accessibility

Question 2 - Weighted Importance: Functionality versus Risk of Implementation										
	9	7	5	3	1	3	5	7	9	
Functionality	☐	☐	☐	☐	☐	☐	☐	☐	☑	Risk of Implementation

Question 3 - Weighted Importance: Functionality versus Timeframe										
	9	7	5	3	1	3	5	7	9	
Functionality	☐	☐	☐	☐	☐	☑	☐	☐	☐	Timeframe

Question 4 - Weighted Importance: Functionality versus Cost										
	9	7	5	3	1	3	5	7	9	
Functionality	☐	☐	☐	☐	☐	☐	☐	☐	☑	Cost

Question 5 - Weighted Importance: Accessibility versus Risk of Implementation										
	9	7	5	3	1	3	5	7	9	
Accessibility	☐	☐	☐	☐	☐	☐	☐	☐	☑	Risk of Implementation

Question 6 - Weighted Importance: Accessibility versus Timeframe										
	9	7	5	3	1	3	5	7	9	
Accessibility	☐	☐	☐	☐	☐	☑	☐	☐	☐	Timeframe

Question 7 - Weighted Importance: Accessibility versus Cost										
	9	7	5	3	1	3	5	7	9	
Accessibility	☐	☐	☐	☐	☐	☐	☐	☑	☐	Cost

Question 8 - Weighted Importance: Risk of Implementation versus Timeframe										
	9	7	5	3	1	3	5	7	9	
Risk of Implementation	☐	☐	☑	☐	☐	☐	☐	☐	☐	Timeframe

Question 9 - Weighted Importance: Risk of Implementation versus Cost										
	9	7	5	3	1	3	5	7	9	
Risk of Implementation	☐	☐	☐	☐	☐	☐	☐	☑	☐	Cost

Question 10 - Weighted Importance: Timeframe versus Cost										
	9	7	5	3	1	3	5	7	9	
Timeframe	☐	☐	☐	☐	☐	☐	☐	☐	☑	Cost

REVISED Cindy DeLyon - Part 2 - Product Grading

Question 11 - Grading the Product Performance: Functionality										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☑	☐	☐	☐	☐	Solution B

Question 12 - Grading the Product Performance: Functionality										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☑	☐	☐	☐	Solution C

Question 13 - Grading the Product Performance: Functionality										
	9	7	5	3	1	3	5	7	9	
Solution B	☐	☐	☐	☐	☐	☑	☐	☐	☐	Solution C

Question 14 - Grading the Product Performance: Accessibility										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☑	☐	☐	☐	☐	Solution B

Question 15 - Grading the Product Performance: Accessibility										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☑	☐	☐	☐	Solution C

Question 16 - Grading the Product Performance: Accessibility										
	9	7	5	3	1	3	5	7	9	
Solution B	☐	☐	☐	☐	☐	☑	☐	☐	☐	Solution C

Question 17 - Grading the Product Performance: Risk of Implementation										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☑	☐	☐	☐	☐	☐	Solution B

Question 18 - Grading the Product Performance: Risk of Implementation										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☐	☐	☐	☑	Solution C

Question 19 - Grading the Product Performance: Risk of Implementation										
	9	7	5	3	1	3	5	7	9	
Solution B	☐	☐	☐	☐	☐	☐	☐	☐	☑	Solution C

Question 20 - Grading the Product Performance: Timeframe										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☑	☐	☐	☐	☐	☐	Solution B

Question 21 - Grading the Product Performance: Timeframe										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☐	☐	☐	☑	Solution C

Question 22 - Grading the Product Performance: Timeframe										
	9	7	5	3	1	3	5	7	9	
Solution B	☐	☐	☐	☐	☐	☐	☐	☐	☑	Solution C

Question 23 - Grading the Product Performance: Cost										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☑	☐	☐	☐	☐	☐	Solution B

Question 24 - Grading the Product Performance: Cost										
	9	7	5	3	1	3	5	7	9	
Solution A	☐	☐	☐	☐	☐	☐	☐	☐	☑	Solution C

Question 25 - Grading the Product Performance: Cost										
	9	7	5	3	1	3	5	7	9	
Solution B	☐	☐	☐	☐	☐	☐	☐	☐	☑	Solution C

