SAAS SOLUTIONS FOR SHIPMENT TRACKING IN VUCA AND BANI CONDITIONS: DIGITAL TRANSFORMATION CHALLENGES AND ADAPTIVE STRATEGIES

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INTRODUCTION

The modern business environment is often described as volatile, uncertain, complex, and ambiguous (VUCA). Recent global crises – from a pandemic to geopolitical conflicts – have underscored this volatility. Supply chains have experienced unprecedented disruptions: for example, a 2022 industry survey revealed that 80% of supply chain executives could not digitally track the movement of materials across their networks, indicating critical visibility gaps in logistics operations[1]. The full-scale war in Ukraine further exemplifies a VUCA scenario: volatile and dangerous conditions including blocked trade routes and infrastructure damage have severely disrupted shipments, making conventional tracking methods unreliable[2]. These challenges confirm that we have "VUCA for breakfast," meaning such turbulence is now the norm rather than the exception[3].

To better conceptualize the escalating chaos, futurist Jamais Cascio in 2018 introduced the BANI framework (Brittle, Anxious, Nonlinear, Incomprehensible) as an evolution beyond VUCA. BANI portrays a world where systems that seem strong can shatter suddenly (brittle), constant uncertainty breeds widespread anxiety, cause-and-effect relationships are nonlinear and disproportionate, and events often feel incomprehensible. In a BANI environment, traditional planning and linear supply chain strategies prove insufficient; organizations must embrace agility, resilience, and adaptability at a new level. Business leaders in logistics observe that global supply networks are more fragile and unpredictable than ever, requiring fresh approaches to survive and thrive.

[1] 80% of Supply Chain Executives Cannot Digitally Track the Movement of Direct and Indirect Materials Across Their Networks; Verusen Unveils 2022 State of Supply Chain Management Research Findings. URL: http://globenewswire.com/news-release/2022/12/08/2570283/0/en/80-of-Supply-Chain-Executives-Cannot-Digitally-Track-the-Movement-of-Direct-and-Indirect-Materials-Across-Their-Networks-Verusen-Unveils-2022-State-of-Supply-Chain-Management-Resea.html

[2] Nebster E. How the Russian-Ukrainian war affected supply chain tracking: challenges & solutions. XME.digital (Blog). 2023. URL: https://www.xme.digital/post/how-the-russian-ukrainian-war-affected-supply-chain-tracking-challenges-solutions

[3] Cascio J. Human Responses to a BANI World. Medium. 2022. URL: https://medium.com/@cascio/human-responses-to-a-bani-world-fb3a296e9cac

In these conditions of heightened uncertainty, digital transformation has become not just an option but a necessity for sustainable development. Firms are turning to advanced technologies to enhance visibility, responsiveness, and robustness in their supply chain management. In particular, Software-as-a-Service (SaaS) solutions for shipment tracking and supply chain visibility are emerging as critical tools. By leveraging cloud-based platforms, IoT sensors, and real-time data analytics, companies can monitor shipments end-to-end, anticipate disruptions, and react swiftly – capabilities essential for navigating both VUCA volatility and BANI chaos. For countries like Ukraine, which faces not only global market instability but also war-induced chaos, such digital solutions offer a path to maintain logistics operations and economic continuity under extreme conditions[4]. Scholarly analyses of the Ukrainian logistics sector during the crisis highlight the urgent need for new strategies and technology integration: political instability and military conflict have forced immediate strategic adjustments and accelerated the adoption of advanced supply chain technologies[5]. In short, ensuring sustainable development in logistics now depends on how well organizations can implement adaptive digital tools in an unpredictable world.

This section examines the challenges and prospects of deploying SaaS-based shipment tracking solutions under VUCA and BANI conditions. We first discuss the impact of VUCA/BANI characteristics on logistics and the imperative of digital transformation. Next, we analyze the capabilities of modern SaaS shipment tracking platforms and how they address these challenges. We then explore the implementation hurdles that companies face (from technological to organizational) and present adaptive strategies to overcome them – from building resilient, collaborative networks to embracing agile management practices. Finally, we present conclusions on how adaptive digital transformation, centered on SaaS tracking solutions, can bolster supply chain sustainability and competitiveness even in the most turbulent environments.

1. VUCA, BANI, and the Impact on Logistics

Volatility, uncertainty, complexity, and ambiguity in the external environment profoundly affect logistics and shipment management. The VUCA concept, originally coined in the late 1980s by the U.S. Army to

[4] Logistics Guide. Supply Chain Management and Logistics SaaS Products: Transforming the Future of Global Trade. LinkedIn. 2025. URL: https://www.linkedin.com/pulse/supply-chain-management-logistics-saas-products-future-guide-8hxcc

