THINK Executive White Paper Series

April | 2019

The Logistics Institute – Asia Pacific

Urban Grid Logistics – Adaptive Orchestration of Resources Leveraging Smart Technologies

The Logistics Institute Asia Pacific

A Collaboration Between

NUS National University of Singapore

Georgia Institute of Technology

Presented at:

THINK EXECUTIVE SUMMIT:

URBAN GRID LOGISTICS – AGILITY THROUGH ORCHESTRATION OF RESOURCES AND LEVERAGING SMART TECHNOLOGIES FOR ADAPTIVE RESPONSIVENESS AND EFFICIENCY

24 April 2019

Singapore

EXECUTIVE SUMMARY

This white paper addresses the complexity inherent in any supply chain that makes it difficult to experiment with probable design and execution challenges piecemeal. A balance is required in orchestrating transformation for responsiveness and efficiency.

A granular virtuous approach, appropriate to the challenges posed in migrating from an as-is to a to-be model is presented where the coarseness of data utilized or gathered is commensurate with the problem statement under study.

An Urban Grid for Adaptive Orchestration of Resources Leveraging Smart Technologies is presented. The Urban Grid platform aims to create a data-driven supply chain where information is shared across the entire supply chain to connect the various supply chain actors and provide end-to-end supply chain agility. With such a platform, firms can easily develop strategic collaboration with other supply chain partners and conduct business activities more transparently on merged but secure data sets.

This orchestration from an as-is to a to-be faces immense data challenges as one moves through several transition phases from planning to execution, each perhaps requiring different modelling methods and progressively finer data tuning.

The physical supply chain is not easily tweaked. Authors have variously coined the term digital twinning where the essential characteristics of the supply chain are captured in a digital model. However, such a digital twin varies with modelling method, albeit visualization, to analytical to optimization or simulation. The twin itself may vary in complexity and data requirements. It is our belief that we orchestrate to and fro with tools best suited to the task but have a progressively finer matched data set that can be utilized across modelling methods - a supply chain meta twin of twins!

Creating out-of-the-box ideas requires a sandbox for safe experimentation within the digital twins of transformative ideas. The initial tools in the sandbox have been carefully picked and open to enhancements as better castles need to be built with bridges across moats. The tools are organized to deliver interim milestone results and data collection itself is progressive and matched to granularity required in the respective digital twin.

Thus, in this information intensive world, the focus has been to progressively turn simple data into worthy out of the box intelligence and use that in a smart way to streamline and integrate supply chains that will save time and costs for each participant company as well as its customers.

We hope that you enjoy reading this white paper and that it provides some journey mapping in your digital transformation and that you will contribute to the ensuing discussion at the THINK Executive events on 24 April 2019

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Chapter 1

SHARING FOR RESPONSIVENESS AND EFFICIENCY

BACKGROUND

Logistics is changing rapidly. Today's logistics industry is truly not comparable to the industry 20 years back in time. Looking 20 years in the future, we can expect even more far-reaching disruptions. In the wake of digitalisation, supply chains become more complex, and claims for agility, responsiveness, and flexibility rise continuously.

In the wake of omni-channel commerce, companies are faced with enormous delivery demands across many locations. While three years ago 800,000 individual deliveries were conducted on a daily basis in South-East Asia, the current number jumped to 3 million, indicating a growth rate of 375% in shipping volumes. Focusing on Singapore, the nationwide e-commerce market is worth 1.8 billion US$ and grows rapidly. Recent analysis predicts numbers of 5 billion US$ for 2025, approximately a tripling in market size within a period of only six years (The Straits Times, 25th February 2019).

As the omni-channel business grows, delivery volumes increase continuously. Simultaneously, Singapore has to face ever-increasing urban challenges, such as population density, congestion, environmental pollution (e.g., through carbon emissions), and lower utilisation rates. Changing consumers who adapt to digital, mobile technologies and demand increasing speed as well as more flexible deliveries, demographics, and urbanisation density further fuel these urban challenges. Therefore, in the realm of increasing connectivity and data availability, today's logistics ecosystem is now gradually shifting towards omni-channel commerce, characterised by decentralised shopping behaviour, fragmented and highly variable demand, and a higher delivery diversity (Figure 1.1).

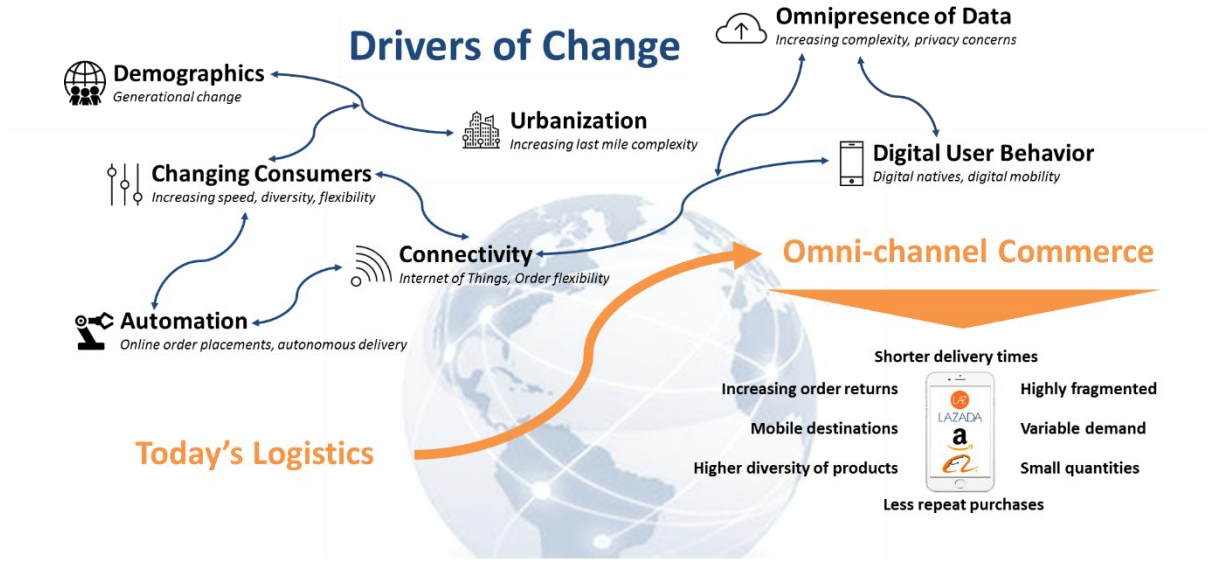


FIGURE 1.1 DRIVERS OF CHANGE IN LOGISTICS

In order to stay on top of these developments and to maintain a competitive edge in international (and urban) logistics, Singaporean supply chains need to leverage the opportunities of digitalisation. Alarming investigations reveal that more than 70% of all trucks are less than 40% full, delivery routes are substantially longer than necessary, firms frequently struggle with supply chain transparency (e.g., knowing their value chain partners) and traceability of products and disruptions are handled on a less responsive and non-agile react-on-incident basis (Figure 1.2). For all these challenges, digital technologies could help to achieve operational efficiency, eventually leading to supply chain transparency, industry collaboration in order to increase asset utilisation, and flexibility (Figure 1.2).

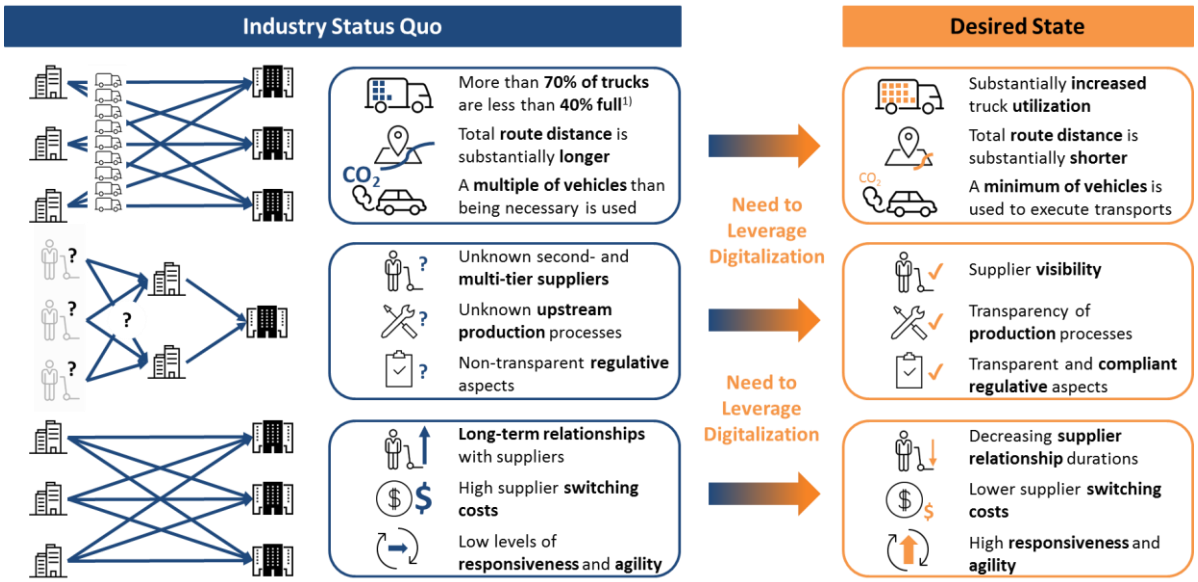


FIGURE 1.2 STATUS QUO VS. DESIRED STATE

URBAN GRID LOGISTICS PLATFORM

Platform Configurations

Leveraging 3D geospatial data as well as company-specific shared data, this project aims to implement a superior shared logistics platform, the first of its kind to provide a full suite of capabilities to support supply chain distribution network design, day-to-day delivery fulfilment operations, and the efficient allocation of resources to help our partners in tackling complexities of the digital supply chain and addressing their problem statements (Figure 1.3).

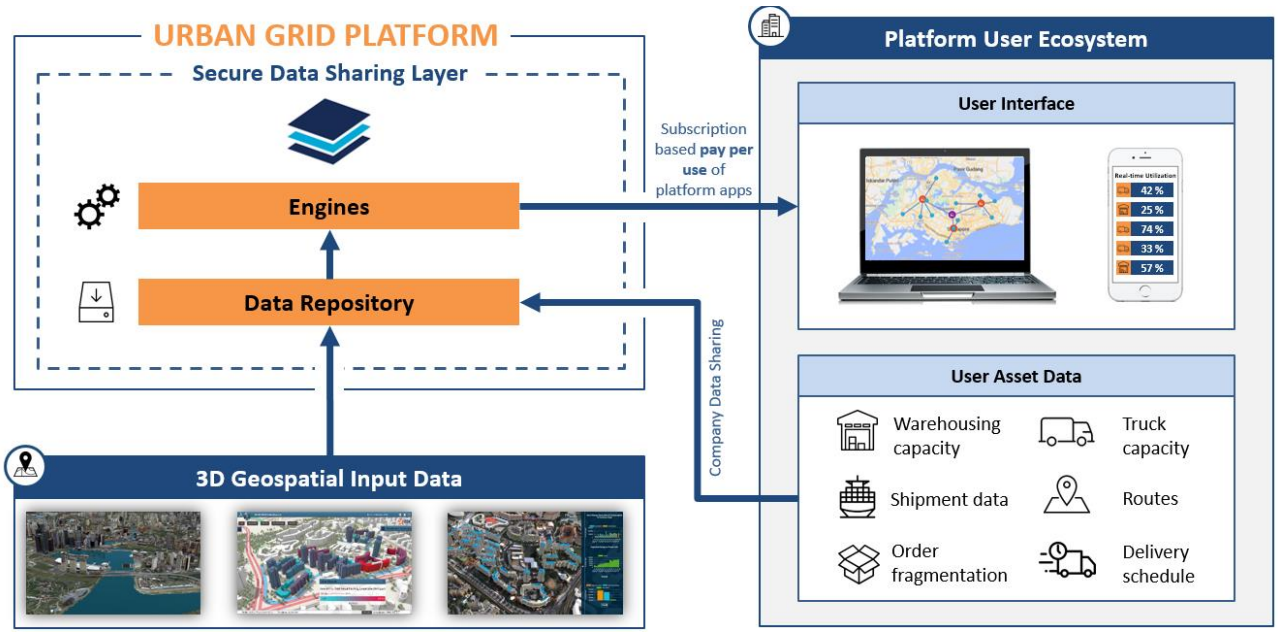


FIGURE 1.3 URBAN GRID PLATFORM APPROACH AND ECOSYSTEM

Drawing from both 3D geospatial and company sharing data, the platform will use intelligent engines to analyse, visualise, and optimise supply chain related problems of users. In the realm of rising cybersecurity relevance and increasing concerns regarding confidentiality, privacy, data security, and intellectual property (IP) protection, the platform will build on a secure data exchange infrastructure. Against this background, secured data exchange protocols will be used to safeguard crucial company transactions, providing a sufficiently high level of distributed data security. Platform users can easily access all tools and applications through an intuitive user interface (UI) which functions as a supply chain control tower. This UI will not only allow to access optimisation and planning applications, but will further provide dashboard views to dynamically monitor relevant supply chain KPIs.

