Intelligent Supply Chain

For Aerospace and Defense

Capgemini

Executive summary

The Problem

The Aerospace and Defense industry is facing significant challenges due to the upswing in demand post-pandemic, geopolitical factors, and the advent of new aircraft technologies.

The commercial aviation order backlog is currently at over 16,500 aircraft, but the industry faces hurdles in expanding capacities, optimizing processes and tools, and collaborating with supply chains.

The ambitious goal of achieving net-zero carbon emissions by 2050 adds to the challenge. Additionally, uncertainties like rising inflation, economic trajectories, and geopolitical disruptions increase industry challenges.

The Solution

This paper proposes a major transformation towards an intelligent supply chain specifically designed for the Aerospace and Defense sector.

Such a supply chain would utilize advanced technology, leverage data analytics, and adaptive mechanisms to seamlessly synchronize production with market demands.

This supply chain would be more than just a means for material provision but a strategic asset that prioritizes resilience, innovation, and long-term sustainability. It would orchestrate the extended enterprise as a cohesive and anticipatory system.

The Value

Adopting an intelligent supply chain can provide multiple benefits such as improved operational efficiency, a strong framework for environmental sustainability, and a reliable defense mechanism against economic and geopolitical uncertainties.

This transformation can help develop a new paradigm that views supply chain disruptions as opportunities for innovation and adaptation rather than obstacles.

Implementing this advanced supply chain architecture can play a crucial role in meeting the increasing demand for aerospace and defense products while supporting ambitious environmental targets.

Keys to Success

The transition to an intelligent supply chain hinges on several critical factors:

- **Strategic Risk Management:** Developing robust risk assessment and mitigation strategies to navigate an increasingly complex global landscape.
- **Collaborative Ecosystems:** Fostering partnerships across the supply network to create a seamless and resilient value chain.
- **Sustainability Integration:** Weaving sustainable practices into the fabric of the supply chain to fulfill eco-friendly mandates.
- **Agile Response Mechanisms:** Establishing systems to quickly adjust to market changes and supply chain disruptions.
- **Digital Transformation:** Incorporating AI, IoT, and full-scale digitization to optimize decision-making processes.
- **Talent and Innovation:** Prioritizing human capital development and fostering a culture of innovation.

CONTENT

Introduction

Implementing an intelligent supply chain is critical for the success of the Aerospace and Defense Industry.

This paper highlights the significance of this shift, its strategic pillars, and the substantial benefits it offers. It serves as a call to action for stakeholders, providing a practical path that aligns with the sector's high-stakes demands and the pressing need for a sustainable future.

CHAPTER

01

The case for intelligent supply chain in A&D

The case for intelligent supply chain in A&D

The Aerospace and Defense sector is undergoing a major transformation, driven by an upswing in demand post-pandemic, geopolitical factors, and the advent of a new generation of aircraft technologies.

Aircraft orders have surged as air travel traffic rebounds, surpassing pre-pandemic levels. Projections indicate 30% growth in the next 5 years, with a doubling by 2041.

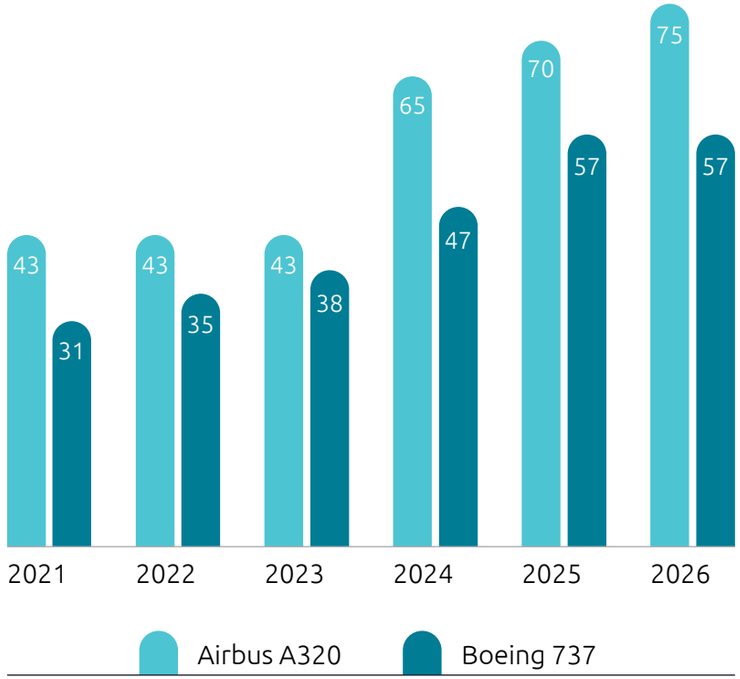
However, this heightened demand places considerable strain on the entire ecosystem, from small manufacturing companies to Original Equipment Manufacturers (OEMs).

The commercial aviation order backlog is currently at over 16,500 aircraft, mostly narrow-body jets. However, production may take some time to ramp up for various reasons, such as supply chain delays, talent shortages, or quality issues. The industry is committed to scaling but faces hurdles in expanding capacities, optimizing processes and tools, and collaborating with supply chains. More than 80% of the value of a final product is delivered by the supply chain ecosystem to the OEMs. Commercial aircraft OEMs are planning to increase their production capacity from around 50 to 100 aircraft per month for the next 5 to 10 years, and the success of this ramp-up will depend largely on the different supply chain players. A commercial aircraft OEM relies on a network of over 10,000 suppliers (over 15,000 for the latest products, and almost 20,000 if we include non-flying parts and related services) to manufacture an aircraft. This complex value chain model reaches up to 15 levels of depth and is present worldwide in more than 100 countries.

The ambition to achieve net-zero carbon emissions by 2050 adds to the challenge. Investing in Sustainable Aviation Fuels (SAF) and Hydrogen technology requires a balancing act between present and future industrial setups, requiring reshaped strategies and investments. The shift to greener operations is mandatory for a sustainable future and to ensure market positioning.

Additionally, uncertainties like rising inflation, economic trajectories, and geopolitical disruptions increase industry challenges. The defense sector has been experiencing significant growth with global defense spending setting new records every year, doubling in many countries. As a result, there is a need for new strategies to address the challenges that come with this growth.

The Aerospace and Defense industry is intrinsically linked to its supply chain. The supply chain impacts every aspect of the industry, from design and manufacturing to products, support and repair. As the industry faces challenges across the board, it is essential to prioritize the creation of an intelligent supply chain to address these issues and keep up with the increasing demand without jeopardizing the quality standards.