[5] Siryk Z., Hrafska O., Pavlov K., Samoilenko B., Chornyi R. Sustainable development trends in the Ukrainian logistics market. E3S Web of Conferences. 2024. 567:01024. DOI: https://doi.org/10.1051/e3sconf/202456701024

describe the post-Cold War world, has proven apt in characterizing 21st-century market dynamics. In a logistics context, volatility manifests as sudden changes in supply or demand, extreme fluctuations in transport costs, and unpredictable disruption events. The COVID-19 pandemic, for instance, caused sharp swings in consumer demand and capacity shortages in freight markets. Uncertainty means it is difficult for companies to forecast and plan; logistics managers often lack reliable insight into factors like transit times or supply availability amid rapidly changing conditions. Past data and trends offer limited guidance when black swan events (pandemics, geopolitical conflicts, natural disasters) strike without warning. Complexity in supply chains has grown due to globalization and outsourcing – there are many interdependent actors, from suppliers and carriers to distribution centers and regulators. A single shipment may involve multiple handovers and jurisdictions, creating a complex web where a failure at one node can ripple across the network. Ambiguity refers to the lack of clarity in interpreting information or situations. In global logistics, data may be incomplete or conflicting – for example, differing trade regulations or inconsistent tracking data can make it hard to decide on the correct course of action. Ambiguity also arises in novel scenarios where standard operating procedures do not clearly apply.

Over the past decades, businesses adapted to VUCA by developing more agile and flexible supply chain practices – for example, maintaining safety stocks or alternate suppliers to buffer volatility, and using scenario planning to cope with uncertainty. However, the shock of recent crises suggests that the traditional VUCA mindset might not be enough. The BANI paradigm extends the conversation by capturing the brittleness and extreme fragility of today's systems, the anxiety that pervades decision-making, the nonlinearity of cascading disruptions, and the incomprehensibility of certain events. In logistics, brittleness is seen when seemingly efficient supply chains collapse under stress. A notable example was the March 2021 six-day blockage of the Suez Canal by a single container ship, which halted hundreds of vessels and billions of dollars of goods, revealing how brittle global trade routes can be. Similarly, just-in-time supply chains optimized for efficiency showed brittle failure modes during COVID-19 lockdowns when production stopped and inventories were depleted. Anxious decision-making in logistics is now commonplace – managers operate on edge, aware that any shipment could face sudden disruption. This can lead to overly cautious strategies or, conversely, panic responses such as rush-orders and overstocking, which may not be optimal. Nonlinearity means small triggers can have disproportionate effects on supply chains. A minor delay at one port, for instance, can escalate into global container shortages and price spikes. Feedback loops – like panic

buying amplifying shortages – make outcomes hard to predict or control. Finally, incomprehensibility acknowledges that some supply chain disruptions seem beyond rational explanation. The complexity of global logistics networks means that when something goes wrong, pinpointing the root cause is often challenging – was it a supplier's bankruptcy, a policy change, a cyber-attack, or a combination? Even with extensive data, companies can struggle to comprehend exactly why a well-planned logistics operation derailed.

The ongoing war in Ukraine starkly illustrates how a BANI scenario can impact logistics. The conflict introduced extreme brittleness: established trade corridors were abruptly cut off, such as the closure of Black Sea ports, forcing companies to scramble for alternate routes or cease shipments. Transportation infrastructure suffered damage from attacks, meaning routes that once seemed reliable could literally disappear overnight. The danger to personnel introduced new anxiety – trucking goods through active conflict zones involves life-threatening risk, making drivers and logistics operators understandably fearful. Nonlinear effects of the war have radiated globally: a regional conflict led to worldwide supply shortages (e.g., grains, metals) and energy price spikes that cascaded into broader supply chain disruptions. Many of these outcomes were difficult to foresee or quantify in advance, underscoring incomprehensibility. Moreover, frequent power blackouts and internet outages in war-torn areas disrupted digital tracking systems, rendering high-tech solutions ineffective at times. As one analysis notes, even sophisticated IoT-based tracking cannot function when the power grid is down or the device is destroyed by an attack. Thus, companies operating in Ukraine had to resort to ad-hoc and community-based methods to shadow shipments, such as manual checkpoints and peer-to-peer communication among drivers, to ensure deliveries where digital tools failed. This scenario highlights that in extreme BANI conditions, resilience may come from a combination of advanced technology and human adaptability (for instance, volunteer networks coordinating deliveries when official systems break down).

Globally, the persistent string of disruptions has pushed businesses to re-evaluate the balance between efficiency and resilience in their supply chains. In the early 2000s, many firms pursued lean, just-in-time logistics to minimize costs. But after the shocks of the past few years, resilience has surpassed leanness as the top supply chain priority[6]. Companies recognize that hyper-optimized supply chains can be dangerously brittle. To protect against "unknown unknowns," organizations are now building slack into their

[6] El Bekri M. Resilience Has Replaced Leanness as Top Supply Chain Priority. Sustainable Brands. 2023. URL: https://sustainablebrands.com/read/resilience-top-supply-chain-priority

systems – keeping strategic stock reserves, diversifying supplier bases, and investing in real-time monitoring. Central to these efforts is the need for greater visibility. Visibility refers to the ability to see the status of goods and materials in transit and across the supply chain in real time. Studies show that many organizations still lack adequate information about their own supply chains. Even by 2024, only about 60% of companies reported having comprehensive visibility into their immediate suppliers, and visibility drops off significantly for sub-tier suppliers 9. This opacity makes it hard to anticipate and respond to disruptions, as problems brewing deep in the supply chain (for example, a raw material shortage at a sub-supplier) can remain undetected until they halt production. Improving transparency is not just a strategic choice but increasingly a compliance issue: new regulations in the EU and other regions require companies to trace the origins of their products and ensure compliance with environmental and labor standards throughout the supply chain. For instance, the European Union's sustainability due diligence directives and anti-deforestation regulations mandate firms to know their supply sources and prove they are free of illegal practices. However, a recent survey found that only 9% of companies consider their supply chains fully compliant with these emerging transparency laws 9. This regulatory pressure adds another layer of urgency for companies to deploy systems that can track and record supply chain data end-to-end.