Platform Architecture

The platform architecture (Figure 1.4) is aligned with the typical iterative optimisation process including the solution's implementation. Initially, the current status quo (***As-Is***) has to be recorded, analysed and potentially visualised. Secondly, optimisation tools and algorithms can find an optimal (***To-Be Ideal***) solution for the identified problem. However, in the real world, defined by huge amounts of constraints, details, and exceptions, an ideal model solution will most likely not be ready for implementation. Thus, thirdly, a realistic and implementable solution (***To-Be Real***) has to be derived from the ideal model solution. Finally, as conditions change dynamically on a rolling basis, the to-be real solution becomes the new as-is status, closing and restarting the iterative optimisation loop. This process loop, which is accessible through the platform visualisation UI, mathematically builds on a broad set of intelligent platform engines (i.e., algorithms and concepts). In the first place, supply chain specific engines (e.g., Greenfield analysis, fleet optimisation, vehicle routing) support relevant logistics decision making. Another layer below, so-called core engines build the analytical foundation (e.g., multimethod modelling or analytical optimisation). The platform itself is fed by two main data sources, namely 3D geospatial data and company sharing data. Further data sources (e.g., commercial reports or news and web data) could optionally be included.

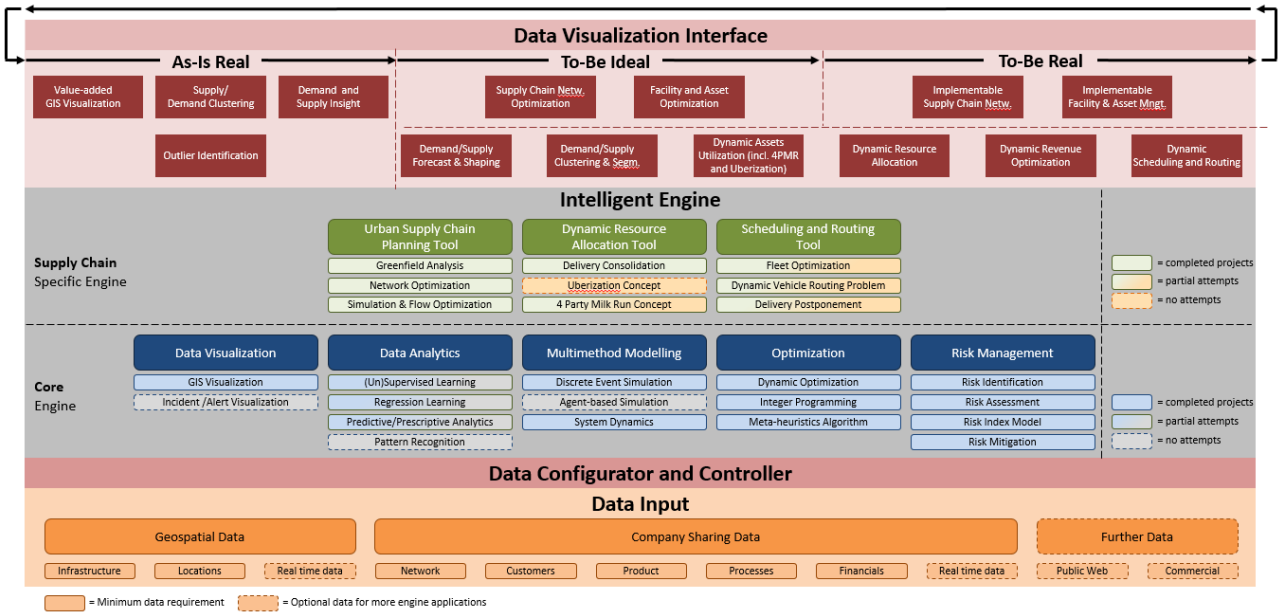


FIGURE 1.4 URBAN GRID PLATFORM ARCHITECTURE

Every supply chain is unique and comes with its own idiosyncrasies. The data visualisation layer which comprises of As-Is and To-Be allows users to capture the features and make adjustments to represent the changing traits of the supply chain network. System constraints, rules, and risks can be pre-set and used to generate accurate visualisation of the actual and simulated environments. Operations inside the four walls, such as a factory, warehouse or retail store, can also be simulated to demonstrate the movement of goods outside the supply chain network.

CONCLUSION

Conclusively, our approach, integrating cutting-edge visualisation technology, intelligent algorithms, and multimethod modelling, allows seeding new insights in logistics and supplying chain management by leveraging the opportunities of digitalise to eventually initiate industry collaboration, optimise transparency, and increase flexibility. Our platform provides a holistic industry-wide solution that has the potential to strengthen the international competitiveness of Singapore's logistics industry significantly.

Chapter 2

GRID ORCHESTRATION

INTRODUCTION

Stepping into the twenty-first century, companies are constantly finding ways to digitize their operations and automate their processes for improved work efficiency. However, it is observed that such improvement efforts are concentrated at a corporate level with no extension to industry or national scale. As a result, low asset utilisation rates are still persistent in companies, and key resources are constantly in demand due to poor deployment strategies.

Urban Grid Logistics Platform, which taps on the seamless sharing of data across industries, intends to connect the nodes in the urban supply chain landscape for dynamically improved asset utilisation. In the process, it breeds the emergence of new business models and orchestrates the systematic planning and execution in an urban supply chain environment.

DATA-POWERED SUPPLY CHAIN TRANSITION

Nowadays, companies are investing heavily in new information technologies, for instance, enterprise resource planning radio frequency identification, to trace the goods, automate transactions, and optimise inventory levels and support supply chain decisions within the enterprises. The adoption of these technologies has generated a massive amount of data that flows in real-time but sometimes are shelved instead of being used to assist in company operations. Since 2012, approximately 2.5 Exabyte of data is generated daily with signs of doubling every three years, with a large amount being transactional data between corporates. If properly managed, harnessed and utilised, these data have the potential to drive revolutionising changes and enable leapfrogging improvements in supply chain performance and capabilities. Given the positivity, companies have started to view data as a critical source for business insights, value creation, and competitive advantage.

In today's business environment, companies are undergoing different phases in the data-driven economy with some spearheading the efforts to use data to improve supply chain processes and open up new business opportunities whereas some are still hesitating in their digital decisions. Even for early adopters, the enterprise data are collected mostly for greater visibility into their operations, for example, expenditure tracking, trend identification in costs and performance, process planning and control, inventory monitoring, capacity tracking, and production optimisation.

It is observed that there is significant lack of research to address the effects of these big data on the supply chain performance and capabilities and how software can harness and strategically utilise these data to generate industry-wide supply chain planning and execution.

GRID INITIATED SUPPLY CHAIN PERFORMANCE IMPROVEMENT

Even with big data and marginal efficiency improvement, the efforts are still concentrated at the corporate level. It is becoming an increasingly acute problem for many companies, which are experiencing isolated asset utilisation, enterprise-centric transport and warehousing management and unused silo information (Figure 2.1). The challenge that these enterprises face is that different supply chain members use different technologies and systems and are often constrained to their own silo information due to data security controls. In order to maximise the benefits of data for greater profits, information should be shared across processes and companies so as to provide a real end-to-end process view for all supply chain partners.

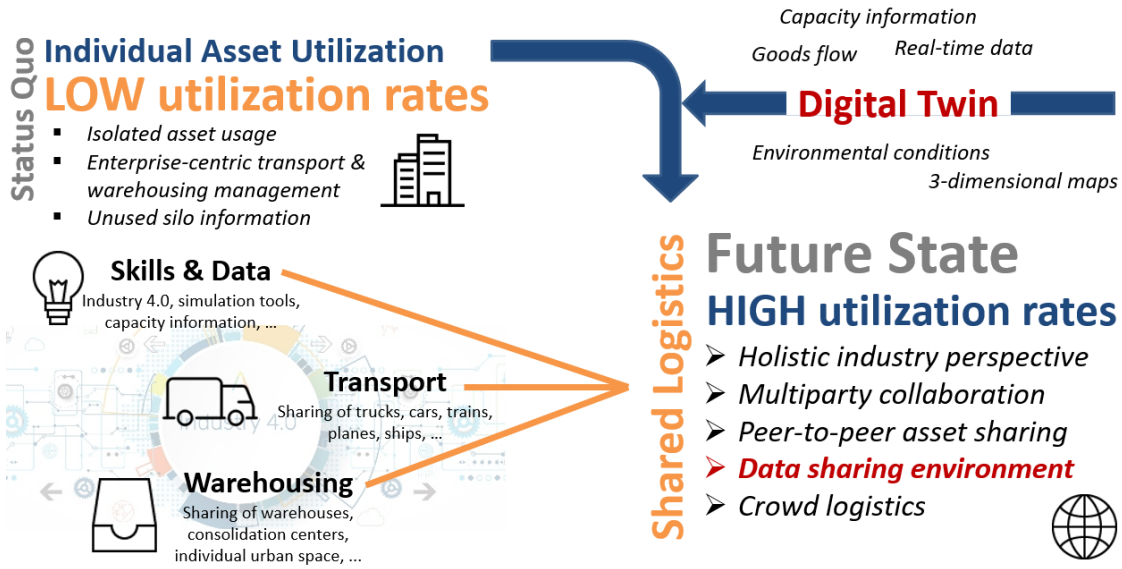


FIGURE 2.1 GRID-INITIATED SUPPLY CHAIN PERFORMANCE IMPROVEMENT

The Urban Grid platform aims to create a data-driven supply chain where information is shared across the entire supply chain to connect the various supply chain partners and provide end-to-end supply chain data access. If successfully integrated into the organisational protocols, it can bring about daily supply chain improvements and greatly enhance the capabilities of supply chain staff. To increase its effectiveness, there is a constant need to bring in more supply chain partners and build a robust system that can plan and execute supply chain functions with high accuracy. With such a platform, firms can easily develop strategic collaborations with supply chain partners and conduct business activities more efficiently.

VALUE ADDING SUPPLY CHAIN ANALYTICS

In the Grid, smart decision supporting engines are the key to improved resource utilisation, which generally refers to the warehouses, skilled manpower, and transportation assets. The engines, which are a dynamic simulation, network optimisation, analytical optimisation, Greenfield analysis, predictive demand forecasting, and pattern recognition, are to be gradually added to the platform to bring about greater supply chain capabilities (Figure 2.2). By leveraging on the large multi-company datasets, the firms could improve demand forecasting and supply planning by integrating their own data, supplier data, and

customer data. Enterprises can also easily form strategic collaborative relationships to achieve great advancements in managing the increasingly complex supply chain.