Aircraft production ramp-up per month

Source 1 Source 2

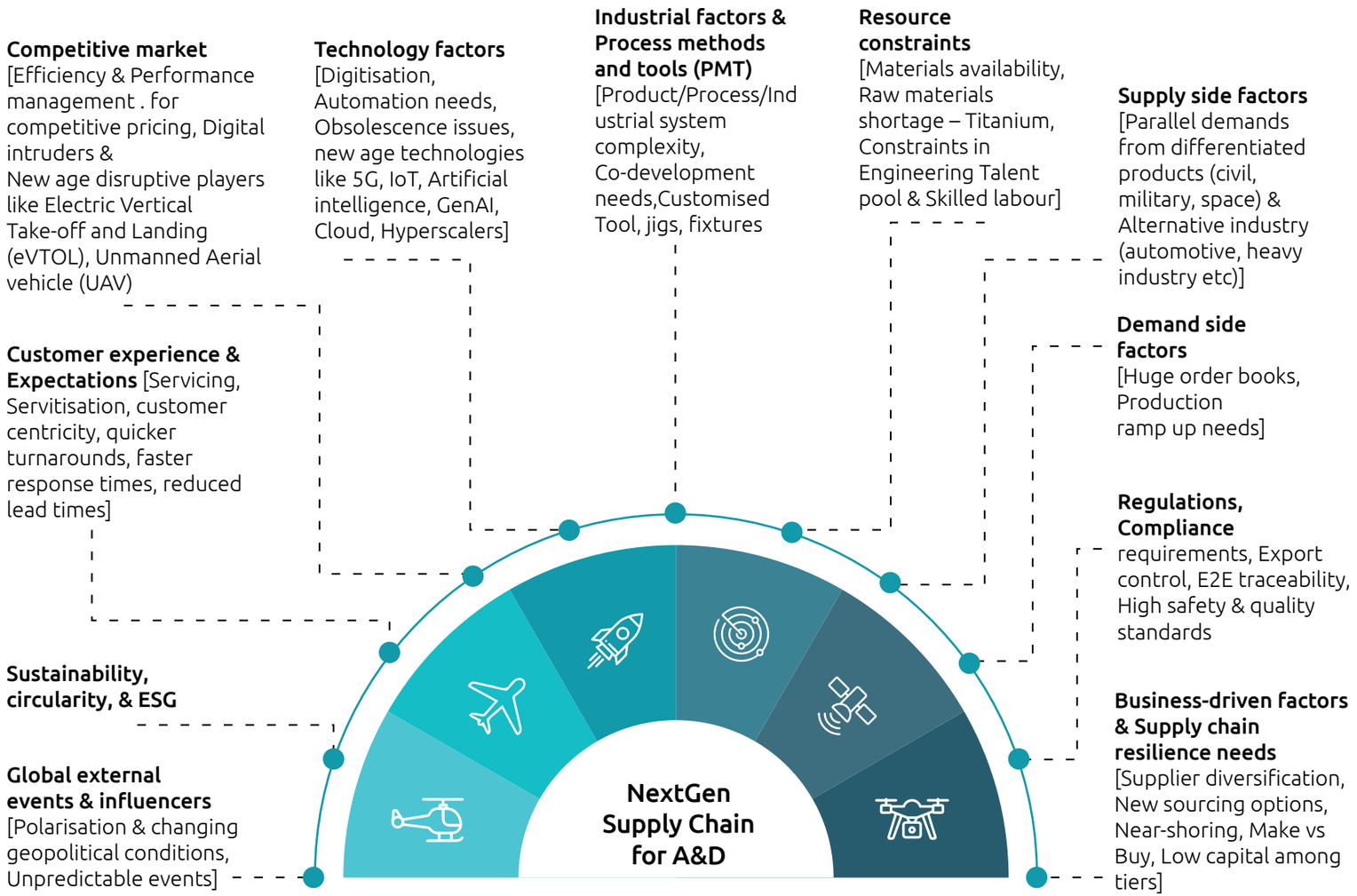
The next-generation supply chain will need to resemble the following model, which reflects today's need for agility in the market.

WHAT IS AN INTELLIGENT SUPPLY CHAIN?

An intelligent supply chain in the Aerospace and Defense industry refers to a dynamic, interconnected network of suppliers, manufacturers, and distribution systems that utilizes advanced technologies, real-time data analytics, and adaptive strategies to efficiently align production with current and forecasted demand. This system is designed to optimize resource allocation, reduce lead times, and mitigate risks associated with global geopolitical events, economic fluctuations, and environmental sustainability goals. It ensures the timely delivery of high-quality components and services across a complex, multi-tiered global ecosystem, enabling the industry to meet ambitious production targets and future-proof operations against a rapidly changing world.

This paper will delve into the imminent challenges and outline the strategic steps necessary to initiate and sustain this transformative shift within the Aerospace and Defense sector.

NEXTGEN SUPPLY CHAIN – NECESSITATED BY SHIFT FROM 'JUST-IN-TIME' TO 'JUST-IN-SEQUENCE'



CHAPTER

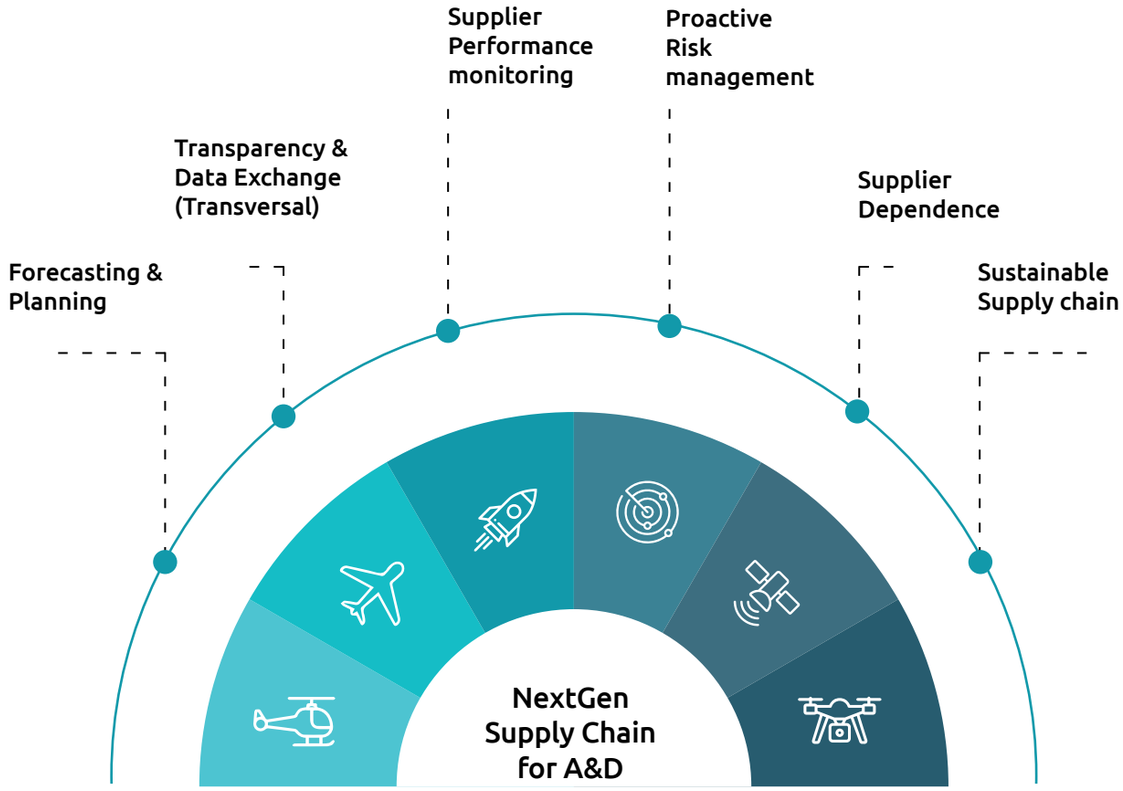
02

The major challenges facing supply chain in Aerospace: Tactical and strategic enablers

The major Challenges facing supply chain in Aerospace

Considering the complex nature of the A&D supply chain and the current industry context, we have identified six major domains of supply chain challenges that are of utmost importance:

NEXTGEN SUPPLY CHAIN – COMPLEMENTING ‘JUST-IN-TIME’ WITH ‘JUST-IN-SEQUENCE’ AND ENABLING DESIGN OF SUPPLY CHAINS WITH INHERENT RESILIENCE



The major challenges facing supply chain in Aerospace

#1 - FORECASTING AND PLANNING

Forecasting and planning in the Aerospace and Defense industry has historically presented impressive challenges due to the industry's long development cycles, product and industrial footprint complexity and technological shifts. Extended lead times for the high-complexity industry products make accurate predictions difficult, leading to the risk of demand misalignment.

Those intrinsic difficulties to the OEMs are immediately cascaded down to the supply chain ecosystem through a bullwhip effect, considerably multiplying their pernicious effects down the road.