In summary, the VUCA/BANI world is forcing logistics managers to rethink traditional practices. The challenge is to design supply chain systems that can absorb shocks, rapidly adjust to new conditions, and maintain flow of goods with minimal interruption. Achieving this requires both organizational agility and enabling technologies. Digitally transforming logistics – especially through solutions that provide real-time shipment tracking and data visibility – has become a cornerstone of building resilience. The next section will explore how SaaS-based shipment tracking solutions are enabling companies to navigate volatility and uncertainty by enhancing supply chain visibility, responsiveness, and control.

2. SaaS Shipment Tracking Solutions
and Digital Transformation in Logistics

The history of shipment tracking spans millennia, beginning with rudimentary manual processes and evolving into the highly sophisticated digital systems prevalent today. In ancient civilizations such as Egypt and Rome, courier services relied on physical messengers to transport goods and information, using simple signals like fires, smoke, or even the type of bird feathers on a letter to convey importance 40, 42. This era was characterized

by slow communication and limited visibility, making real-time tracking virtually impossible.

The early 20th century saw the rise of major carriers like UPS (founded in 1907), which leveraged cars and trucks for freight transport. However, true digital transformation in tracking began with the invention of the internet, fundamentally changing how information could be shared. Initially, email notifications became a primary method for business-to-business updates, gradually expanding to consumers as internet adoption grew. The introduction of mobile devices, particularly smartphones, dramatically transformed consumer expectations, leading to widespread email and text notifications, and eventually, real-time location data and push notifications, especially for last-mile delivery 40. Amazon played a pioneering role in e-commerce, making digital tracking functionality a standard expectation for consumers.

Parallel to these advancements in shipment tracking, warehouse management systems (WMS) also evolved significantly. Early WMS were entirely manual, relying on paper logs for inventory and physical labor for order fulfillment, leading to inefficiencies and inaccuracies. The 1970s and 1980s marked the digitalization of record-keeping with the introduction of the Universal Product Code (UPC) in 1973, enabling barcoding and scanning for improved inventory control. Subsequent advancements included the development of Automated Storage and Retrieval Systems (AS/RS) and increasingly sophisticated WMS software offering functionalities like pick path and warehouse layout optimization.

The emergence and rapid growth of Software-as-a-Service (SaaS) models have been pivotal in the digital transformation of logistics and supply chain management. The global logistics SaaS market is experiencing substantial growth, projected to expand significantly in the coming years, underscoring its rapid adoption across industries. This growth is largely driven by the inherent advantages of SaaS solutions. Unlike traditional on-premises systems that demand heavy upfront investments in software licenses, hardware, and IT infrastructure, SaaS operates on a subscription-based model. This structure eliminates large initial capital outlays and significantly reduces ongoing IT overhead, making advanced logistics capabilities more accessible. Furthermore, SaaS solutions are cloud-based, offering accessibility from anywhere and the ability to seamlessly accommodate fluctuating order volumes and expanding operations without costly upgrades This model also allows companies to offload the maintenance and upkeep of complex WMS environments to expert providers, further reducing internal resource burdens.

The shift to SaaS represents a significant development in the logistics sector, effectively democratizing access to advanced logistics capabilities. Historically, cutting-edge supply chain management tools and real-time

tracking functionalities were primarily the domain of large enterprises due to the substantial capital expenditure required for proprietary software and dedicated IT infrastructure. The subscription-based, cloud-accessible nature of SaaS fundamentally alters this dynamic. It enables small and medium-sized enterprises (SMEs) to leverage sophisticated shipment tracking and supply chain optimization tools that were once out of reach. This accessibility levels the competitive playing field, allowing smaller businesses to enhance their operational efficiency, customer experience, and overall resilience, thereby fostering greater competitiveness in the market. Consequently, this widespread adoption across various enterprise sizes accelerates the overall digital transformation of the logistics industry, as more participants can afford to implement and benefit from these innovative solutions.

Digital transformation in logistics focuses on leveraging modern information technologies to make supply chains more connected, intelligent, and agile. In the context of shipment tracking and delivery management, Software-as-a-Service (SaaS) solutions have risen to prominence as flexible, powerful tools to achieve real-time visibility. SaaS solutions are cloud-based software platforms that users can access via the internet, usually on a subscription basis. In contrast to traditional on-premises logistics software, SaaS requires no heavy IT infrastructure investment, can be updated continuously by the provider, and is accessible from anywhere by authorized stakeholders. These characteristics make SaaS particularly well-suited for turbulent environments, since companies can scale usage up or down quickly and get timely updates with the latest features or data integrations. Over the last decade – and especially accelerated by the pandemic – logistics SaaS products have transformed how companies track and manage shipments.