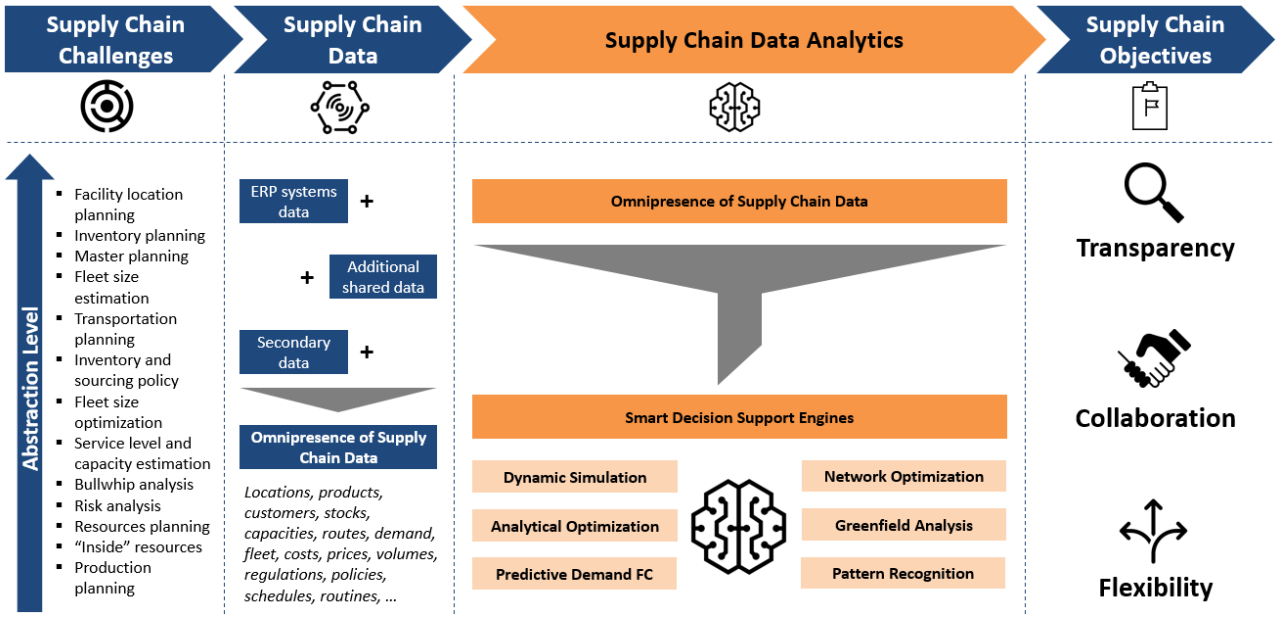


FIGURE 2.2 GRID - SUPPLY CHAIN DATA ANALYTICS

CONCLUSION

Ultimately, the data-driven Grid platform aims to bring about greater supply chain transparency, collaboration and flexibility in the urban landscape. With these advancements, parties in different stages of the supply chain can experience greater ease in coordination, operations and transactions. Looking into the future, the data-powered supply chain should be a shared environment that enables peer-to-peer asset sharing and multi-party collaboration where all supply chain partners holding a holistic industry perspective.

Chapter 3

ORCHESTRATED PLANNING

Jointly contributed by The Anylogic Company and

The Logistics Institute – Asia Pacific, National University of Singapore

INTRODUCTION

Analytical optimisation and dynamic simulation are the two most commonly adopted technologies to solve complex supply chain problems. However, there has been a lot of confusion around the terms optimisation and simulation in the industry. People often misinterpret them and companies offering supply chain solutions, used in the wrong context, or have different meanings.

Many managers question the differences between these techniques, which is better or more efficient, and what problem does each solve? This white paper will help resolve the confusion and explain when it is best to apply each of these methods.

ANALYTICAL OPTIMISATION

Analytical optimisation is probably the most common technique for improving supply chains. Most of the analytical optimisation tools work the following way: a manager visually describes their supply chain as a graph and parameterize it with a set of tables; after that, the manager describes the constraints, populates the model with data, and then pushes "solve" to find the optimal, or suboptimal, solution to the problem.

At this stage, the model is converted into a set of linear equations, constituting a linear and mixed integer programming (LP and MIP) problem. These equations are then solved using optimisation engines (popular ones include IBM ILOG CPLEX®, Gurobi® Optimiser, or FICO® Xpress Optimisation). The results appear in the user interface of the supply chain tool as a set of tables with material flows and finances.

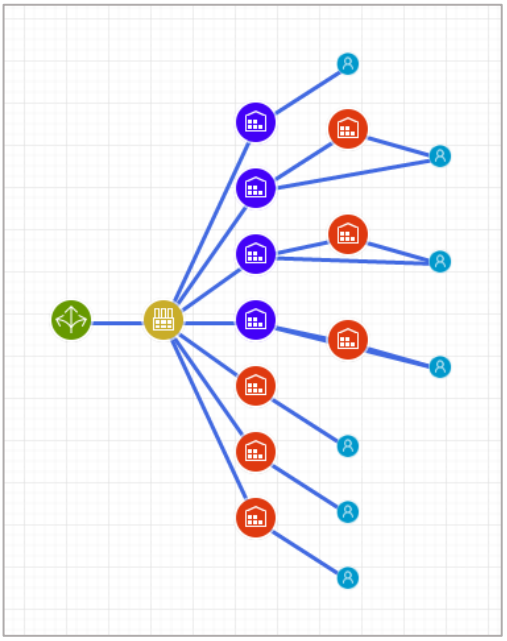


FIGURE 3.1 SUPPLY CHAIN NETWORK

When to use optimisation?

Analytical models are well-equipped for large-scale data-intensive problems. You can optimise supply chains that include tens of thousands of sites and thousands of product categories. This is the main advantage of this method.

Problems that can be solved using analytical optimisation:

- Supply chain design: where to locate facilities, what their throughput should be, how to arrange product flows.
- Master planning by period: where to produce or stock goods, how much to produce and order, how to provide for seasonal peaks in demand.
- Transportation: what size fleet is required.

Limits to optimisation

In order to map a supply chain to a set of equations, a supply chain manager must simplify the real-world system and employ certain generalisations and assumptions:

- All the relations in such a model have to be represented as linear dependencies or step functions – a significant simplification of the world's unevenness.
- Products, orders, and deliveries are modelled as a set of flows between facilities and costs associated with flows, abstracting from unique shipments or product units.
- Time is represented with periods, e.g. week, month, and year. Disruptive or random change can only occur at the beginning or the end of a period, and not inside it. Any event may happen only once within a period (e.g. closing a facility). Also, analytical models assume that all parameters are uniformly distributed within a period.
- Analytical models cannot represent actual supply chain behaviour, such as process logic, resource availability, randomness, and time-related dynamics.

Analytical models are ideal for solving supply chain challenges at the network level, when you don't need to take into account operational logic, randomness, and dynamics. If your challenge requires considering any of these, you still can use analytical optimisation to get a first approximation of the solution, and then do detailed in-depth analysis with dynamic simulation modelling.

DYNAMIC SIMULATION

A dynamic simulation model is a description of a system and the rules by which it operates – business process logic, and the interdependencies between system components. A simulation model is dynamic because it is **executable** – you can run the model and see how the system behaves over time, just like in a computer game.

When to use simulation?

Dynamic simulation is especially useful when the operational logic and processes inside the supply chain significantly influence financial efficiency and, as a consequence, need to be accounted for during the supply chain design stage.

Simulation helps describe the system with all the details and complexity. Time-dependent, random, and interacting effects within the system can cause such complexity, with examples being demand fluctuations, lead-time variability, or multi-echelon inventory policies. These traits cannot be taken into account with an analytical model.

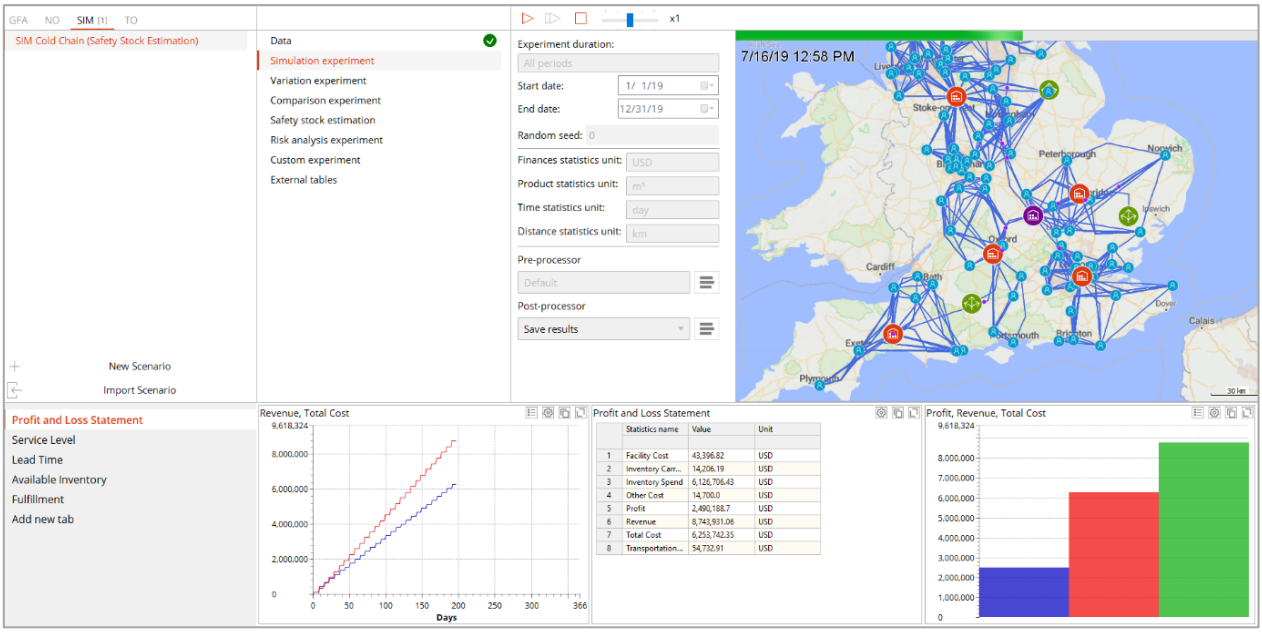


FIGURE 3.2 RESULTS OF SIMULATION EXPERIMENT

Some of the challenges that can be addressed using dynamic simulation:

- **Implementing a new supply chain design.**
  - How to introduce a solution suggested by network optimisation?
  - What if the solution suggested by optimisation cannot be implemented in the real world?

- **Understanding supply chain operations.**
  - To efficiently manage your network, you need to understand how it operates over time and in detail, down to the level of every resource and policy.
  - Estimate safety stock at each facility for each product.

- **Experimenting with supply chain innovations.**
  - With a high-level network design in place, you may want to know how to improve its operational performance.

  - Ideas can be tested prior to implementation.

- **Risk assessment.**
  - What are the risks related to this supply chain structure?

- **"Inside the four walls" business process assessment.**
  - How do the internal processes in your DCs or factories influence operations across the whole supply chain?

A benefit of simulation modelling is information on how your supply chain operates in the conditions you set. Here, we don't optimise anything; we simulate a certain scenario using the model and see the results. We can inspect model results in depth and understand how the supply chain changes over time. You can test multiple scenarios and come to a business decision based on testing and the evaluation of results.

How Do Simulation and Analytical Methods Differ?

- Flows vs. logic and policies

Analytical methods describe the system as flows between facilities, while simulation employs the real logic of their communication. When you build a model in terms of flows, you have to abstract from most of the real processes, which makes the model less accurate. At the same time, representing flow in a real-world supply chain means finding the right logic to make it work. To overcome these restrictions, we must turn to dynamic simulation.