Highly variable forecasts with more than 20% variation on a weekly basis and relatively low quality (less than 80% quality forecasts are typical for complex products in the industry) can lead to delays in the delivery of critical components, causing significant impacts in the final assembly lines. This decrease on the on-time delivery performance would typically come with higher costs, and in extreme cases, it would threaten the operational and financial stability of affected businesses.

This is amplified by the inconsistent data exchange between the players and a lack of shared tools enabling smart production. While a smart production should not be highly decoupled, an intelligent and pragmatic approach to minimize effects is required in order to be adaptive to eventual forecast changes avoiding high inventories, work-in-progress levels, queues, missing parts, overcapacity or no-load and disruptions on the shop floors.

A comprehensive supply chain transformation strategy in the industry must focus on forecasting and planning as it is crucial for the smooth functioning of the supply chain ecosystem.

The challenges that we must address to be successful are twofold:

1. Prioritize how to synchronize the development/industrialization/production of a new aircraft with a complex supply chain.
2. Minimize product and industrial variability (while fulfilling customer demands) to optimize associated lead time to avoid too high disruption in production.

#2 - TRANSPARENCY AND TRANSVERSAL DATA EXCHANGE

All the players of the industry know that streamlined data and flow enabling transversal collaboration across the supply chain is a powerful way to drive improvement and transformation across all the above-described challenges. However, the vision of a truly integrated supply chain is far from being a reality, as data exchange and data quality remain extremely limited and do not flow beyond the direct supplier/client level.

The main contributing factors to this situation are:

- The lack of an efficient operating model and alignment on standards across the industry. The standards for the exchange of more complex and sensitive data are not yet developed. Some data are considered to be too sensitive to be shared with external partners, and participants often lack a common understanding of the value or accuracy of one another's data. Additionally, there is no entity in charge of orchestrating the overall data sharing mechanism, so echanges are done "ad-hoc" and in a "point-to-point" basis.
- The current technologies used to exchange data between supply-chain participants tend to be relatively unsophisticated, allowing only limited information exchanges.

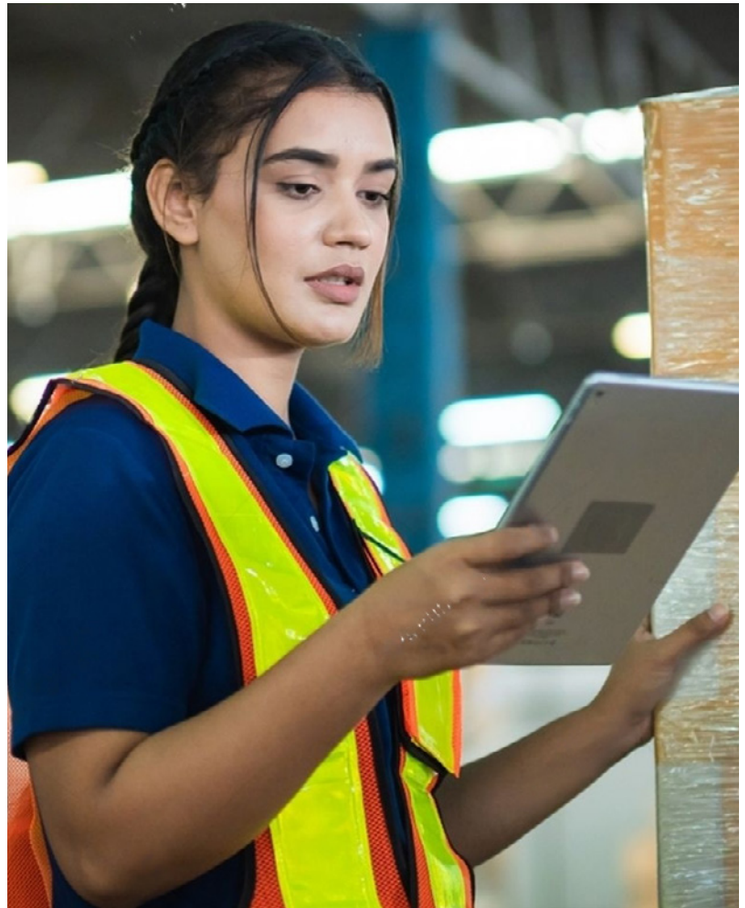
Establishing and implementing appropriate solutions to overcome those hurdles (and critical additional ones as cybersecurity and data sovereignty would bring significant value to the entire aerospace and defense industry ecosystem. It would enable a successful set of mechanisms to address challenges that will drive the industry's evolution in the next decades. Real-time management of information and data flow is a must.

#3 - SUPPLIER PERFORMANCE MONITORING

Managing supplier performance in real-time within the Aerospace and Defense industry presents a formidable challenge due to the intricate nature of the supplier network, sprawling across the global landscape and involving thousands of contributors. Effective monitoring of supplier performance is paramount to ensure the seamless operation of the supply chain.

The Aerospace and Defense industry faces several key obstacles in managing supplier performance:

- Data availability, quality, and traceability: The foundation of informed decision-making within the supply chain hinges on access to reliable and traceable data. A robust system is necessary to manage the extensive data originating from various sources and, as explained in the point above, it is today far from being a reality.
- Lack of established Key Performance Indicators (KPIs): The absence of mutually agreed-upon KPIs makes it challenging to measure supplier performance quantitatively. It is crucial to establish a few clear KPIs to align expectations and encourage ongoing improvement.
- Collaborative benchmarking and target setting: The industry's dynamic nature demands a joint effort to establish benchmarks and targets that accurately reflect the current landscape, adding complexity to performance management.
- Automation and data Silos: The deficiency in automation and the presence of data silos obstruct the efficient capture and analysis of performance data. Streamlining data collection and dismantling silos are essential steps to improve the effectiveness of performance management.
- Regulatory and policy changes: Lastly, the rapid pace of regulatory, compliance, import/export policy, and global data exchange requirement changes introduces additional complexity to effective performance management. Keeping up-to-date with these changes is vital for ensuring compliance and optimizing performance in the ever-evolving Aerospace and Defense industry.



#4 – PROACTIVE RISK MANAGEMENT

In a dynamic industry, anticipation is key to mitigate risks and disruption to production, which can impact schedules and revenue. Identifying, addressing, and preventing vulnerabilities proactively before they escalate helps mitigate financial losses, maintain customer trust, and ensure on-time and on-quality delivery.

Due to the recent events, the increasing complexity of the product and the industrial footprint, Aerospace and Defense industry players have become experts in managing crisis in a reactive mode, which consumes resources and exhausts the teams.

An OEM typically suffers from about 100 major supply chain crises a year that strongly endanger the on-time delivery of aircraft (and therefore the on-time cash flow for OEMs), and intensive (human, material and technological) resources must be deployed during months each time to mitigate the associated risks and, ultimately, bring back the situation so it runs under acceptable parameters.

Relying on a purely reactive approach is no longer sustainable in the current market. Instead, the industry must adopt an innovative approach that combines risk anticipation and proactive mitigation to successfully face ramp ups and future threats.

#5 – SUPPLIER DEPENDENCE

Dependency on a few critical suppliers in the aerospace and defense industry amplifies supply chain vulnerabilities in production ramp-up and new development contexts.Relying heavily on a few number of suppliers for crucial components, increases the risk of disruptions cascading throughout the chain and creates a single path of failure across the chain, down to potentially the elementary parts or the raw materials.
If a supplier in this critical path faces financial issues, bankruptcy, or production interruptions, the entire supply chain and the corresponding production plan might be compromised. Additionally, the low number of qualified, certified, or even trusted suppliers leads to a very limited number of alternative sources, in plenty of cases, making the quick implementation of an alternative solution almost impossible.
The majority of those “single point of failures” across the value chain of the industry are typically not direct suppliers to the OEMs, but are rather present at tiers 2, 3 or 4 levels, creating additional challenges for the management of those weak nodes in the chain (as there is limited operational influence from the OEMs to these tiers).
Design and implementation of a strong supply management system and solid processes to simulate/anticipate issues or disruptions become of paramount importance to minimize or even better to avoid exposure to such weak nodes and will allow an accelerated new supplier onboarding process.