A core driver of SaaS adoption in logistics is the need for end-to-end visibility across the supply chain. Lack of visibility has long been a pain point: when a company cannot see where its shipments are or when they will arrive, it leads to surprises like missed delivery deadlines, stockouts in inventory, or idle factories waiting on parts. Modern SaaS platforms address this by providing real-time tracking of shipments at a granular level. For example, cloud-based visibility tools such as *project44*, *FourKites*, and *Shippeo* aggregate data from multiple carriers, GPS devices, and infrastructure feeds to show the live location and status of freight on a single dashboard. These platforms often integrate with Transportation Management Systems (TMS) and Enterprise Resource Planning (ERP) systems, so that tracking information is directly linked with orders and inventory data. As a result, if a delivery truck is delayed due to traffic or a border holdup, the system can flag the delay and even estimate a new arrival time, allowing the company to proactively inform customers or adjust downstream plans. Such dynamic, real-time shipment

tracking empowers companies to anticipate problems rather than react after the fact. Routes can be optimized on the fly – for instance, a SaaS platform might suggest rerouting a shipment to an alternate port if it detects congestion or closure at the original destination. Companies can also use this visibility to perform "what-if" scenarios: if a critical shipment will be late, the system might help identify alternative sources or backup stock to fill the gap. In a VUCA scenario, this kind of agility – supported by live data – is crucial to mitigate volatility.

Beyond just knowing where goods are, SaaS logistics solutions enhance coordination and collaboration among supply chain partners. Since cloud platforms can be securely accessed by multiple parties (shippers, carriers, suppliers, customers), they serve as a single source of truth about shipment status. All stakeholders see the same updates, which reduces ambiguity and disputes. For example, a retailer and its supplier can both monitor a container's progress through the SaaS portal; if a delay occurs, they can communicate through the platform and jointly decide on corrective actions (like expediting a different shipment) with full context. This transparency builds trust and allows for more synchronized supply chain operations even under uncertainty. Some SaaS offerings provide *customer-facing* visibility as well – tools like *AfterShip* or *Convey* enable end customers to track their orders in real time and receive notifications. In an anxious environment, keeping customers informed can significantly improve satisfaction and reduce the "Where is my order?" inquiries. It also relieves pressure on the logistics team, as customers self-serve information from the tracking portal.

Another benefit of SaaS shipment tracking solutions is scalability and accessibility. Cloud logistics platforms remove traditional barriers, enabling even smaller companies or those in developing markets to access advanced capabilities that were once affordable only to logistics giants. Because the software is provided as a service, users avoid large upfront costs. They can subscribe based on their shipment volume or required features and can scale the subscription up as their business grows or during peak seasons. This is particularly beneficial in emerging economies or for small-and-medium enterprises (SMEs) striving to remain competitive under volatile conditions. In Ukraine's case, despite the war disruptions, digital innovation has been a lever for resilience – cloud-based systems allow businesses that have relocated or downsized to continue managing shipments digitally from any location with internet. The government and tech sector in Ukraine have also promoted cloud solutions as part of the drive to keep services running during wartime, illustrating how SaaS can bolster continuity even when physical infrastructure

is under threat[7]. Moreover, leading SaaS logistics providers invest heavily in security and reliability (offering high uptime, data redundancy, and cybersecurity measures) which individual companies would struggle to achieve on their own. In a time of rising cyber threats and data breaches, using a reputable cloud platform often provides stronger protection for sensitive shipment data than in-house IT systems, as SaaS providers comply with standards like ISO 27001 and continuously patch vulnerabilities.

Machine learning algorithms improve Estimated Time of Arrival (ETA) calculations over time, learning from historical trip data and real-time conditions. Some SaaS systems use IoT sensor integration for condition monitoring: devices attached to cargo (or vehicles) can transmit data on temperature, humidity, shock, etc. in real time to the cloud. This is vital for sensitive shipments (like pharmaceuticals or food), as companies can be alerted to any condition excursion (e.g., a cold-chain breach) and act immediately. In a volatile scenario, if a refrigeration unit fails during transit, an IoT-enabled tracking system might notify the shipper early enough to prevent product spoilage by rerouting to a storage facility. Blockchain technology is being explored within SaaS platforms to provide immutable, secure ledgers of shipment events and handoffs – boosting traceability and trust. For instance, every time a shipment changes custody or passes a checkpoint, a blockchain entry can be made that all parties (including regulators) can verify. This kind of traceability is increasingly important for compliance with sustainability and anti-counterfeiting requirements. As regulations demand proof of ethical sourcing and product authenticity, blockchain-backed tracking can furnish tamper-proof documentation of a product's journey from origin to destination.