- Time instead of periods

Analytical models represent time as a set of periods (e.g., weeks or months), while simulation follows the true passing of time. In an analytical model, a period is a static thing – there is the beginning of a period and the end of a period. Periods are good for high-level problems, where you can abstract from the dynamic nature of reality. If you need to account for days or even hours, you have to use dynamic simulation.

- Risk and Uncertainty

Analytical models are by nature deterministic, which means they do not consider randomness. Every parameter in the model is predefined and averaged, including naturally varying things like lead times or demand. What you can vary are the input parameters: running the optimisation multiple times with, for instance, different demand values, and achieving a different result for each variation.

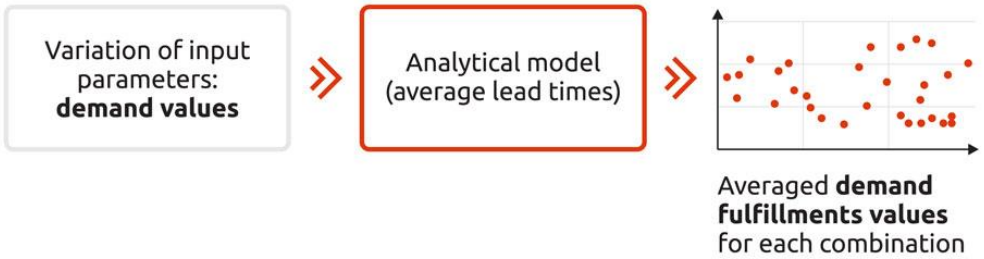


FIGURE 3.3 INPUT PARAMETER FOR ANALYTICAL MODELS

However, to understand how the system will perform in real life, in most cases you will need to vary internal model parameters, like production time for each unit. For example, let us assume production time is 4 to 8 hours instead of an average of 6. If we include this uncertainty in the model, so that production times fall in this range each time, the results may not be the same as using the average of 6. To reflect this uncertainty in the model, you must use dynamic simulation.

To make this probability-based model represent the reality more closely, we need to run it multiple times (iterations), varying production times with every run, to get a statistical distribution of results. Such statistics allow us to better understand fulfilment risks for a certain demand volume, providing us with more realistic data and helping us make better decisions.

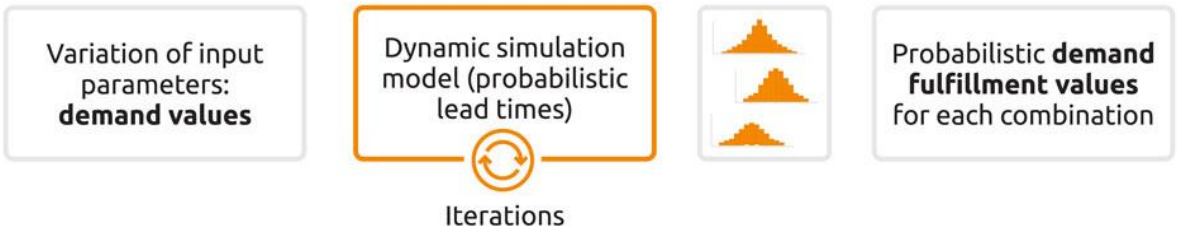


FIGURE 3.4. DYNAMIC SIMULATION MODEL

Risks and uncertainties can only be considered with a probability-based, or stochastic, simulation model.

- Model Transparency

With an analytical model, you may know what happens. However, you do not know why it happens. A model is a "black box" – you cannot see what exactly is going on inside. Dynamic simulation models allow you to see the result and to validate how it was achieved.

- Measure real metrics

Analytical models are typically built around a single supply chain KPI – such as, costs or profit. By contrast, in a dynamic simulation model, many various metrics can be measured at the same time. For example, costs, DC capacity utilisation, service levels, fleet utilisation rates, and more, can be all calculated within the same model.

Limits of dynamic simulation

First, when using dynamic simulation, in addition to data preparation, the analyst must invest a lot of time and effort in the creation of the model itself. Building a model from scratch may be a laborious task. Although, today there are flexible tools that allow analysts to quickly build simulations using out-of-the-box functionality, without losing the capabilities required for complex challenges and in-depth model customisation.

Secondly, to build a helpful simulation model, you must be careful when choosing the level of abstraction, deciding whether you need to include various policies and resources in the model or not. Including too many extra details may increase processing time.

Lastly, with simulation, you cannot calculate the optimum – you only can test different what-if scenarios to see which one is better. Simulation-based optimisation exists, but it is fundamentally different from analytical, or mathematical, optimisation. In the case of simulation, the optimisation engine is a separate program working in conjunction with the simulation model. The optimiser measures the model output and generates a new set of input parameters based on this data, trying to better achieve the optimisation goals. As a result, a simulation model has to be run many times to achieve an optimal result, and this can take a lot of time – for really data-intensive models on a desktop computer this can be days. However, these problems are now being solved, with an emergence of cloud technologies, and simulation model execution is now moving to cloud.

Simulation does not produce an optimal solution from multiple combinations, but allows the analyst to comprehensively study particular dynamic scenarios and supply chain interdependencies. Dynamic simulation should be used when the supply chain is heavily affected by uncertainties, influenced by a sites' internal logic and processes, and requires many details to be considered. It is the only technology available that can solve such challenges.

CONCLUSION

The more details you consider in your supply chain model, the more opportunities for improvement you have. The more efficient a supply chain analyst wants to become, the more is their need for dynamic simulation. It is a crucial tool for analysts striving to make their supply chains both lean and agile. However, all that doesn't actually mean that dynamic simulation is *better*. It's just targeted at different kinds of problems: it cannot handle challenges suitable for analytical methods well, and vice versa. Analytical methods allow you to handle large-scale problems while dynamic simulation addresses more details plus dynamics to go for deeper supply chain analysis.

To become efficient, the best option is to use these techniques together.

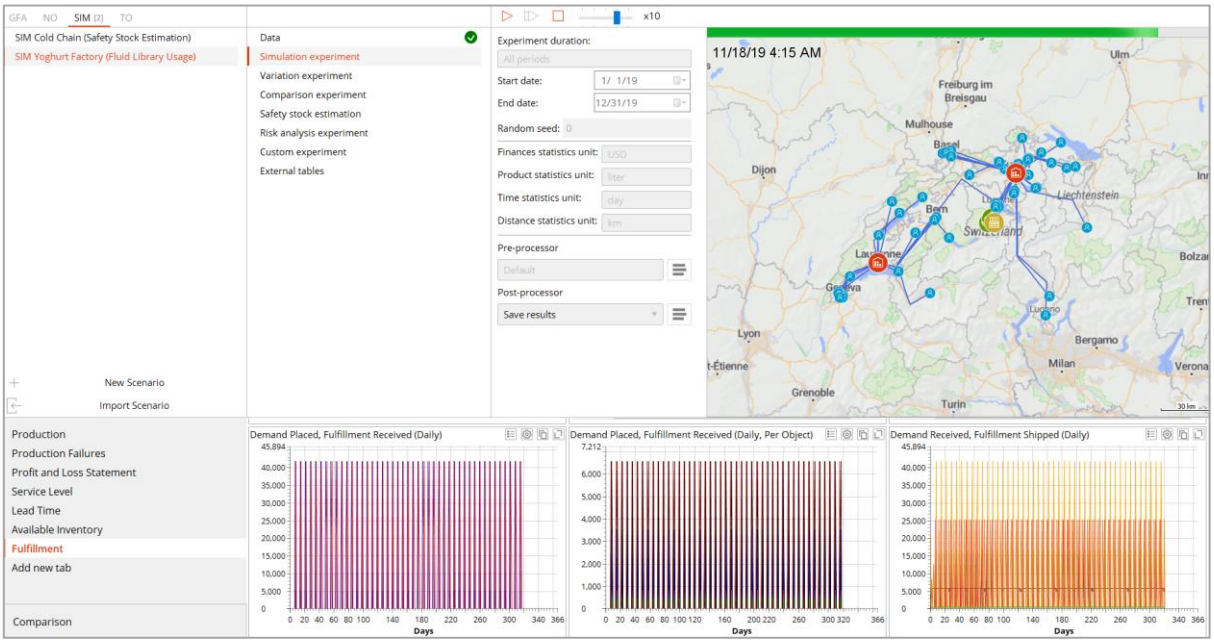


FIGURE 3.5 RESULT OF SIMULATION EXPERIMENT

Gartner advice that optimisation and simulation can be utilised together in different formats:

- Find the solution with optimisation, and then check its quality and validity by simulating the resulting scenario.

- Simulate the supply chain to understand the dynamics of the business system better, and then create a more tailored optimisation model based on these insights.

Combining these two methods is critical for building a proficient supply chain analytics toolset, and more companies are acquiring this technique every day.

anyLogistix™ (ALX™) is a software tool that combines powerful analytical optimisation approaches together with innovative dynamic simulation technologies. This empowers supply chain experts with a comprehensive set of tools for detailed end-to-end network analytics.

Chapter 4

ORCHESTRATED EXECUTION

Jointly contributed by ST Electronics (Info-Software Systems) Pte. Ltd. and

The Logistics Institute – Asia Pacific, National University of Singapore

INTRODUCTION

The goal of Urban Logistics innovation is to enable the supply chain network to accurately meet demands at the lowest possible cost yet maintaining the safety and quality of the goods in transit. To this end, recent advancement in technologies and innovation in operating models will allow greater intelligence, visibility, and control to be placed in the hands of logistics and shipping companies. The changes in today's digital economy are rapid and sweeping. This article will discuss some ways logistics companies can gain the upper hand through greater visibility and enhanced visualisation into their supply network and operations.

The intensifying population growth in urban cities coupled with e-commerce driven consumers' behaviour has presented new challenges to urban logistics companies. There is an unprecedented increase in the volume of package deliveries, comprising mostly small size packages. Consumers are also less patience, and more willing to try new products, even from small online retailers. Such an intricate web of demand and supply will create much inefficiencies and wastage if poorly handled. There is also the need to ensure safety and security in handling the goods during production, storage, and delivery. Last but not least, logistics companies are faced with the challenge to contain escalating costs and to reduce wastage.

DIGITAL INTELLIGENCE AND OPERATIONS CONTROL TOWER

One way to address the challenges of urban logistics is through the setting up of a Digital Intelligence and Operations Control Tower. The Control Tower would have the following functions:

- Digital Logistics Hub – 24x7 Intelligent Ops Centre Comprehensive Visibility and Intuitive Visualisation Monitor, Track, Alert, Notify, and Respond Optimisation and Predictive Planning
- Regulatory and Security compliance
- Customer satisfaction and KPI adherence
- Multi-party co-ordination and collaboration

FIGURE 4.1 LOGISTICS OPERATIONS CENTRE

Operations Control Centre

In Singapore, e-commerce sales are poised to reach S$10b (US$7.4b) within 2017 to 2020, with a growth rate of 11.7%. (Singapore Business Review, 2017). Investments are also expected to be pumped into the industry, estimated at US$50b until 2025. The thriving of e-commerce in recent years resulted in the ever-increasing delivery volume, but interestingly it has been observed that packages have been reduced in the physical dimension. Another phenomenon is the increasing delivery expectation from the end customers; delivery not only need to be fast; it also must be safe, secure, reliable and trackable.

In addition, the services offered must be scalable and elastic to accommodate demand surges due to festive seasons or special events; for example, Alibaba's Single's Day on November 11 and from the western hemisphere, Black Friday and Cyber Monday. This demand surge will put a huge strain on the supply chain network, and if not managed properly, will result in many unhappy buyers and sellers.