#6 – SUSTAINABLE SUPPLY CHAIN

Sustainability pressures in the aerospace and defense industry are becoming increasingly significant due to growing environmental awareness.

As global concerns about global warming and resource depletion intensify, demand for more eco-friendly and fuel-efficient technologies is massively increasing.

The biggest challenge of all is the wide gap between the cost of decarbonization and the value it generates for shareholders, making it difficult for the industry to invest significantly.

Adapting the entire ecosystem and supply chain to meet these requirements is a complex challenge.

OEM and suppliers must include sustainability into the core of their development activities and source sustainable materials, develop energy-efficient manufacturing processes, and design products with reduced environmental footprints considering on top circularity, recycling criteria, dismantling, etc.

This involves close collaboration with suppliers to ensure adherence to sustainable practices and compliance with strict emissions standards. Implementation can be complex and costly, potentially requiring significant investments in research, development, sourcing (onshore vs offshore), and reindustrialization.

Balancing sustainability goals with operational efficiency, while also maintaining cost competitiveness, is a complex task that requires strategic alignment and well-controlled processes across the entire supply chain. It is essential that every actor involved commits to creating a greener and more responsible industry.

SYNTHESIS - COMPLEMENTING THE ‘JUST-IN-TIME’ WITH RESILIENT ‘JUST-IN-SEQUENCE’

HORIZON 1 → NOW

01

IMMEDIATE ACTION FOR CURRENT OPERATIONS

The plan emphasizes immediate improvements in execution within the existing supply chain framework, focusing on optimizing current operations, enhancing data transparency, and monitoring supplier performance to ensure efficiency and sustainability right now.

HORIZON 2 → FROM 4 TO 18-MONTH

02

MID-TERM PREDICTIVE AND COLLABORATION

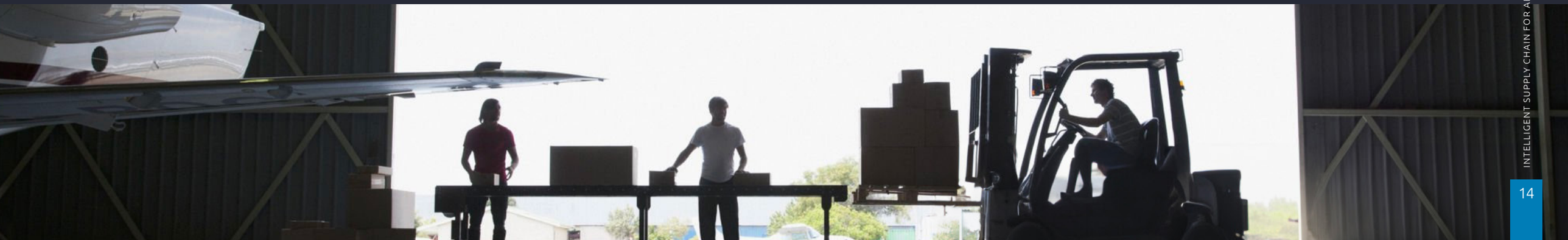
In the medium term, the plan shifts towards developing predictive models and strengthening collaboration among supply chain partners. This aims to build a resilient supply chain capable of anticipating disruptions and strategically adjusting to unplanned events within a 4 to 18-month timeframe.

HORIZON 3 → > 18-MONTH

03

LONG-TERM STRATEGIC DEVELOPMENT

Looking towards the future, the strategy involves preparing for new developments and implementing changes that will carry the industry over the next 18 months and beyond. This includes integrating new technologies, responding to market shifts, and ensuring compliance with evolving regulations to maintain a competitive edge.



HOW LONG WILL IT TAKE TO TRANSFORM INTO AN INTELLIGENT SUPPLY CHAIN?

All these issues need to be addressed consistently. However, since the time horizons to implement the solutions vary, the transformation must be carried out in progressive steps characterized by:

The following chart presents a phased approach to address supply chain challenges in the Aerospace and Defense industry. The plan outlines initiatives according to different time frames and levels of urgency, ensuring a structured implementation of changes. Each stage builds upon the achievements of the previous one, resulting in a sequential and effective reform of the supply chain.

SYNTHESIS - COMPLEMENTING THE 'JUST-IN-TIME' WITH RESILIENT 'JUST-IN-SEQUENCE'

	« OPTIMIZED EXECUTION » SUPPLY CHAIN • Performance optimization • Short term and fix rate • Brownfield	« PREDICTIVE » & » COLLABORATIVE » SUPPLY CHAIN • Performance increase/optimization • Resilience to unplanned events • Production rate adaptations • Brownfield and Greenfield	« NEW » SUPPLY CHAIN DEVELOPMENT & IMPLEMENTATION • New company (Greenfield) • New products or major changes • Re-design of the existing supply chain
	HORIZON 1 > NOW	**HORIZON 2 > 4-m to 18-m**	**HORIZON 3 > Next program >18-m**
Forecasting & Planning	Gain transparency in the cascade of the demand forecast and the corresponding feedback loop from suppliers.	Tactical & Operational planning to anticipate and ensure that the set up will be resilient against demands evolution	Articulation of joint multi-tier transformational actions in the industry based on the strategic planning: Business case evaluations for product designs, market study, evolving better costing strategies, sourcing strategies, Make vs Buy decisions for the market and customer segments
Transparency & Data Exchange (Transversal)	Operational improvements in the data sharing and collaboration process in the current point-to-point (client-supplier) perimeter: collaboration beyond pure demand cascade Implementation of strong data quality securing mechanisms before sharing data with partners	Creation of a multi-tier data exchange and collaboration model for highly critical use cases and processes. Establishment of the aplicable cross-industry data sharing standards and governance mechanisms	Seamless multi-tier data exchange and visibility in (near) real time Mature supply chain digital twin model allowing to simulate at any time, any event and hence model and asses any recovery before implementing it.
Supplier Performance monitoring	Definition and measurement of cross-industry basic performance KPIs. Point-to-point (client-supplier) development and deployment	Multi-tier roll out of relevant KPIs, enabling an end-to-end monitoring of the performance across the chain. Foster multi-tier collaboration based on those indicators	Increasingly autonomous system to monitor performance, measure impact and action proposal, including simulation capabilities
Proactive Risk management	Structured crisis management based on data. Compilation of lessons learned that prevent the same issue from occuring in the future	Quantitative identification and evaluation of weak signals that enable the anticipation of a part of the future crisis (focus on single-tier approach)	Multi-tier end-to-end weak signal identification and processing, through a standardized automatic alert system. Complete turn of the supply chain management focus from crisis management to risk anticipation
Supplier Dependence	Identification of key weak nodes in the supply chain of OEMs to take diversfiication actions	Explore strategies for 'Near-shoring' to build on local supplier base as much as possible, building sustainability in sourcing	Completely redesign and rethink the make/buy strategy and the supplier base for new products, collaborating with new players
Sustainable Supply chain	Implement immediate efficiency improvements such as optimizing transportation routes, reducing packaging waste, etc. Collaborate with suppliers to promote sustainable practices	Integrate sustainability criteria into supplier selection and procurement processes Implement supply chain transparency measures to identify areas for improvement and accountability.	Transform the supply chain towards a circular economy model by designing products for durability, reuse, and recyclability, and establishing take-back programs for end-of-life products.