In practical terms, companies implementing SaaS tracking solutions have reported significant efficiency and service gains. One case study (reported in industry literature) described a mid-sized apparel exporter that adopted a cloud TMS and warehouse management system (WMS) integrated with real-time tracking during the COVID-19 pandemic; as a result, they reduced order fulfillment times by 25%, cut warehouse costs by nearly 20%, and improved on-time delivery to 96%. Another example is large retailers using RFID tags and a centralized SaaS platform to achieve near-perfect inventory visibility from factory to store shelf – Decathlon, a sporting goods company, tagged 100% of its products with RFID and leveraged a cloud analytics platform, reaching industry-leading traceability that not only improved stock management but also supported sustainability reporting. These examples illustrate how digital tracking solutions contribute to both operational

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efficiency (faster, more reliable deliveries at lower cost) and strategic goals (resilience and sustainability). By having real-time data on shipments, companies can optimize routes (saving fuel and reducing emissions), coordinate transport modes better, and reduce the need for emergency shipments (which are costly and often less energy-efficient). Fewer surprises in transit mean less buffer stock is required to guard against delays, which can lower inventory holding costs. Furthermore, the data collected by SaaS platforms can feed into analytics for continuous improvement: companies can identify bottlenecks, frequently delayed lanes, or underperforming carriers and address them systematically.

However, simply deploying a SaaS platform is not a panacea. The effectiveness of these digital solutions in a VUCA/BANI environment depends on implementation and integration into the broader process. Key success factors include ensuring data quality (garbage-in, garbage-out remains true; shipments must be scanned or sensor-equipped properly to generate accurate data), training staff and partners to use the systems, and aligning organizational policies with the new capabilities (for example, empowering decision-makers to act on real-time alerts without bureaucratic delay). The next section will delve into these and other challenges companies face when integrating SaaS tracking solutions, and discuss adaptive strategies to maximize the benefits of digital transformation under volatile conditions.

3. Challenges in Implementation
and Adaptive Strategies for Resilient Supply Chains

Implementing SaaS-based shipment tracking and other digital solutions in logistics is not without its challenges. Organizations often encounter technical, organizational, and environmental hurdles that can impede the full realization of benefits. In the context of VUCA and BANI conditions, being aware of these challenges and proactively developing adaptive strategies is essential. Below, we identify key challenges and outline strategies to address them, ensuring that digital transformation efforts truly enhance supply chain sustainability and resilience.

1. Data Silos and Legacy Systems: one of the most common challenges is the fragmentation of data across different systems and the continued use of outdated legacy software. Many logistics companies have multiple IT systems (for warehousing, transportation, orders, etc.) that are not well integrated. This siloed data environment makes it difficult to implement a unified SaaS tracking platform that needs to pull information from various sources. In fact, 76% of supply chain executives surveyed in 2022 pointed to disparate data silos and lack of unified knowledge as a major hurdle to digital transformation. Additionally, legacy systems might not be compatible with modern APIs or

cloud services, hindering seamless data flow. These older systems can be slow, inflexible, and expensive to maintain, yet companies are often reluctant to replace them due to high switching costs or fear of disruption during the transition. The adaptive strategy here is to adopt a phased integration approach. Rather than a rip-and-replace of all legacy software (which is risky in a volatile environment), companies can use middleware or integration platforms to connect legacy systems with the new SaaS solution. For example, implementing an integration layer or using the SaaS provider's APIs to bring in data from an old ERP ensures that shipment trackers have the needed information without fully discarding the legacy system upfront. Over time, legacy systems that hinder agility should be modernized or migrated to cloud-based solutions when feasible[8]. Embracing modular, microservices-based architectures can also help; this allows adding new digital capabilities as small components that interface with existing systems, gradually building a more connected IT ecosystem. From a management perspective, breaking down internal silos also requires change management – encouraging cross-functional collaboration so that all departments (procurement, logistics, sales) share data on one platform. Some companies establish a "control tower" team that has end-to-end visibility and can coordinate data and decisions across silos.

2. Data Quality and Security Concerns: along with integration comes the challenge of data quality. Real-time tracking generates a flood of data – location pings, sensor readings, status updates. If not managed properly, this can include duplicates, errors, or noise, leading to false alarms or mistrust in the system's outputs. Companies need to invest in data validation and cleansing processes. Moreover, sensitive data about shipments and customers must be protected. Some organizations, particularly in regions with strict data sovereignty laws, express concern about putting logistics data on the cloud (SaaS) where it is stored on external servers. Security is paramount: a cyberattack that compromises a tracking system could disrupt operations or leak valuable information (such as high-value shipment routes, which could be targeted by thieves or adversaries). The strategy to tackle these issues includes choosing SaaS providers that offer robust security certifications (ISO, SOC 2) and compliance with privacy laws (GDPR, etc.), and implementing strong access controls on the user side. End-to-end encryption of data, multi-factor authentication for users, and network security protocols are standard measures that should be in place. To ensure data quality, businesses should define clear data governance rules – for instance,

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[8] McEwan V. Digitalization in logistics: 5 challenges and how to overcome them. SER Group Blog. 2022. URL: https://www.sergroup.com/en/knowledge-center/blog/5-digitalization-challenges-and-how-to-overcome-them.html

standardizing how shipment milestones are scanned and recorded, training staff to input correct information (right codes, consistent units of measure), and employing automated checks. Regular audits of data accuracy can keep the system trustworthy. Blockchain-based traceability could be a future strategy to enhance data integrity: by recording key events in an immutable ledger, it becomes easier to verify that data hasn't been tampered with. The use of blockchain in "visiceability" (combined visibility and traceability) initiatives is already being explored to strengthen sustainable supply chains in VUCA contexts[9]. Researchers emphasize that integrating visibility with traceability through technologies like blockchain (termed *visiceability*) can greatly improve transparency and trust in chaotic conditions[10].