It is thus the desires of logistics companies that the supply chain network accurately meets demands at the lowest possible cost yet maintaining the safety and quality of the goods in storage and transit. Yet, these objectives are pulling in opposite directions – usually, to achieve on-time delivery and maintain the safety and quality of the goods will increase storage and delivery cost.

To achieve a more balanced and optimal outcome, greater visibility and ability to visualise the logistics ops is crucial. A new advancement in technologies will allow greater intelligence and control to be placed in the hands of logistics and shipping companies. At the core, a 'brain' is needed to coordinate and adapt continuously to changing parameters.

As in any large-scale operations, an Operations Control Centre is vital to smooth running and effective response to any incident. Thus, we recommend that a Digital Logistics Hub – a 24x7 Intelligent Ops Centre – be setup. It would act as the 'brain' that 'sees' and process information from multiple sensors input, and acts upon them after gaining deep insights. This hub – a Control Tower - will have the following key functions:

- **A Digital Logistics Hub – Intelligent Ops Centre.** Non-stop sensing of the logistics network pulse. Central command to facilitate response and perform a deep analysis. To maintain high availability, a secondary site may be setup as a backup.

- **Comprehensive Visibility and Intuitive Visualisation.** Through digitisation of work processes, and gathering of sensors input data at multiple points in the delivery network, we can attain much greater visibility into the supply chain. With the data captured, business intelligence tools can be utilised to display the information in meaningful ways that aid in decision-making.

- **Monitor, Track, Alert, Notify, and Respond.** The Ops Centre can serve to monitor the overall health of the logistics ecosystem, and also track particular business activities of interest in the supply chain. Whenever there is a major incident, it will receive alerts automatically. It may then notify affected parties, and coordinate the necessary response, in accordance with pre-defined eSOP (electronic Standard Operating Procedures).

- **Optimisation and Predictive Planning.** With a large amount of information gathered, the Ops Centre can carry out optimisation strategy to benefit the stakeholders. Consolidated demand forecasts, route and resource optimisation, and risk mitigation are but some of the advantages that can be derived from a centrally managed ops centre.

- **Regulatory and Security compliance.** Increasingly, businesses are faced with new threats and logistics companies are not spared. Identity theft, data leaks, virus infection, and ransomware are just some of the cybersecurity attacks taking place daily and on a massive scale. Tampering and theft of goods in storage and transit are also a major risk to businesses. Massive recall due to tampering will result in huge losses; likewise, cyber-attacks causing disruption to the supply chain need to be fought back and operations restored to normal. Such defence and recovery activities are best coordinated through this central ops centre.

- **Customer satisfaction and KPI adherence.** With greater visibility and insights gleam from data analytics, customer satisfaction can be further enhanced. Performance degradation resulting in failed KPI can be promptly looked into and prevent from happening again. This can form a continuous cycle of improvement, resulting in cost reduction and improved customer satisfaction.

- **Multi-party co-ordination and collaboration.** In this new era, collaboration among multiple logistics companies to share resources to compete against larger competitors, as well as take advantage of economy of scale, can be a strategic means to winning in the market. A co-owned, or subscribers based, centrally managed Ops Centre can act as a key platform for multi-party collaboration that benefits all stakeholders.

Key Benefits of the Digital Logistics Hub

- **Complete and Comprehensive Situational Awareness.** Such knowledge is crucial in sustaining an optimum daily operation as remedies could be swiftly deployed in the event of any anomalies. A Common Relevant Operating Picture. Beneficial for all stakeholders to truly understand the actual state of business.

- **Actionable intelligence.** The key word here is "actionable". Analytics can show the trends, but only with actionable recommendations allows user to be proactive and be ahead of the game. Collective Wisdom. Simply put a culmination and collective of knowledge over time. A closed loop continuous learning and improvements through data analytics and knowledge management.

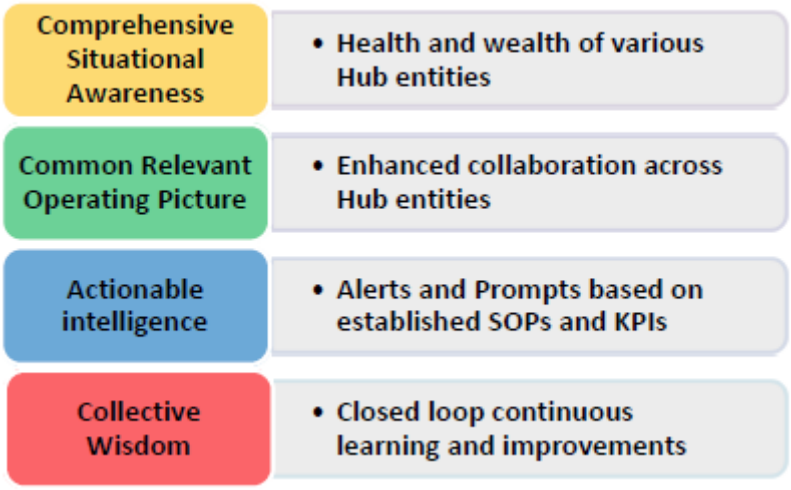


FIGURE 4.2 BENEFITS OF A DIGITAL LOGISTICS HUB

ENABLING TECHNOLOGIES

The concept of a "Digital Logistics Hub" is made possible today through some key advancements in technology, mainly in the areas of cloud, mobility, IoT and data analytics. Ideally, every transaction point within the entire supply chain that could provide data should provide data, so as to offer visibility and facilitate the backend Digital Hub to perform the necessary Big Data crunching and output the "actionable" intelligence for optimised operation.

Cloud and Edge Computing

Cloud computing offers many advantages, mainly the ability to scale as your business grow. Cloud computing also enables companies to handle seasonal spikes and a special sales event. On the other hand, edge computing brings computing power closer to the location where it is needed. In a delivery truck, edge computing can perform all the necessary data crunching, taking inputs from multiple on-board sensors, cameras, and pre-loaded maps. This will help to lower transmission costs and over-dependence on backend system performance.

FIGURE 4.3 ENABLING TECHNOLOGIES FOR DIGITAL URBAN LOGISTICS

Mobility (Connectivity and Apps)

Mobility in the form of connectivity through 3G/4G/LTE/Wifi/Bluetooth and IoT wide area network such as SigFox/Lora/NBIoT has made possible low-cost data collection throughout the supply chain. In the past, data collection from the field is too expensive to enable big data crunching. Now, with low-cost connectivity, data from the field can provide much-needed visibility. Coupled with mobile apps in a smartphone, widespread use of QR code, etc. mobility has greatly transformed workflows in the supply chain.

Internet of Things (Sensors and GPS)

The sizable growth in the Internet of Things (IoT) devices has driven down its cost, making it possible for widespread deployment. Sensors with built-in comms can monitor temperature, humidity, noise, vibration, brightness and even odours. IoT devices are especially useful for supply chain security, and cold-chain transportation.

2D and 3D Geospatial Mapping and Analysis

The advances in computing power especially in graphics, due to the popularity of Gaming, Crypto-Currency and now Machine Learning, also lowers the cost for 2D and 3D geospatial visualisation. Of special interest are new platforms such as Virtual Singapore – "a dynamic 3D digital platform that will enable the public, businesses, government, and research agencies to derive insights, develop solutions and run simulations using a large-scale city model of Singapore." Other 2D and 3D maps (e.g., Google Map and Google Earth) will allow supply network simulation and planning at a much lower cost than before.

Business Intelligence and Visualisation

Business Intelligence (BI) tools have become more powerful and easy to use. BI transforms data into actionable insights that allow an organisation to make strategic and tactical business decisions. It presents analytical findings in the form of reports, dashboards, graphs, charts, and maps. Such visualisation tools have become indispensable in all operation centres, as they help to monitor the day-to-day hub operations,

perform analytics to improve the logistics operations, as well as respond to any events or emergencies in a timely manner.

Blockchain and Security

Besides cryptocurrency, Blockchain next big use case is in the supply chain. With Blockchain, multi-party collaboration can be transacted at a lower cost, as blockchain can overcome some complex issues and the lack of transparency in the current supply chain. The transparency of blockchain also allows consumers to support companies who share the same values as them, as every step in producing and delivering the product from source to store can be verified. Such verifiable visibility in the supply chain takes certainty and transparency to a whole new level. Blockchain also adds security as tampering of the ledger is near impossible, due to its immutable and distributed nature. Combining with IoT technology, blockchain can also help to protect the safety and security of goods moving through the supply chain. Containers sealed with smart locks can automatically record on the blockchain any tampering attempts.

Big Data and Data Analytics

With increased visibility of the supply network through the gathering of millions and millions of input data, big data management, and data analytics is needed to 'visualise' and make sense of the voluminous data. Predictive analytics and location intelligence are some ways the logistics companies can make use of data. This can lead to improvements in demand forecast, route planning, resource planning, fraud detection and risk management and so on.

In summary, we highlight two applications that implemented some of the concepts described. Technology and business landscape is continuously evolving, and logistics firms need to adapt and innovate to succeed. We believe that increase visibility and enhanced visualisation on the supply chain network would give a competitive edge to logistics companies in today's complex marketplace.

APPLICATIONS

Applications 1

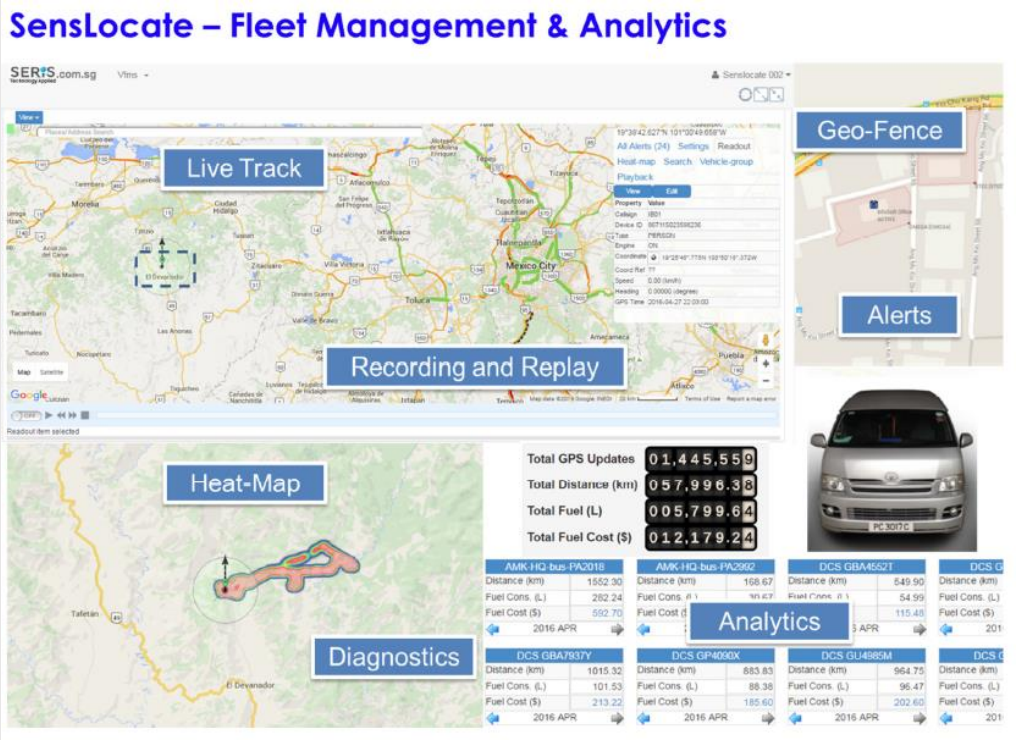


FIGURE 4.4 SENSLOCATE - FLEET MANAGEMENT & ANALYTICS

For Goods Transport, several enabling technologies can be implemented. With the trend in the Internet of Things (IoT), sensors and communications cost are now low enough to implement on a wide scale. For example, we can install GPS tracker, smart temperature sensors and humidity sensors on goods transport vehicles. We can track and monitor the location and the environmental conditions throughout the delivery of the goods. We can also install smart locks and security cameras on the vehicles. With that, we can monitor the safety and security of the goods, the drivers and the vehicles. With smartphones and mobile tablets, the monitoring can be done anytime, anywhere. At the backend, analytics can also be done for route optimisation, emergency planning, and smart scheduling to avoid congestion.