CHAPTER

03

Additional specific issues for Civil Aeronautics, Defense, Helicopters and Space

The common and specific challenges

The common challenges

On top, we are facing several constraints, impacting the overall performance.

- Lack of resources (qualified workers, energy, material, expertise such as dynamic analysis of helicopters), Raw material shortages (Titanium).
- Changes in legislation and regulations
- The shift in the automotive world can also impact the ability of the supply chain to invest in Aerospace industry transformation.

We are also facing global inflation, leading to higher costs and cash constraints at Tier-x levels contradicting the raising demands, production rate and investments increase being required.

Following pain points must be considered for the following Aerospace industry segments:

The specific challenges

HELICOPTER

The challenge for supply chain management as such, is particular for the Helicopter environment and is very similar to the Aerospace civil aeronautics industry.

- Due to the lower volumes, rate, and price than commercial aerospace but high customer variability (search and rescue operations, oil & gas, combat etc.) the willingness on part of the suppliers to invest is limited.
- A larger variety of programs adds complexity vis-à-vis of the suppliers.

DEFENSE AEROSPACE INCLUDING SUB-MARINES AND MISSILES

The challenge for Supply Chain Management is:

- Sovereignty generating a limited number of suppliers.
- Higher constraints on Data classification, segregation for protecting IP, complexity in data sharing with customers.
- Defense market requires Export Control regulations.
- Huge challenges around systems integration within a product, integration of multiple systems and platforms in the integrated battlefield, example FCAS.

SPACE

- Space market has very specific requirements and low quantities on one side, on the other hand, there are constellation of satellites which require which requires standardization, low cost and high production volume which is not the DNA of big companies.
- For launchers, the challenge is to make innovative and cost-effective solutions with a mastered development leadtime
- Space industry supply chain is highly fragmented. Many of the ecosystem players are new age startups, so this brings new vulnerabilities related to financial stability, raw materials supply, logistics and talent.
- The Space industry is still heavily relying on the old age ecosystem players while the space technology is changing at a rapid pace. This poses significant challenge in managing faster time to market for Space industry organizations.
- Dependency on limited number of suppliers.

COMMERCIAL AEROSPACE

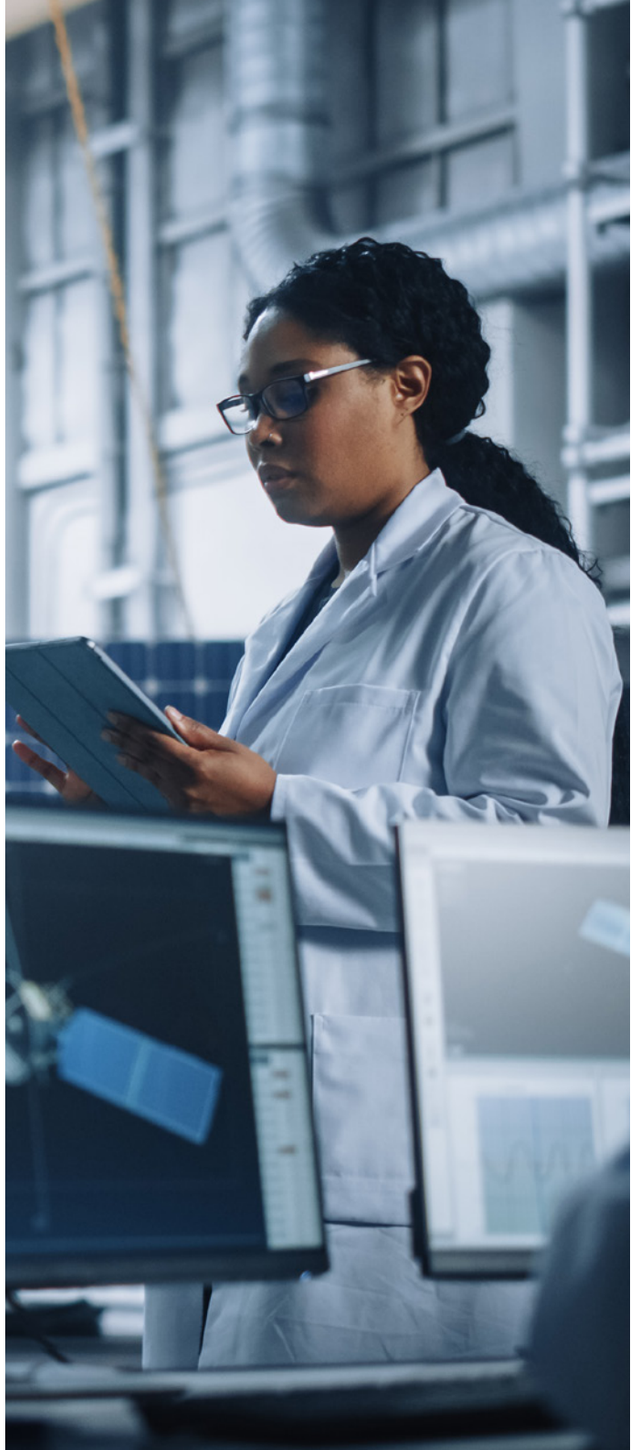
Dependency on a few critical suppliers in the aerospace and defense industry amplifies supply chain vulnerabilities in production ramp-up and new development contexts. Relying heavily on a few number of suppliers for crucial components, increases the risk of disruptions cascading throughout the chain and creates a single path of failure across the chain, down to potentially the elementary parts or the raw materials.

The challenge for the Aerospace civil aeronautics industry is to prepare the next generation of aircraft and services while managing now huge ramp-up and demand on current programs. This could lead to conflicting objectives plan like:

- Different value chain models and associated supply chain for next generation aircraft more focused on services and upgradability.
- Supply chain ecosystem is shared between Civil and Defense – Improve the way we interact with the common extended enterprise eco-system.
- For current programs, limited numbers of qualified and certified suppliers leading to a low number of alternatives.
- High dependencies on the existing suppliers (from current programs) while you should embark and develop new suppliers for the future.
- New regulations, new constraints, and new certification requirements.

For example, for next generation of Hydrogen or electric aircraft, there is tendency for OEMs to become End-to-End integrator of the new propulsion system and to become direct competitors to engine manufacturers of today.

At the same time, these Engine manufacturers must invest in today's ramp-up of the current engine technology and also in invest the next generation of propulsion system. And probably, with a new business model less profitable on maintenance and after-market.



CHAPTER

04

The system approach for the extended enterprise

The definition of a system

Systems and sub-systems, the extended enterprise as a system

In general, the concept of a system is fundamental in understanding how different elements work together to achieve a common purpose. A system is composed of interconnected processes, parts, components, or elements that collaborate to produce outcomes that individual elements cannot achieve on their own.

This interdependence is crucial, as the elements interact and influence each other's behavior.

The environment surrounding system and its sub-systems also plays a relevant role in it. It includes external factors, conditions, or influences that impact the system's behavior and performance.

These external factors can include physical conditions, economic trends, social dynamics, regulatory requirements, and any other directly influencing factor.

The environment interacts with the system and its sub-systems, affecting its operation, effectiveness, and sometimes even its boundaries.