3. Change Resistance and Skill Gaps: digital transformation often meets human resistance. Employees and even some managers might be accustomed to legacy processes (like using phone calls and emails to track shipments, or manual spreadsheets for record-keeping). Introducing a new SaaS system requires training and a mindset shift to trust and utilize the digital tools. In some logistics companies, especially SMEs or in regions like Ukraine where until recently logistics was less digitized, there may be a shortage of employees with the necessary digital skills. War-related workforce disruptions exacerbate this, as experienced staff may have relocated or businesses are operating with lean teams. If the users do not fully adopt the SaaS solution – e.g., drivers not consistently using a mobile tracking app, or planners ignoring the system's alerts – the value of the system diminishes. To overcome this, a strategy of comprehensive training and change management is critical. Companies should involve end-users early in the implementation process, perhaps piloting the new system with a small group of enthusiastic users who can then champion it to their peers. Demonstrating quick wins (for example, how the system saves time or prevents a problem) helps build user buy-in. Additionally, selecting a user-friendly platform with an intuitive interface lowers the barrier to adoption. Modern SaaS products often have consumer-grade interfaces (similar to familiar mobile apps), which reduces training time. The importance of providing the right tools is highlighted by workforce studies: employees equipped with modern, efficient digital tools are significantly more engaged and less likely to leave their jobs. According to a Qualtrics survey, employees are 85% more likely to stay beyond three

[9] Alicke K., Foster T., Trautwein V. Supply chains: Still vulnerable. McKinsey & Company. 2024. URL: https://www.mckinsey.com/capabilities/operations/our-insights/supply-chain-risk-survey

[10] Mubarik M. S., Khan S., Kusi-Sarpong S., Mubarik M. Supply chain sustainability in VUCA: role of BCT-driven SC mapping and "visiceability". *International Journal of Logistics Research and Applications.* 2023. 1–19. DOI: https://doi.org/10.1080/13675567.2023.2222660

years if they feel they have technology that helps them perform well. This underscores that investing in good logistics software not only improves operations but can also alleviate skilled labor shortages by improving retention. Organizations should also consider incentivizing digital adoption – for instance, setting KPIs related to system usage (such as percentage of shipments tracked through the platform) or recognizing employees who proactively use data from the system to solve issues.

4. Financial Constraints and ROI Concerns: especially for smaller firms or those under economic stress, the cost of implementing new digital platforms can be daunting. while saas has lower upfront costs than traditional software, subscription fees and related implementation expenses (scanners, iot devices, training time) still require budget. in uncertain times, companies may hesitate to allocate funds to a transformation project without clear, immediate roi. management might question whether investing in tracking technology yields sufficient benefits to justify the cost, particularly when margins are thin. the adaptive strategy for this is to start with a focused implementation that targets the most pain points, thereby ensuring a quick roi that can justify further roll-out. for example, a company might first use a saas tracking solution for its highest-value or most delay-sensitive shipments. if, within a few months, this results in fewer expedites or stockouts, the cost savings and service improvements can be quantified and presented as a success case. many saas providers offer scalable pricing, so companies can begin small (even with a specific lane or distribution center) and expand later. additionally, in some regions, government programs and development organizations are providing financial support or incentives for smes to digitalize (this is noted in ukraine's strategy to promote sme digitalisation for resilience). firms should explore grants or tax incentives that might offset the cost of digital tools aimed at improving supply chain resilience and transparency. importantly, when making the business case internally, companies should factor in the cost of inaction: not having visibility and agility in a vuca world can lead to expensive disruptions. one study estimated that logistics companies collectively stand to gain trillions in economic value over the next decade by adopting ai and digital tools – implying that those who delay may lose competitive ground or incur avoidable losses.

5. unreliable infrastructure and external shocks: a challenge more specific to conflict zones or less-developed logistics networks is that digital solutions depend on underlying infrastructure – electricity, internet connectivity, and transportation networks. As seen in Ukraine, infrastructure volatility (power outages, damaged telecom networks) can cripple the effectiveness of even the best SaaS system **2**. In such cases, companies must plan for contingencies when the tech goes offline. The adaptive strategy might

include maintaining hybrid tracking methods: for instance, combining digital tracking with manual check-in checkpoints. Ukrainian logisticians during the war formed community networks via phone and radio to report shipment progress when GPS tracking was unavailable. A logistics firm could equip drivers with both a smartphone app (for normal conditions) and alternative communication means like satellite phones or HF radio for emergency use in blackout areas. Designing the business processes for resilience means having failover procedures – if the cloud platform is unreachable, perhaps a local database can store updates and sync when connection is restored. Some SaaS providers support offline mode operations, where an app can cache data until it can transmit again. Utilizing multiple communication channels (cellular, satellite, internet, etc.) in trucks and facilities can reduce the single points of failure. The overarching strategy is to not be entirely reliant on one mode of technology. This is akin to a "plan B" for tracking: ensure that critical shipments have redundant tracking or that personnel are in place to take over tracking manually if needed. Flexibility and redundancy, while adding some cost, are vital in a BANI environment where expecting the unexpected is prudent.