Application 2

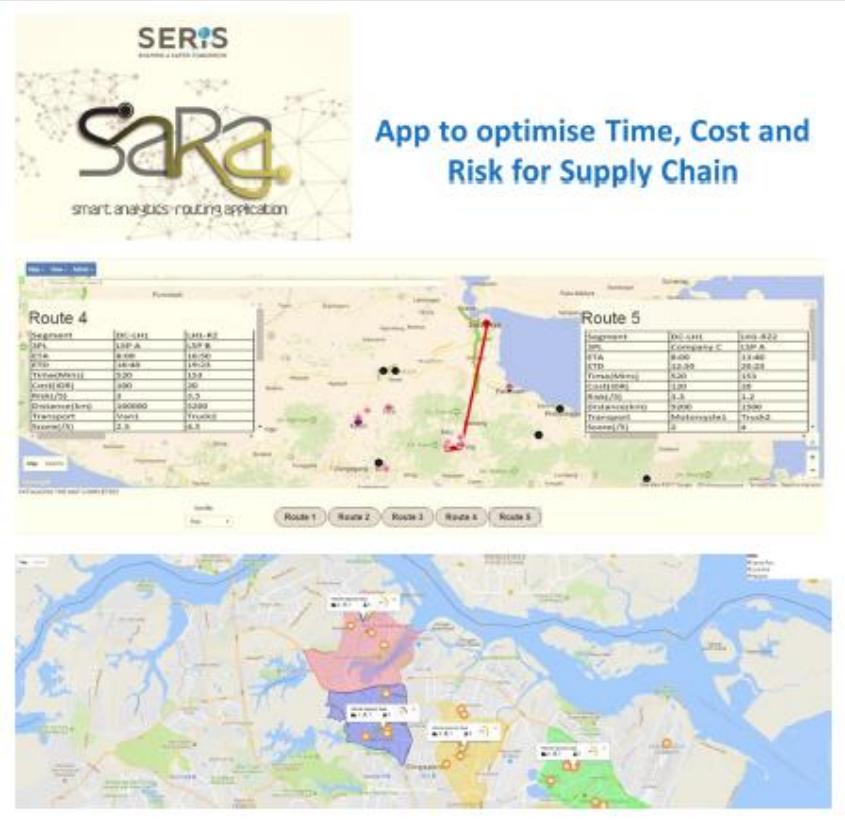


FIGURE 4.5 JOINT COLLABORATION PROJECT BETWEEN TLIAP & ST ELECTRONICS – SARA

To tackle the last mile, companies need to be able to plan, schedule, manage and monitor their logistics assets for deliveries across a wide spectrum of parameters (locations, travel time, travel mode, weather, etc.). The advancement in today's communication and software technology makes it possible to do these using, for example, Smart Analytics Routing Application (SARA) which is currently developed to support supply chain operation and management by displaying and analysing logistics fleets and its routes.

SARA would generate and display fleet load and routes by considering last-mile routing between each delivery nodes. It will try to find the optimal fleet for a certain delivery area and generate routes to deliver a given set of shipments to the nodes in this area. The optimal set of routes found by SARA will consider individual segments between nodes with different properties (such as cost, time, distance, etc.).

Chapter 5

DATA AND ENGINES

DATA REQUIRED TO DRIVE SUPPLY CHAIN ENGINES

Generic Data Requirement

With reference to Figure 1.4, the visualisation and supply chain engines will only function when a sufficient amount of data is channelled into the Urban Grid Logistics platform. For the simpler engines, easily collectable data at surface level is sufficient to power the engines. Whereas for complex functions, it will require a sophisticated network of data to drive the analysis, planning, and execution of tasks. The generic data requirement in the areas of the geospatial, company and other data sources and their increasing level of difficulty in data collection are illustrated in Figure 5.1 below.

Geospatial data, which is used for logistics planning and asset sharing, is an important input to the geographic visualisation and simulation in the increasingly congested cities. Static data of infrastructure and locations are easily retrievable and widely used by many software in the market. Our platform targets the dynamic geospatial data, which includes capacity utilisation, traffic conditions, and demographic changes in real-time. When it comes to the collection of enterprise data, we are aware that companies are often reluctant to share their data in fear of data leakage and loss of competitive advantage. With our secured data repository and data exchange protocols, the enterprises can be enticed to share more data, which will eventually lead to company and industry-wide supply chain performance improvement. The company data required in the platform are the infrastructure, network, customer, product, process, financials and real-time operational data. As companies adopt different technologies and information systems, collection and integration of these data are also key in the data-driven Urban Grid Platform. Complemented by the publicly available company publications and commercial data, the platform can smoothly process all data and instructions and generate the business-enhancing insights and actions.

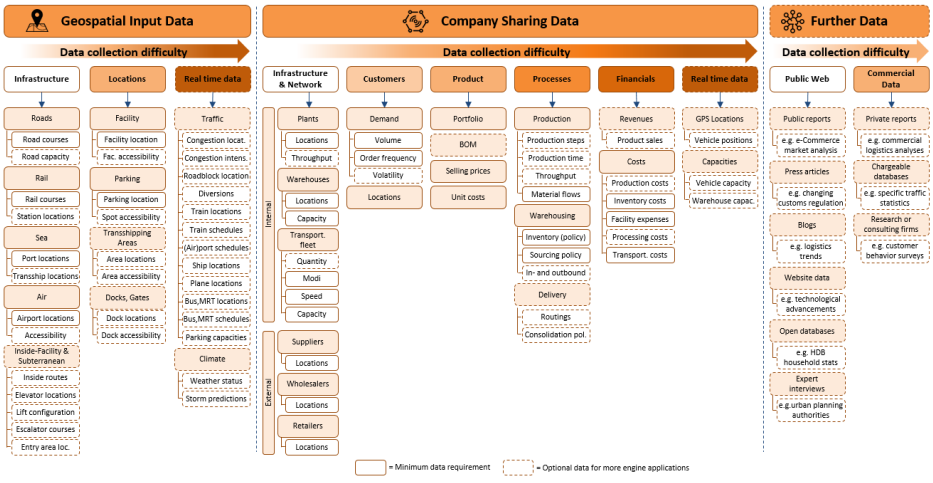
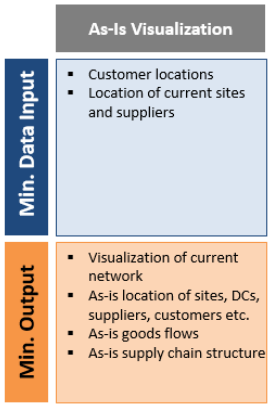


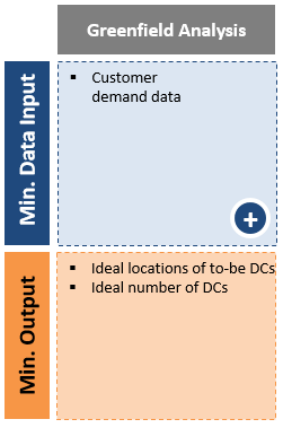
FIGURE 5.1 DATA INPUT FRAMEWORK

Minimum Data Requirement for Specific Engines



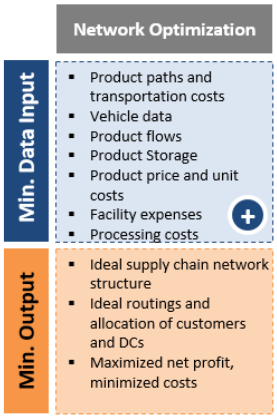
As-Is Visualisation

Platform users would typically (on-demand) begin with a status quo assessment and analysis of the current supply chain structures with the As-Is Visualisation function. In line with the respective user interest, users could easily visualise their supply chain including all relevant nodes such as suppliers, ports, depots, distribution centres, warehouses, production sites, and customers. Additionally, physical goods flows can be visualised and assessed.



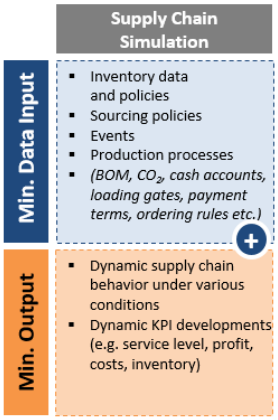
Greenfield Analysis

Tapping on existing data in As-Is Visualisation and Greenfield Analysis, platform users can identify the ideal (i.e., cost optimal) locations for depots or warehouses given a set of customer locations and demand.



Network Optimisation

With the use of data collected in prior stages and this stage, platform users are able to determine the optimal network structure for a given set of supply chain nodes. Data collected include facility expenses, real road infrastructure, vehicle types and transportation costs.



Supply Chain Simulation

When it comes to real implementation of tasks and decision making, dynamic simulation can be a powerful tool to assess supply chains in a virtual and uncertain environment. Data collected in all stages including this stage will support the simulation function.

As illustrated in the framework of Figure 5.2, gradually increasing input data details in turn yield increasingly powerful output models. Proceeding with this logic, future platform versions may also incorporate intelligent AI-driven self-configuration tools.

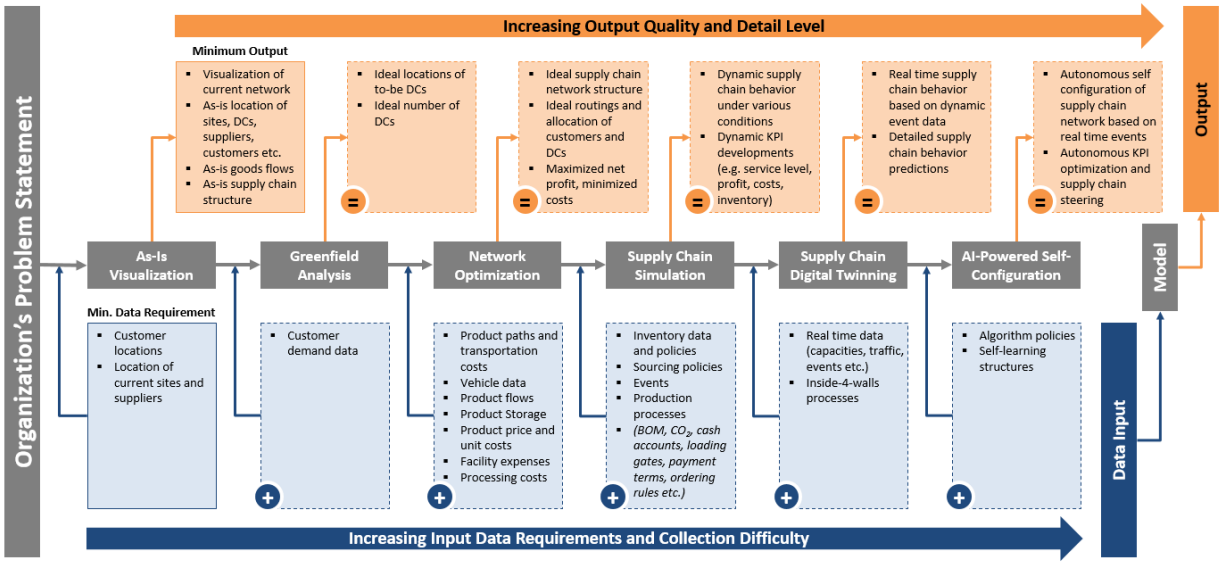


FIGURE 5.2 DATA REQUIRED TO DRIVE SUPPLY CHAIN ENGINES

PLATFORM ARCHITECTURE DEVELOPMENT

To facilitate the functioning of the supply chain engines, the platform must be able to store, process, analyse and synchronise data. It will possess a user-friendly User Interface, data repository functions, relevant data protocols and API integration capabilities (Figure 5.3).