Exhibit F - CFS Lookahead Report

BOL/SSL	VESSEL	CONTAINER(S)	LOCATION	COMMODITY	DESTINATION	SHIPPING NUMBER	JF REFERENCE	COMMENTS
BL123456789	EVERGREEN EXPRESS	ABCU1234567, DEFV2345678, GHIW3456789, LMNY5678901, OPQZ6789012	LOADING VANCOUVER	Fresh fruits (such as apples, oranges, and bananas)	Customer A	SHIP123456789	159702	5 X 20'
BL987654321	CN RAIL	JKIX4567890	LOADED KELOWNA	Automobiles (including cars, trucks, and motorcycles)	Customer A	SHIP987654321	428751	20'
BL456789012	CN RAIL	RSTA7890123	ARRIVED	Textiles (such as cotton clothing, denim jeans, and polyester fabric)	Customer A	SHIP456789012	287510	20'
BL890123456	CN RAIL	DEFA0123456, GHIJ1234567, LMNO2345678	ARRIVED	Machinery parts (including engines, turbines, and mechanical components)	Customer A	SHIP890123456	361245	3x 20'
BL234567890	NEPTUNE VOYAGER	PQRZ3456789, STUV4567890, WXYZ5678901, UVBC8901234, WXYZ9012345	FEB 28/21 Prince George	Consumer electronics (such as televisions, laptops, and smartphones)	Customer A	SHIP234567890	497108	5 X 40'
BL678901234	NEPTUNE VOYAGER	JKIX6789012, LMNY7890123, OPQZ8901234, WXYZ1234567	FEB 28/21 Prince George	Frozen seafood (including fish, shrimp, and scallops)	Customer A	SHIP678901234, SHIP567890123	185630	4 X 40'HC
BL345678901	NEPTUNE VOYAGER	RSTA9012345, UVBC0123456	FEB 28/21 Prince George	Industrial chemicals (including solvents, acids, and fertilizers)	Customer A	SHIP345678901	572391	2 X 40'HC
BL012345678	NEPTUNE VOYAGER	DEFA2345678, GHIJ3456789, LMNO4567890	FEB 28/21 Prince George	Household appliances (such as refrigerators, washing machines, and air conditioners)	Customer A	SHIP012345678, SHIP901234567	364789	3 X 40'HC
BL789012345	NEPTUNE VOYAGER	PQRZ5678901	FEB 28/21 Prince George	Building materials (including steel beams, lumber, and cement)	Customer B	SHIP789012345	920375	1 X 40'

All synthetic data was created using ChatGPT (OpenAI, 2023).

Exhibit G - Drayage Cost Tracker

Date	Trucking Provider Hired	# of Trucks Hired	Hours Worked	Containers Picked Up	Containers Returned	Customer	Product	JF (if available)	Other identifiers	Amount
Monday, September 12, 2022	Provider A	1	2.5	1	1	Customer A	Electronics (such as smartphones, laptops, and consumer electronics)	123456	ABCU1234567	$275.00
Monday, September 12, 2022	Provider A	1	1.5	1	0	Customer B	Clothing and apparel (including fashion garments and accessories)	987654	DEFV2345678	$165.00
Monday, September 12, 2022	Provider A	1	1	0	1	Customer C	Automotive parts and components (such as engines, tires, and body panels)	345678	GHIW3456789	$110.00
Wednesday, September 14, 2022	Provider A	1	4.5	3	0	Customer B	Furniture (including home furnishings and office furniture)	678901	JKIX4567890, LMNY5678901, OPQZ6789012	$495.00
Thursday, September 15, 2022	Provider A	1	2	1	0	Customer B	Agricultural products (such as grains, coffee beans, and fruits)	234567	RSTA7890123, UVBC8901234, WXYZ9012345	$220.00
Monday, September 26, 2022	Provider A	1	1.5	1	0	Customer C	Toys and games (including children's toys and recreational equipment)	890123	DEFA0123456	$165.00
Tuesday, September 27, 2022	Provider A	1	1.5	1	0	Customer B	Chemicals (including industrial chemicals and household cleaning products)	456789	PANU1000296	$165.00
Thursday, September 29, 2022	Provider B	1	3	1	1	Customer A	Machinery and equipment (such as industrial machinery, tools, and construction equipment)	789012		$330.00
Monday, October 17, 2022	Provider B	1	8	3	2	Customer C	Pharmaceuticals and medical supplies (including medications and medical devices)	567890	GHIJ1234567	$880.00
Monday, October 17, 2022	Provider A	1	8	4	2	Customer C	Plastic products (including packaging materials, containers, and plastic goods)	901234	LMNO2345678	$880.00

Rates (per hour)	
Provider A	$110
Provider A w. Chassis Rental	$140
Provider B	$110

All synthetic data was created using ChatGPT (OpenAI, 2023).