6. Maintaining Collaboration and Trust: finally, one of the softer challenges is getting all supply chain partners – who may have different priorities and systems – to collaborate on a shared digital platform. A SaaS tracking solution often works best when carriers, suppliers, 3PLs, and customers participate by providing data or integrating with it. However, third-party logistics providers or suppliers might be hesitant to share data due to confidentiality or simply inertia. Building an ecosystem of trust is an ongoing effort. The strategy here is twofold: incentivize partners by demonstrating mutual value, and possibly mandate integration through contracts for critical partners. If a major supplier sees that sharing production and shipment data through the platform helps them reduce rush orders or penalty costs (because the buyer can adjust plans with advance warning of delays), they are more likely to cooperate. Some large companies use their influence to standardize digital data exchange (for example, requiring EDI or API-based tracking updates as part of logistics service contracts). In an environment of anxious relationships, transparency can actually be an antidote – sharing data tends to build trust over time, as each party becomes more predictable and reliable to the other. Leadership should communicate a culture of "we're all in this together" across the supply chain, especially in crises. During the early pandemic, for instance, companies that openly communicated with their suppliers and logistics providers about issues and jointly found solutions fared better. SaaS platforms often have collaboration features (like shared dashboards or chat functions specific to a shipment) which can be championed

as neutral ground for all parties to problem-solve. By using data as a common language, subjective blame can be replaced with objective analysis of issues.

The following table summarizes some of the key challenges in implementing SaaS shipment tracking solutions under VUCA/BANI conditions and the adaptive strategies to address them:

<div align="right">Table 1</div>

**Key challenges in adopting SaaS tracking solutions
and strategies to overcome them in VUCA/BANI conditions**

Implementation Challenge	Adaptive Strategy
Data silos across legacy IT systems	Integrate via middleware/APIs; phase legacy modernization; create central "control tower" for data.
Poor data quality or security concerns	Enforce data standards and validation; choose secure certified SaaS providers; encrypt data and control access.
Employee resistance and digital skill gaps	Provide comprehensive training; select user-friendly tools; involve change champions; highlight quick wins; incentivize usage (tools shown to boost engagement/retention).
Financial constraints, unclear ROI	Start small with critical lanes for quick ROI; leverage subsidies; calculate cost of inaction; scale up upon success.
Infrastructure unreliability (e.g. war, outages)	Use hybrid tracking (digital + manual); ensure offline capabilities; add redundant comms (satellite, etc.) for critical routes.
Partner/data sharing reluctance	Demonstrate win-win benefits of transparency; incorporate data-sharing in contracts; build trust via collaborative dashboards and joint problem-solving.

By anticipating these challenges and implementing the strategies above, companies can greatly improve the success rate of their digital transformation initiatives. The most resilient supply chains tend to be those that combine advanced technology with agile processes and a culture of continuous adaptation. In a world that is both volatile and brittle, merely deploying new tech is not enough – it must be bolstered by organizational learning and flexibility.

A critical adaptive capacity is developing supply chain resilience as a dynamic capability. This means institutionalizing the ability to sense, respond, and reconfigure quickly in the face of disruptions. SaaS tracking solutions feed into this by providing the sensing and visibility component. But companies must also empower teams to act on this information (response) and make structural adjustments (reconfiguration) such as switching suppliers or modes as conditions change. Recent expert studies and Delphi surveys on

supply chain resilience indicate that strengthening such dynamic capabilities – like agility in decision-making and integration of information flows – is essential to cope with reality VUCA environments. In essence, technology and strategy must align: a digital platform will inform that a route is compromised, but a resilient enterprise will have pre-planned alternatives and the autonomy to execute them rapidly.

Furthermore, sustainable development in logistics today implies not only economic viability under stress but also environmental and social responsibility. Digital tracking can contribute to sustainability by optimizing routes (reducing fuel consumption and emissions) and by enabling supply chain transparency for ethical sourcing. For example, traceability tools help ensure products are not linked to deforestation or forced labor, supporting corporate social responsibility goals. Customers, investors, and regulators are increasingly demanding such accountability. Companies that effectively use SaaS solutions to gather and report accurate supply chain data will be better positioned to meet sustainability targets and reporting requirements (such as carbon footprint tracking or compliance with human rights due diligence laws). Thus, the adaptive strategies adopted for resilience often dovetail with those for sustainability – building a supply chain that is both robust in the face of disruptions and aligned with long-term sustainable practices. Digital tools act as enablers on both fronts.

CONCLUSIONS

Logistics and supply chain management are navigating an era defined by volatility and complexity, encapsulated in the acronyms VUCA and BANI. In this demanding context, the adoption of SaaS solutions for shipment tracking and supply chain visibility emerges as a pivotal strategy for firms seeking to ensure sustainable development and competitiveness. This monograph section analyzed how SaaS shipment tracking platforms address the challenges posed by unpredictable, high-risk conditions and what adaptive strategies enhance their effectiveness.