The working platform will be developed using agile methodology and the detail business requirements will be developed together with target user communities. The working platform will be the proxy for the target user communities to leverage the algorithms/models, and to apply and/or integrate back to their system.

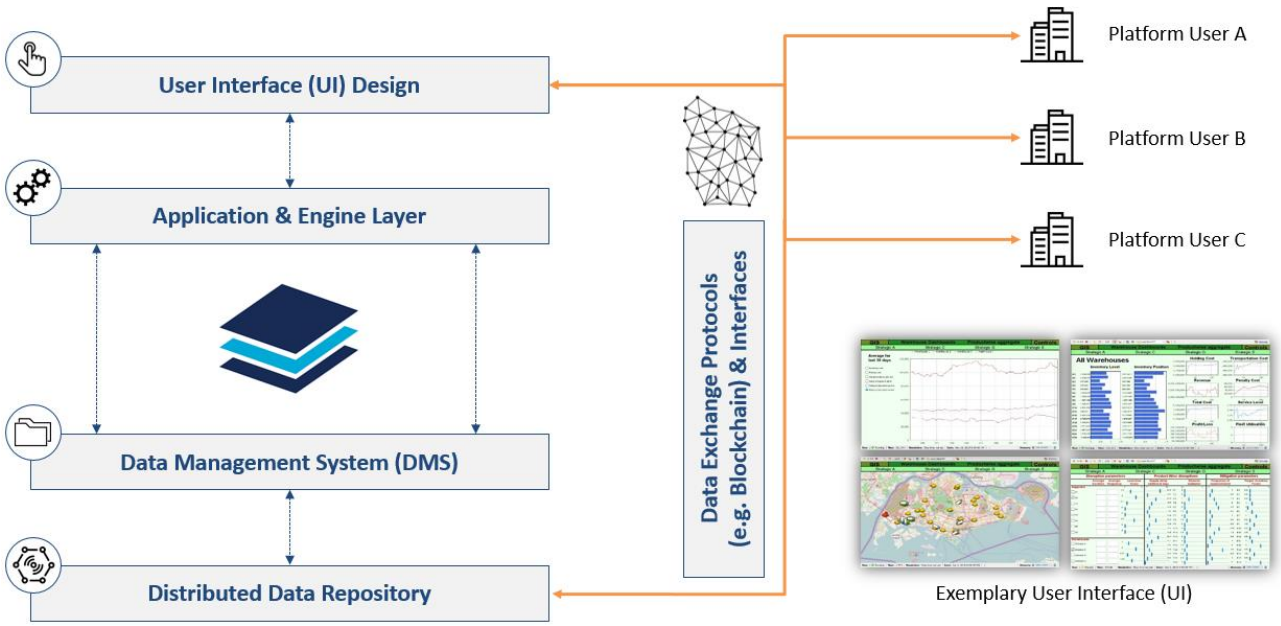


FIGURE 5.3 CONCEPTUAL PLATFORM DEVELOPMENT

Data Repository

The platform will be able to store all data provided by the registered members, possess enough computing power to process, and perform tasks in all supply chain engines. It can also sync the trade, transportation and warehousing data in disparate systems used by different members and encourage more seamless sharing. This holistic data repository and data management system can help all supply chain partners to understand both enterprise and industry-wide asset utilisation conditions.

Data Protocols

The platform will ensure efficient and secured sharing of confidential data with the help of secured data sharing technologies. With matured data sharing protocols, supply chain partners will be more inclined to share their data, utilise the various supply chain features and in turn realise savings in their supply chain management systems.

API Integration

To ensure consistency among registered members, the platform must possess the abilities to integrate existing systems and increase interoperability. Integration standards will have to be crafted and applied to remove system barriers and enable smooth data transmission. Thus, it is key to focus on the development of suitable API to ensure cost-efficient interoperability and dynamic connectivity between internal systems and platforms.

User Interface

The platform aims to be a user-friendly application whereby navigation is simple, and tasks can be performed easily. User-Friendly and intuitive dashboards, which analyse supply chain related data, should be easily configured to assist the business in decision-making and goods tracking.

Chapter 6

ORCHESTRATED INTELLIGENCE

Jointly contributed by Ramco Systems and

The Logistics Institute – Asia Pacific, National University of Singapore

The many solutions that Artificial Intelligence (AI) and Machine Learning (ML) offer can be used to maximise the benefits of multiple stakeholders in the industry of logistics

INTRODUCTION

The boundaries are blurring, and distances are shrinking. We have globalisation to thank for, and perhaps the technology that has enabled it. Globalisation has led to the emergence of supply chains that are spread across oceans, who strive to ensure that their business operations are run smoothly. Connecting the manufacturers to their end consumers are the logistics service providers, a market that is predicted to touch US$ 16445.1 billion by 2026. Right from handling the material and packaging to warehousing and delivery, this industry takes care of every facet and function involved in getting the product to the end user.

As we step into the world of logistics that is governed by various dynamic factors such as international policies, customer dynamic needs, and information technology, one has to keep in mind that supply chain can be managed only when each task is efficiently managed and integrated with the rest. Right from the procurement of goods to delivering it to the customers, each step has multiple sub-tasks that have to be accomplished within a specific time frame. For this very purpose, many organisations try to integrate multiple systems so that all the information to adhere to tight deadlines or manage uncertain deadlines is available to take decisions.

TRANSFORMING LOGISTICS WITH NEW AGE TECHNOLOGY

New Age Technology comes to aid in this particular area where it progressively learns from the data and acts intelligently with more precision. According to a report 'Artificial intelligence in supply chain management: theory and applications' published in the International Journal of Logistics: Research and Applications:

"Recognising the increasing significance of information to SC (supply chain) success, SC professionals have explored various ways to better manage information and leverage it to make better business decisions. One of those ways may include artificial intelligence (AI) that has been in existence for decades but has not been fully utilised in the area of SCM. In particular, machine learning can be a useful tool for understanding the motivation behind collaborative behaviour among SC partners for sharing critical information and improving ways of strengthening the partnership among SC partners through the organisational learning process."

Thus, in this information-intensive world, the focus has been to turn simple data into worthy information and smartly use that to streamline processes that will save time and also costs for the company as well as customers.

RAMCO'S AI AND ML POWERED LOGISTICS SOLUTIONS

Within the context of logistics, the existing ERP systems are constantly fed with data some of which include booking requests, customer information, route information, inbound and outbound orders, put away, picking and packing manifests, customer and vendor information and invoices. Ramco leverages the AI and ML platform to infuse intelligence into an enterprise application.

The important tenets of the solution provided by Ramco include:

- Zero UI: Moving from data-hungry screens to intuitive conversation/ voice-based transactions
- Frictionless Experience: which will allow transactions to go through with east steps and without any hiccup
- Even driven Notification: The model which will notify you of the next step, a time-saving experience that will drive forth the future supply chain
- Self-auditing enterprise system: Predictive engine powered by AI and ML will sense errors and guide you to make corrections

Ramco's technology endeavours to make the system see or visualise, speak or enable voice and think for itself. With multiple tools such as chatbots and voice executions, Ramco's enterprise logistics platforms is used by key stakeholders namely customers, planners, executors (who execute complete operations), partners / suppliers and those who handle the commercial and strategic management aspects of the business.

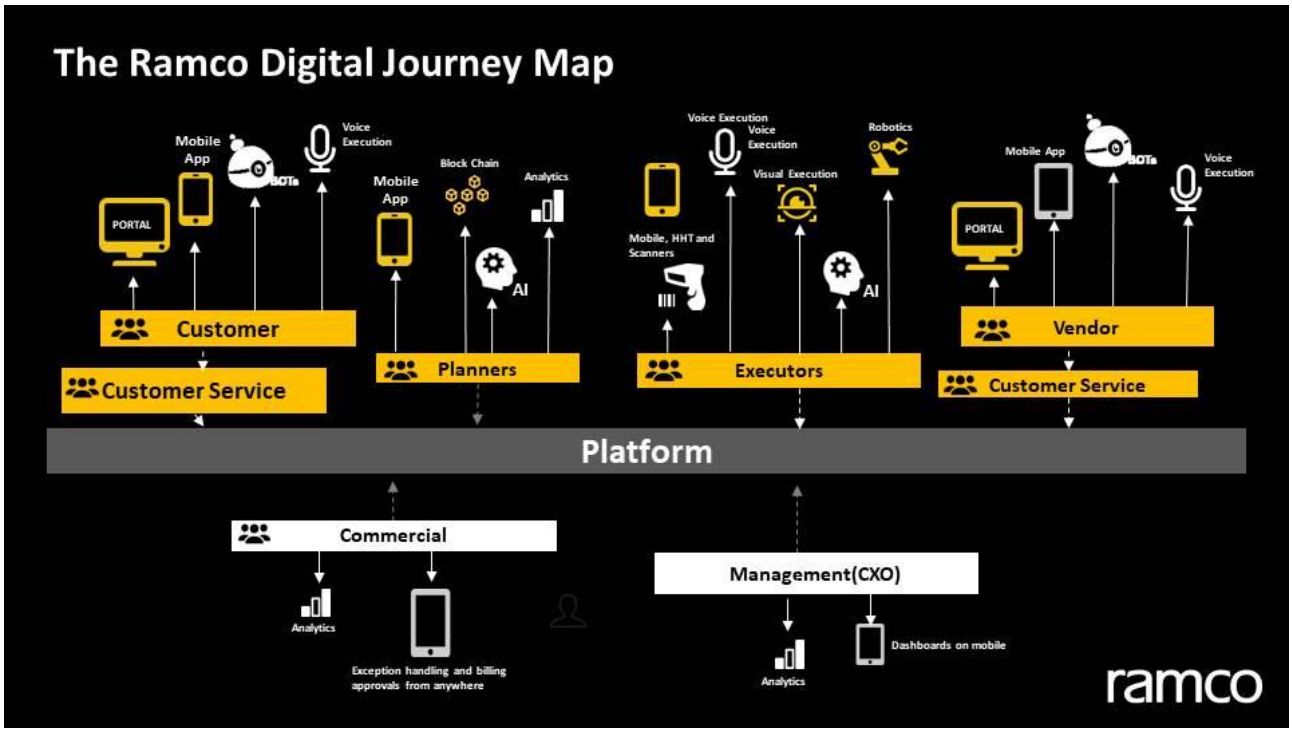


FIGURE 6.1 THE RAMCO DIGITAL JOURNEY MAP

The imperative here is the data in the platform helps the AI engines to understand the patterns better and in turn, provide solutions apt for different situations. Making ERP intelligent has its own advantages. Some of the areas where ERPs can be made intelligent are listed below:

- Universal validation/defaulting: Based on past trends, the system automatically chooses optimal solutions
- Preventing damage: The system recognises the errors and points out so that it can be rectified. This helps in preventing damage and even fraud attempts
- Cost and resource saving: Be it optimal data capture or error-free data inputs, the system can help save costs for the organisation
- Organising for the future: AI-powered forecasting can help the organisation take strategic and important decisions for future

One of the most crucial requirements is data capture in logistics. With the help of AI/ML powered system, it helps in pre-populating data every time need be, for instance, booking request information. A general booking request page looks like the one below:

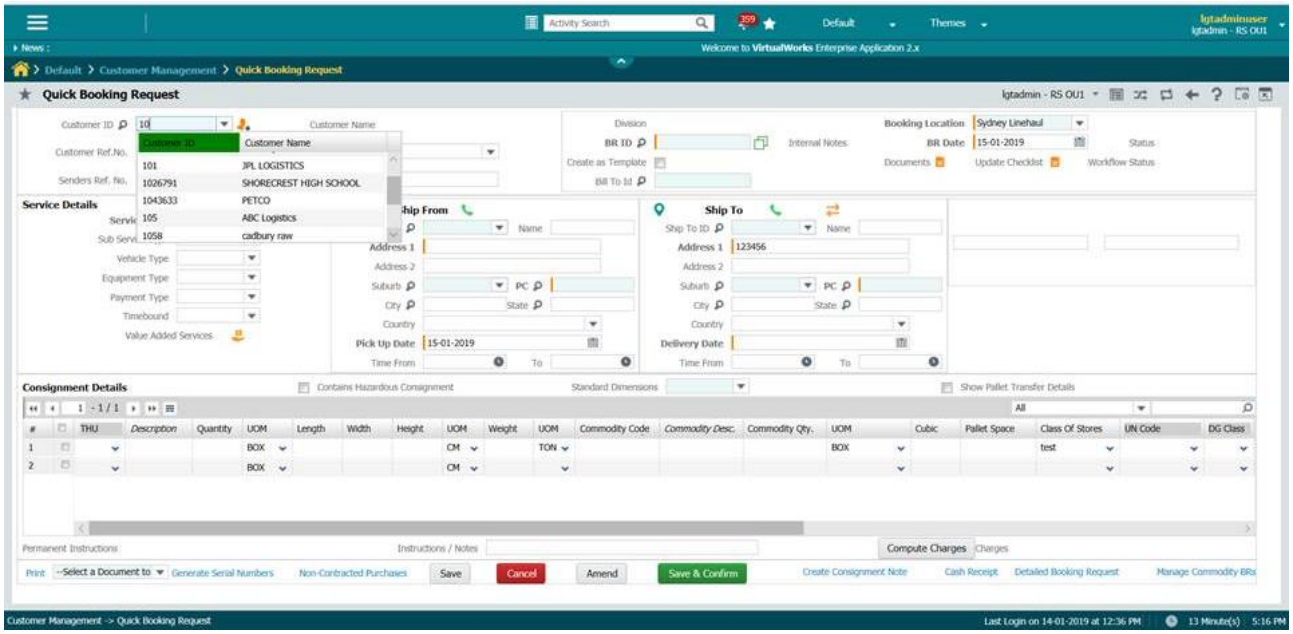


FIGURE 6.2 SAMPLE DATA REQUEST PAGE

Instead of filling more than 20 fields, the system will identify the fields, which can be auto-filled with the help of AI engines. Once auto-suggested, the fields can still be manually edited if need be. This will greatly improve the tedious job, saving time and increasing operational efficiency. From 20+ fields, the booking request transaction can now be completed in just 2. With the help of intelligent ERP, this would save enormous cost and reduce errors drastically:

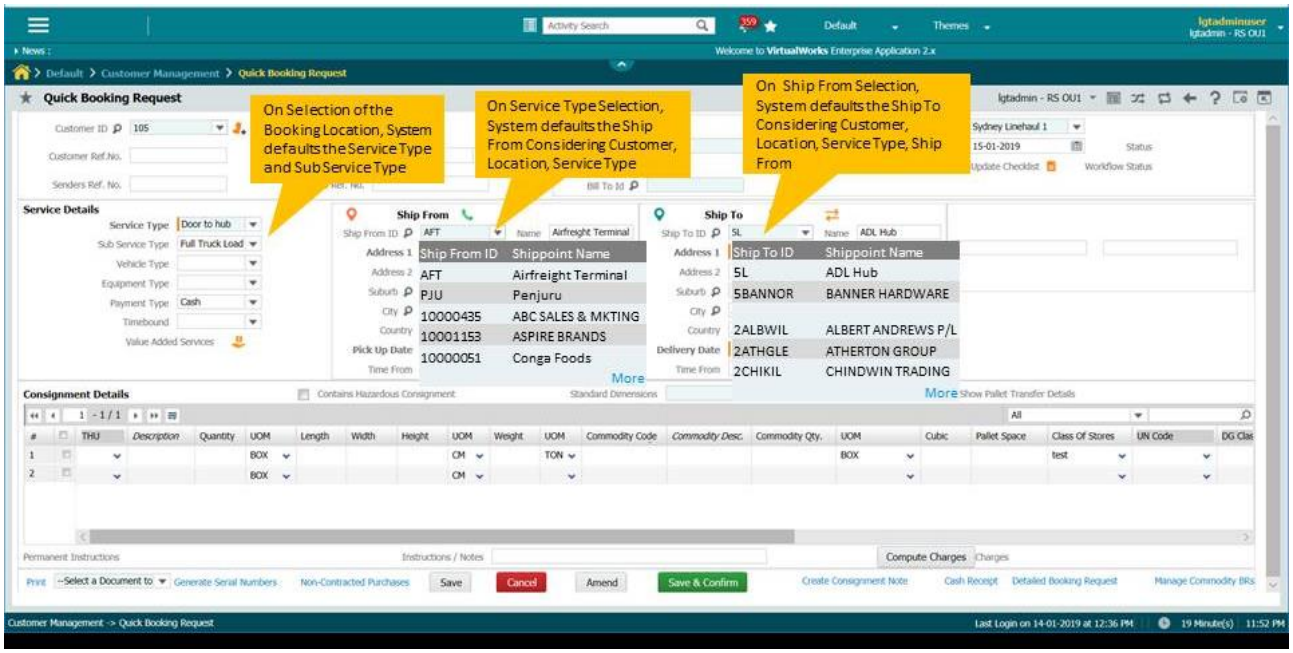


FIGURE 6.3 EXPLANATION OF DATA REQUEST PAGE

Another very important function is anomaly detection, which will prevent the organisation from wrongful spending. This can save both costs and resources for the company. In the case of tendering a load to a vendor, the process can be cumbersome. On the other hand, AI/ML will make it a smoother process, and if the quotes are not within a trend range, the system will even notify the vendor that it greatly deviates from the general quote prices.

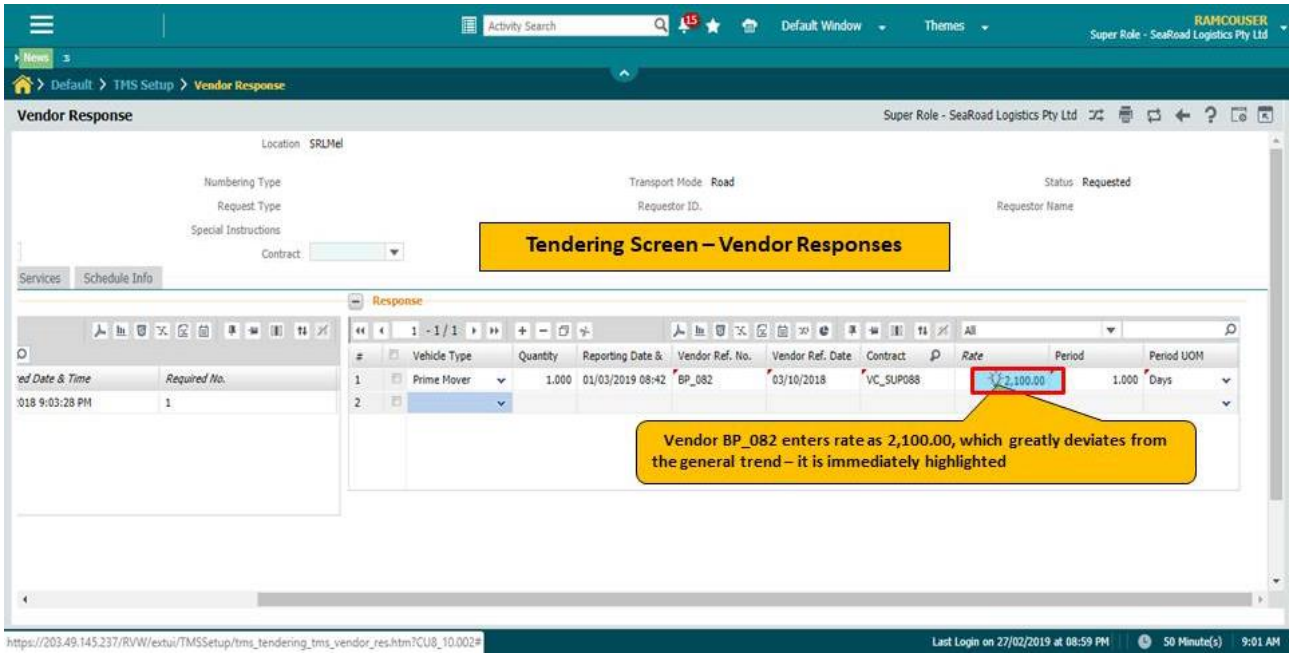


FIGURE 6.4 EXPLANATION OF ANOMALY DETECTION PAGE

CONCLUSION

As propounded in Accenture's report, 'How AI Boosts Industry Profits and Innovation,' AI has the potential to boost rates of profitability by an average of 38 per cent by 2035. With the tools that are already available, it only needs to be imaginatively used in order to revolutionise the logistics sector.

Chapter 7
CONCLUSION

This paper aims to introduce the Urban Grid Logistics Platform which is in the pipeline of The Logistics Institute – Asia Pacific. This platform is developed with the goal of enabling Singapore to stay on top of urban developments and remain competitive in the international logistics landscape. It leverages on the digitalisation waves to help companies in achieving operational efficiency, supply chain transparency and industry collaboration for increased asset utilisation and flexibility.

The Urban Grid is going to utilise data to bring about leapfrogging transitions in the supply chain performance and capabilities of the companies across industries. The platform hopes to create a data-driven supply chain where information is shared across the entire supply chain to connect the various supply chain partners and provide end-to-end supply chain data access. At the same time, it will also incorporate value-adding decision supporting engines to improve utilization of resources, namely warehouses, skilled manpower, and transportation assets. The underlying data mechanisms will in turn create a shared environment where all supply chain partners hold a holistic industry perspective and integrate for more peer-to-peer sharing and multi-party collaboration.

In order to direct companies' focus to planning, we have designed the platform to include supply chain planning tools, ranging from greenfield analysis to dynamic simulation. Also, our platform will incorporate the business intelligence tools that transform data into actionable insights that allow a company to make strategic and tactical business decisions. Such visualization tools have proven to be indispensable in operations as they help to monitor day-today activities, perform analytics to improve logistics operations and respond to emergencies. Artificial intelligence and machine learning solutions are to be adopted by the platform to bring about greater operational intelligence and improved decision making which in turn boost profitability of the businesses.

The working platform will be developed using agile methodology to possess data repository, data exchange protocols and API integration abilities and the detail business requirements will be developed together with target user communities. It will then be the proxy for the target user communities to leverage the algorithms/models, and to apply and integrate back to their system.

With the Urban Grid Logistics Platform, we hope to provide a holistic industry-wide solution that leverages on digitalisation to improve supply chain collaboration, transparency and flexibility, which would in turn strengthen Singapore's position as the leading logistics hub.

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ACKNOWLEDGEMENTS

The Institute would like to express its sincere appreciation to the following co-authors for their contribution towards this white paper:

- The AnyLogic Company
- ST Electronics (Info-Software Systems) Pte Ltd
- Ramco Systems

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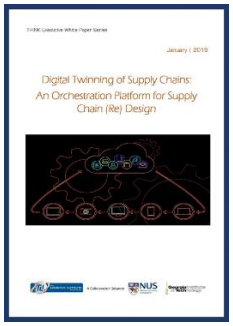

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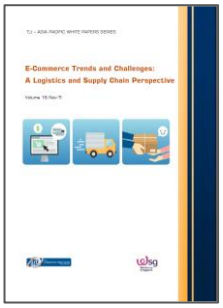

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