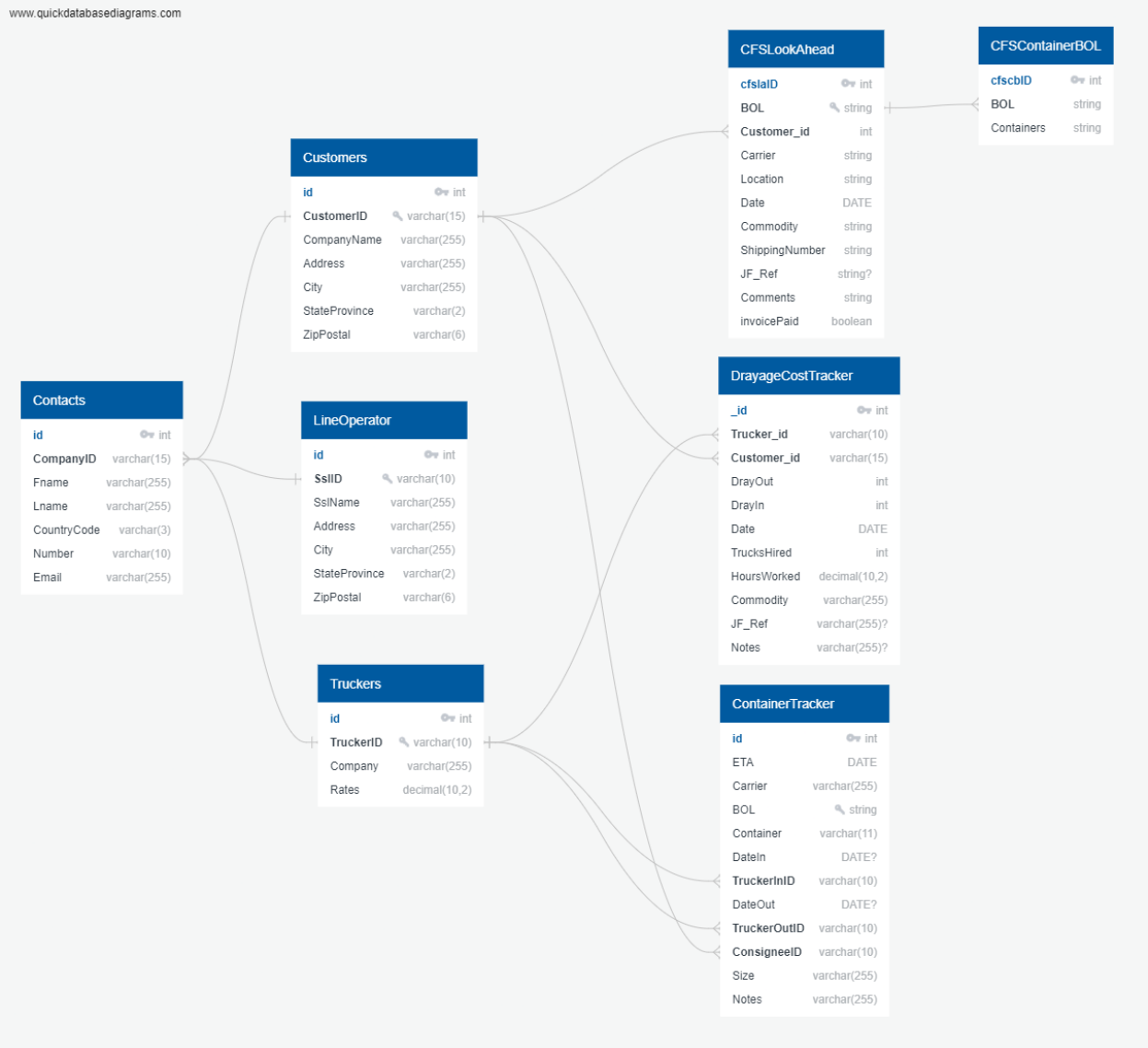
Exhibit H - Container Tracker

Date/ETA	Vessel	BOL	Container #	Date In	Trucker (in)	Date Out	Trucker (Out)	Consignee	Size	Comments
3-Nov-2022	Majestic Wave	BL12093857	DEFA0123456	3-Nov-22	Provider A	4-Nov-22	Provider A	Customer A	Open Top - 40'	
3-Nov-2022	Majestic Wave	BL12093857	GHIJ1234567	4-Nov-22	Provider A	4-Nov-22	Provider A	Customer A	Open Top - 40'	
3-Nov-2022	Majestic Wave	BL12093857	LMNO2345678	4-Nov-22	Provider A	4-Nov-22	Provider A	Customer A	Open Top - 40'	
3-Nov-2022	Majestic Wave	BL12093857	PQRZ3456789	4-Nov-22	Provider A	7-Nov-22	Provider A	Customer A	Open Top - 40'	
3-Nov-2022	Majestic Wave	BL12093857	STUV4567890	4-Nov-22	Provider A	7-Nov-22	Provider A	Customer A	Open Top - 40'	
3-Nov-2022	Majestic Wave	BL12093857	WXYZ5678901	4-Nov-22	Provider A	7-Nov-22	Provider B	Customer A	Open Top - 40'	
3-Nov-2022	Majestic Wave	BL12093857	JKIX6789012	3-Nov-22	Provider A	4-Nov-22	Provider B	Customer A	Open Top - 40'	Some damage to cargo when first opened photos taken
3-Nov-2022	Majestic Wave	BL12093857	LMNY7890123	5-Nov-22	Provider A	7-Nov-22	Provider B	Customer A	Open Top - 40'	

Date	Company	Trips	Time	Hours
3-Nov-22	Provider A	2	130 - 430	3
4-Nov-22	Provider A	6		
5-Nov-22	Provider A	1		
7-Nov-22	Provider A	5		
10-Nov-22	Provider B	1	8:00-10:00	2
14-Nov-22	Provider A	5		
15-Nov-22	Provider A	5		
17-Nov-22	Provider A	6		
24-Nov-22	Provider A	2		

All synthetic data was created using ChatGPT (OpenAI, 2023).

Exhibit I - Entity-Relationship Diagram



ER Diagram courtesy of Quick DBD, 2024.

Exhibit J - Millenni-X Operations As-Is Process