The analysis shows that SaaS-based tracking systems offer significant benefits: real-time end-to-end visibility, data-driven agility, improved coordination across stakeholders, and scalability that democratizes advanced logistics capabilities. These tools directly tackle VUCA/BANI challenges by providing timely information to manage volatility, enabling data-informed decisions amid uncertainty, and increasing transparency in complex, multi-party networks. The case of Ukraine's wartime logistics underscored that, even under extreme brittleness and hazard, digital solutions (augmented by human ingenuity) can help maintain critical supply flows and avert total system collapse. Companies worldwide have learned the hard way that

resilience must trump efficiency in the face of recurring disruptions. SaaS tracking solutions, by enhancing visibility and responsiveness, form a foundation for building that resilience. They help firms shift from reactive firefighting to proactive risk management – rerouting shipments before a storm hits, reallocating inventory when a delay is detected, or alerting customers about issues in advance. Such capabilities not only mitigate immediate operational risks but also preserve customer trust and business continuity, contributing to the long-term sustainability of enterprises.

However, the successful deployment of these digital tools is contingent on addressing implementation challenges. Key hurdles identified include integration with legacy systems, data quality and cybersecurity, workforce adoption, cost justification, and external infrastructure constraints. The section provided a set of adaptive strategies to surmount these obstacles. Central among them is the principle of flexibility: technical flexibility (through modular integration and redundant systems) and organizational flexibility (through training, change management, and collaborative culture). By integrating SaaS platforms gradually and thoughtfully, ensuring clean and secure data, upskilling employees, and maintaining contingency plans, companies can significantly amplify the positive impact of digital transformation. The role of management is crucial in this adaptation process – leadership must champion the change, allocate resources for it, and embed a mindset of continuous improvement. Firms that treat disruptions as learning opportunities and evolve their processes with each challenge tend to emerge stronger ("antifragile"). For example, those that suffered from information blindspots in one crisis invested in visibility tools and supplier collaboration, which then protected them in subsequent disruptions.

Importantly, digital shipment tracking is not a standalone solution but part of a broader paradigm shift in supply chain strategy. This shift embraces resilience, agility, and sustainability as core objectives, rather than afterthoughts. The convergence of factors – market expectations, regulatory mandates, and the frequency of extreme events – means that companies must design supply chains that can withstand shocks while also meeting environmental and social governance (ESG) criteria. SaaS logistics platforms help on both counts by enabling detailed monitoring (for risk and compliance) and optimization (for efficiency and footprint reduction). For instance, an organization can use its tracking data to calculate carbon emissions per shipment and then take steps to reduce it (choice of greener modes, consolidation of loads, etc.), feeding into its sustainability reporting and goals.

In conclusion, SaaS solutions for shipment tracking serve as a catalyst for adaptive, resilient, and sustainable supply chain management in the VUCA/BANI world. They provide the digital nervous system for modern

logistics, sensing and conveying the state of the supply chain in real time. But to fully realize their value, companies must align technology implementation with strategic foresight and human adaptability. Those organizations that successfully marry advanced digital tools with agile management practices will be best positioned to weather the storms of uncertainty and seize opportunities in the chaos. The research and cases discussed confirm that while challenges are substantial, the prospects of digital transformation – smarter, more transparent, and more responsive supply chains – are both achievable and indispensable for sustainable development. As the environment continues to evolve unpredictably, the continued study and sharing of best practices in this domain will be essential. Firms, policymakers, and researchers must collaborate to refine these adaptive strategies, ensuring that supply chains become not only more efficient but truly resilient and sustainable for the future.

SUMMARY

The section examines how cloud-based shipment tracking platforms can support sustainable supply chain development amid highly volatile and unpredictable conditions, characterized by VUCA (volatility, uncertainty, complexity, ambiguity) and the newer BANI (brittle, anxious, nonlinear, incomprehensible) framework. The author outlines the impacts of a VUCA/BANI environment on logistics – including disruptions from the COVID-19 pandemic and the war in Ukraine – which highlight the need for real-time visibility and agility in supply chains. SaaS (Software-as-a-Service) logistics solutions are presented as a key part of digital transformation, offering capabilities such as end-to-end shipment tracking, data analytics, and multi-stakeholder collaboration through the cloud. The section identifies challenges in implementing these technologies (e.g., data silos, legacy systems, user resistance, security and infrastructure issues) and proposes adaptive strategies to overcome them. It emphasizes that simply adopting technology is not enough; organizations must also cultivate resilience and flexibility, integrating digital tools with processes and training that enable quick response to disruptions. Case examples and studies are discussed to demonstrate how effective use of SaaS tracking can improve operational resilience, transparency, and even compliance with sustainability standards. In conclusion, the research finds that SaaS shipment tracking solutions, when implemented with a clear strategy and adaptive approach, significantly enhance a supply chain's ability to withstand shocks and maintain performance, thereby ensuring more sustainable development in an era of constant uncertainty and change.

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