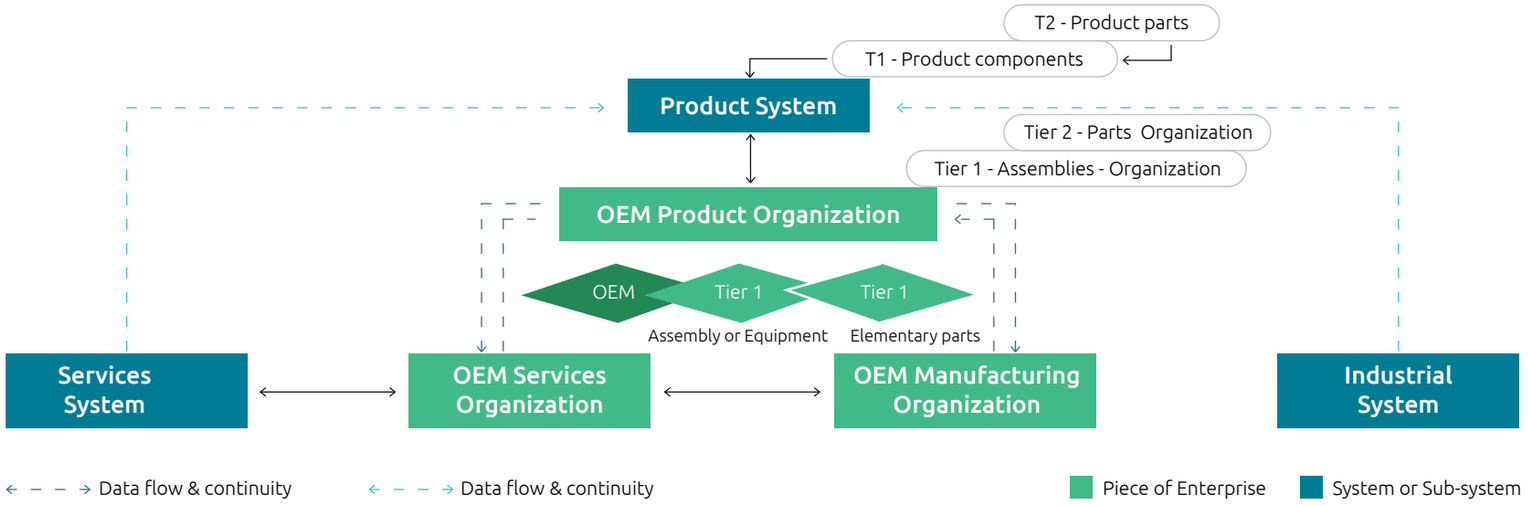
The Extended Enterprise within the Aerospace and Defense industry is a system composed of several sub-systems. We have identified 6 sub-systems to fully categorize the A&D Extended Enterprise.

- The Product itself, its Industrial System, and its Services activities.
- The Product organization, the Manufacturing organization, and the Service organization.

The Extended Enterprise system is more than just the sum of the 6 sub-systems. It involves intricate relationships, dependencies, and interactions that impact the physical flow of materials, components, and information/data flow from raw material sources to end customers.

These relationships exist at OEM level but also at the layers of the Tier 1, Tier 2, etc. The graphic below shows the data flow between OEM, Tiers 1, Tier 2.. and the customers, mapped also with the physical flow.

A&D IS COMPOSED OF SEVERAL SYSTEMS: PRODUCT-MANUFACTURING-SERVICES



The extended enterprise system can be seen as a cube

MODELIZATION AND SIMULATION OF THE SYSTEM AND ITS SUB-SYSTEMS

Our view is, therefore, to approach the Extended Enterprise as system composed of 6 sub-systems.

Thanks to this approach, we can structurally tackle the supply chain challenges through a better understanding of its complexities, being able to treat performance issues, to anticipate potential challenges and define new supply chain models.

We firmly believe that this holistic perspective allows for

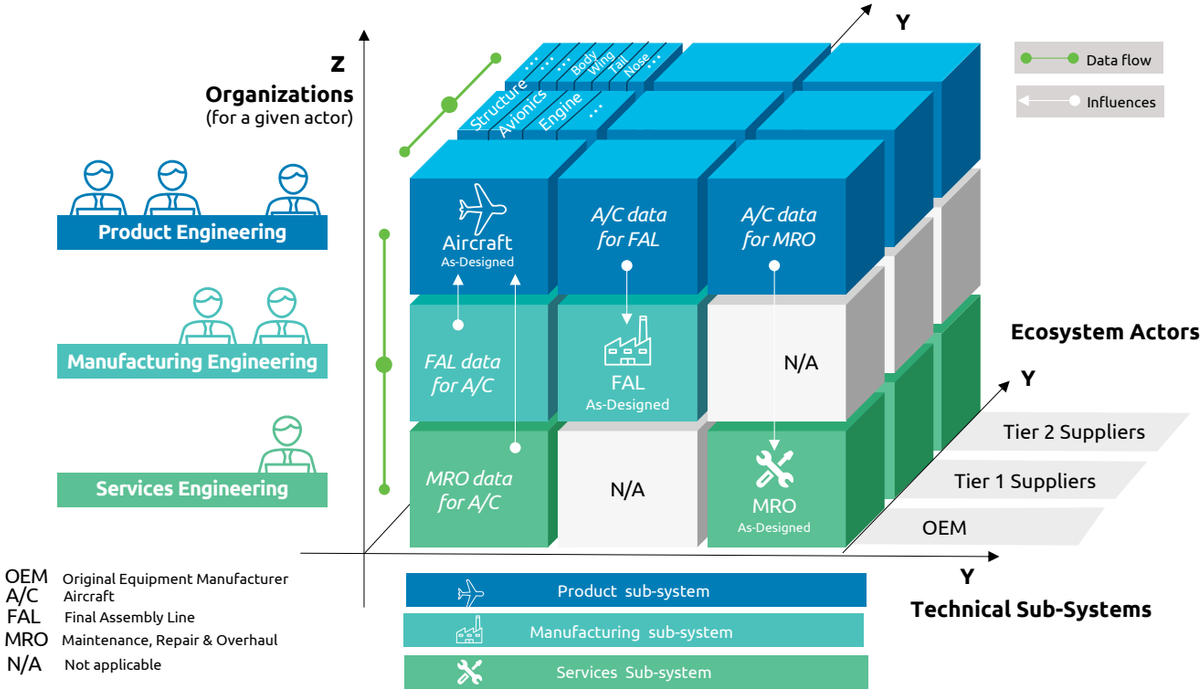
- More effective and pro-active decision-making, invent new concepts of collaboration among the different entities involved in the Extended Enterprise
- By simulation de-risk the complexity of eco system, ultimately contributing to the industry's resilience and success

EXAMPLE, THE PRODUCT AS A SYSTEM

For instance, we can consider an "aircraft product" as a sub-system.

It includes not only the physical components like wings, engines, and avionics but also the operational procedures, maintenance protocols, regulatory compliance, and the broader ecosystem of air traffic control, airports, and passenger experiences.

This comprehensive view allows stakeholders to holistically assess, manage, and optimize the aircraft's performance and its impact on its environment throughout its lifecycle, and, in essence, these concepts highlight the interconnectedness of elements and their interactions, emphasizing that the collective whole is greater than the sum of its parts.



CHAPTER

05

Different ambitions and means to supply chain transformations

GREENFIELD VERSUS BROWNFIELD

The Aerospace and Defense industry's supply chain is subject to constant transformation, driven by disruptions, technological advancements, and evolving needs.

There are two primary paths for this transformation: a greenfield approach, where systems are built from scratch to meet entirely new conditions, and a brownfield approach, where existing systems are modified and updated.

The choice between these paths hinges on the capability and performance of the current subsystem, such as the Industrial sub-System, to adapt to new or targeted conditions.

THE TRANSFORMATION CAN BE DETAILED INTO THREE STRATEGIC OBJECTIVES

#1 - Optimized Execution of the Supply Chain: *it focuses on leveraging the 'brownfield context' to enhance the existing supply chain. It's about immediate improvements, performance optimization, and tackling short-term rate fixes within the current operational setup.*

#2 - Predictive and Collaborative Supply Chain: *This mid-term perspective involves both 'brownfield and greenfield contexts'. It is about being prepared for the unexpected, increasing performance resilience, and facilitating adjustments in production rates while fostering collaboration*

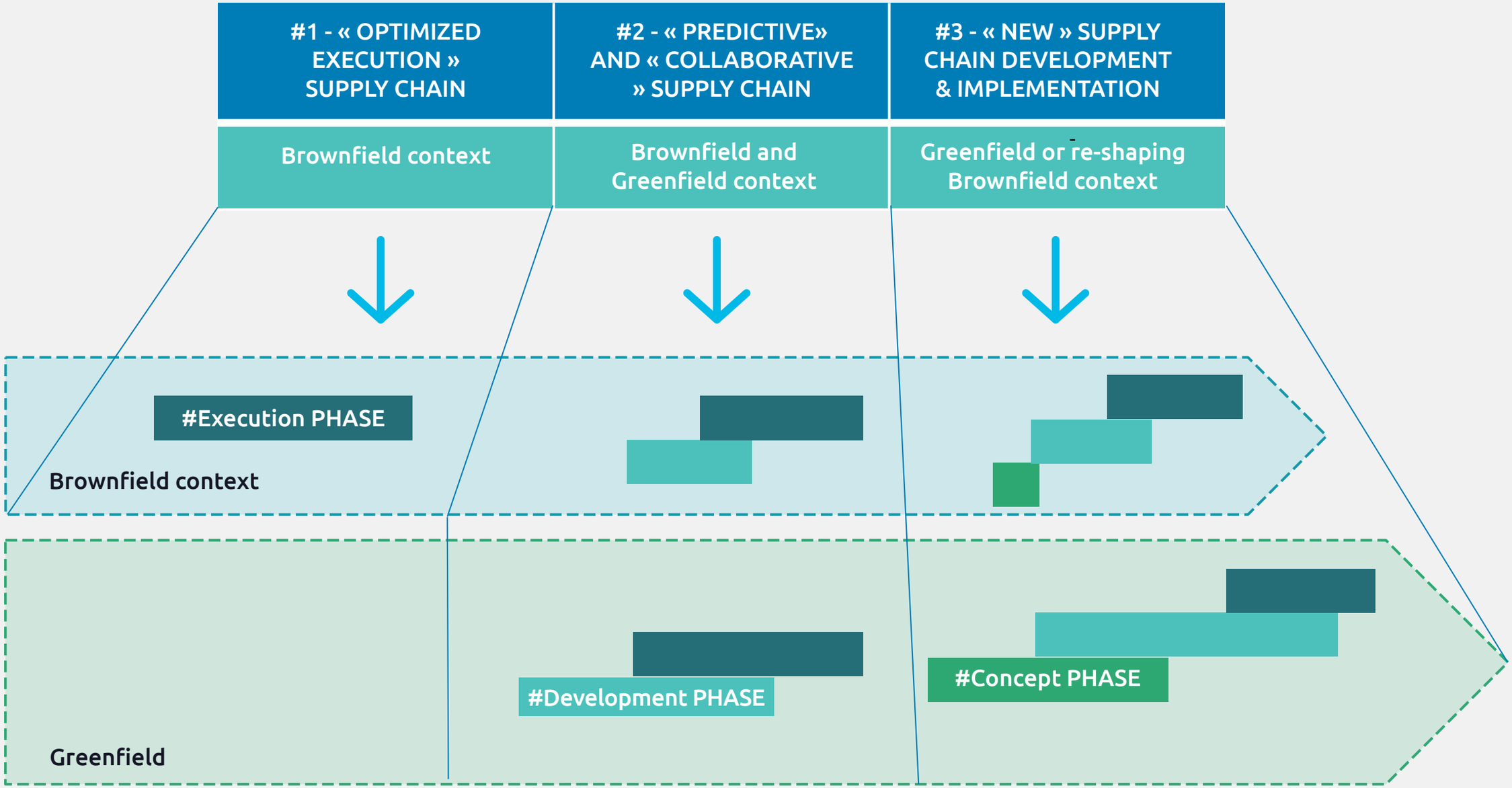
#3 - New Supply Chain Development & Implementation: *Looking at the long-term horizon, this approach may require a 'greenfield' transformation - designing a new supply chain system from the ground up.*

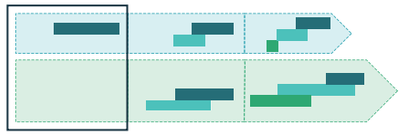
This radical approach is for situations where the subsystems are incapable of coping with the new ambitions, necessitating a full-scale redevelopment.

This chart offers a roadmap for evolving the supply chain in the Aerospace and Defense industry, with a phased approach ranging from immediate, incremental improvements to potential complete system overhauls. This transformation journey emphasizes the need for agility, foresight, and the strategic use of both brownfield and greenfield methodologies to ensure the supply chain's robustness and readiness for future demands.

A&D IS COMPOSED OF SEVERAL SYSTEMS PRODUCT-MANUFACTURING-SERVICES

#1 - « OPTIMIZED EXECUTION » SUPPLY CHAIN			Tactical ↕
• Brownfield context • Performance optimization • Short term approach and fix rate of the industrial system	→	Operational performances (OTD,..) as main issues	
#2 - « PREDICTIVE» and « COLLABORATIVE » SUPPLY CHAIN			
• Brownfield and Greenfield context • Performance increase and optimization • Resilience to unplanned events • Production rate adaptations • Transversal co llaboration instead of Top-down hierarchic, with same product and actors	→	Operational performances with stiff ramp-up and Resilience to unplanned events as main drivers	
#3 - « NEW » SUPPLY CHAIN DEVELOPMENT & IMPLEMENTATION			Strategic ↕
• Greenfield or re-shaping Brownfield context • New company • New products or major changes • Re-design of the existing supply chain	→	Co-Develop new supply chain model as main objective to achieve new programs ambitions	


#1 - « OPTIMIZED EXECUTION » SUPPLY CHAIN
#2 - « PREDICTIVE» AND « COLLABORATIVE » SUPPLY CHAIN
#3 - « NEW » SUPPLY CHAIN DEVELOPMENT & IMPLEMENTATION
Brownfield context
Brownfield and Greenfield context
Greenfield or re-shaping Brownfield context
#Execution PHASE
Brownfield context
#Development PHASE
#Concept PHASE
Greenfield



#1 - OPTIMIZED EXECUTION SUPPLY CHAIN

To optimize the performance of supply chains in Aerospace and Defense, organizations must prioritize day-to-day execution activities. The transformation approach should be short term and incremental.

#Execution PHASE

EXECUTION of the INDUSTRIAL Supply Chain

EXECUTION of the Service Supply Chain

Execution of the INDUSTRIAL Supply Chain or SERVICE Supply Chain

FORECAST the plan.

In the context of supply chain optimization, one of the key challenges is to ensure the quality and stability of forecasting. This is particularly important in a brownfield environment where there may be existing infrastructure that needs to be optimized. If the forecast is inaccurate, it can have a cascading effect down the chain, leading to a significant impact on the overall efficiency of the system. This is often referred to as the bullwhip effect.

CASCADE the plan.

This includes proactive order management, ensuring meticulous follow-up on order books, with an emphasis on suppliers recovery strategies.

Implementing preventive measures, such as onsite assessments, supplier development programs.

RUN the Methods and Tools.

Furthermore, embracing advanced technologies like data analytics, artificial intelligence, and Internet of Things (IoT) in daily operations can significantly enhance supply chain visibility and performance.

MONITORING on EXECUTION/OPERATIONS

Continuous monitoring and evaluation of supplier performance metrics are vital for identifying potential risks and areas for improvement. Implementing a robust Key Performance Indicator (KPI) system facilitates objective assessments, guiding organizations in making informed decisions regarding supplier relationships and strategic sourcing.

MONITORING on FLOW/LOGISTIC

#2 - PREDICTIVE AND COLLABORATIVE SUPPLY CHAIN

In the Aerospace and Defense industry, where over 80% of the final product's value is delivered by its supply chain, factors like supplier cost, quality, innovation, and delivery performance are critical for success.

The post-pandemic landscape, marked by production rate fluctuations, has underscored the urgent need for a significant transformation. Although studies are currently being conducted to improve daily operations in the supply chain, there is a growing realization that a collaborative approach with suppliers can be the first major step towards a complete transformation. This approach can prove to be a game changer in the industry.

Achieving a truly integrated end-to-end supply chain, however, remains a significant challenge. The Original Equipment Manufacturers (OEMs) and suppliers, aiming to enhance data sharing and cooperation across their supply networks, have faced historical obstacles.

To address these challenges, we propose a hybrid brownfield/ greenfield system redefinition approach aiming to transform interactions within the aerospace and defense industry.

This approach envisions creating a fully integrated end-to-end supply chain ecosystem, ensuring the industry's readiness and resilience for future challenges and unforeseen risks.

Let´s start, by qualifying the main barriers that historically prevented industry players from effectively collaborating. We will then define the transformation pillars of the proposed greenfield approach.

Our proposed hybrid brownfield and greenfield approach, structured across three interlinked pillars, aims to implement a collaborative end-to-end ecosystem within the A&D industry.

To summarize, our proposed hybrid approach aims to revolutionize the supply chain of the A&D industry while retaining the current supply base and industrial processes.

This approach emphasizes the importance of technology, standards, and governance, with the integration of these three pillars creating a collaborative end-to-end ecosystem.

By prioritizing industry readiness, resilience, and long-term success, this approach prepares for new programs, described just after.

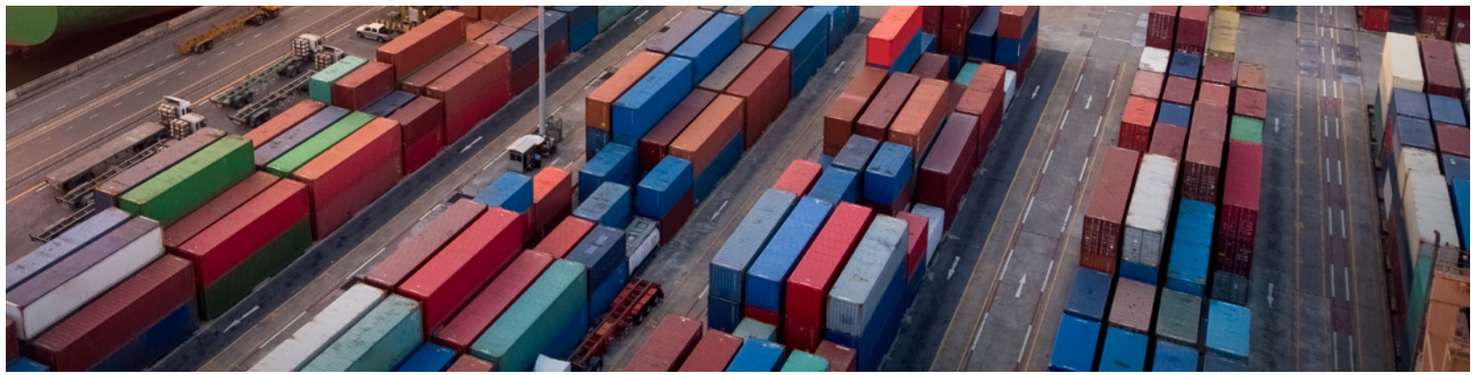
#Concept PHASE

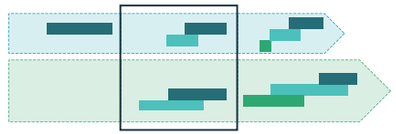
#Development & Implementation PHASE

#Execution PHASE

EXECUTION of the INDUSTRIAL Supply Chain

EXECUTION of the SERVICE Supply Chain



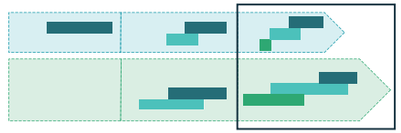


#2 - PREDICTIVE AND COLLABORATIVE SUPPLY CHAIN

#CONCEPT PHASE	
DEFINE and UNDERSTAND the supply chain concepts.	From a technological perspective, the data exchange technologies currently used between the supply chain members are relatively rudimentary (which is not only true in the Aerospace and Defense sector). Additionally, there are very few concrete standards to share complex data (such as planning, tracking or carbon footprint related). Only high-level frameworks exist. Lastly, building confidence and trust among involved parties is vital. Some data is deemed too sensitive for sharing. Furthermore, participants frequently have different assessments of the value and credibility of each other's data. This incongruity poses a challenge for organizations to agree on the conditions and incentives for data-sharing. It can also lead to hesitance in integrating external data into their own management and planning systems.
ASSESS the supply chain SYSTEM	ASSESS the supply chain SYSTEM versus the targeted top-level objectives such as performance and resiliency.
ASSESS the supply chain SYSTEM	ASSESS the "critical" companies of this new Extended Enterprise
VALIDATE the new collaborative model	VALIDATE the new collaborative model Companies demonstrating a higher level of collaboration with suppliers have traditionally experienced superior growth, reduced operational expenses, adaptability to unplanned events, and increased profitability. A close collaboration approach offers advantages such as more reliable production and delivery from suppliers, reduced inventory levels, enhanced transportation efficiency and improved quality management within value chain operations.

#DEVELOPMENT & IMPLEMENTATION PHASE	
DEFINE KPIs	DEFINE operational KPIs
DEFINE and DEVELOP Methods & Tools	DEFINE and DEVELOP Methods & Tools to operate the new collaborative concept. **Technology:** Numerous technology providers offer systems facilitating near-real-time data exchange among entities and supply-chain partners. Cloud-based platforms integrate with IoT and ERP systems, addressing data management, security, access rights, and control challenges. Digital twins, generated by manufacturing entities and software companies, model the production system and enhance performance through analytics and artificial intelligence. **Standards:** While technology addresses collaboration challenges within individual companies, additional facilitators are needed for profound integration across the supply chain. This involves agreements on platform use, consensus on data exchange standards, defining terms of data access and ownership, and establishing shared conventions for naming objects and products. The aerospace industry is in the initial stages of defining open standards for data exchange, a key subsystem in this collaborative approach.
INSTANTIATE KPIs	INSTANTIATE KPIs around the collaboration level and quality of the data exchanged
RUN overall assessment	Overall assessment versus the targeted objectives, including the orchestration role Governance Model: The third pillar focuses on defining and deploying the necessary infrastructure and standards. A collaboration orchestrator within the supply chain ecosystem is envisioned, working with actors to agree on standards and protocols, build digital platforms for data exchange, and oversee the run phase. To avoid dependency on a single player, the orchestrator should ideally be a third party funded or supported by multiple OEMs and major suppliers. Trust issues may persist, necessitating the potential appointment of a "trustee," an impartial third party to review sensitive data and establish equitable incentive arrangements.

ADAPT/UPDATE/CORRECT (if needed) the Extended Enterprise model



#3 - NEW SUPPLY CHAIN DESIGN AND IMPLEMENTATION

In the ongoing transformation of Aerospace and Defense Industries, several key challenges have emerged, necessitating a shift from a traditional continuous improvement plan to embrace a new operating model and, consequently, a new supply chain model.

The nature of these challenges includes

- breakthrough technologies for developing sustainable-built aircraft
- the demand for high production volumes (between 75 and 100 aircraft per month)
- quick adaptation to customer demands, maximizing value through new services,
- resilience to unplanned changes (geopolitical, technical, suppliers' disruptions),
- and the development of a sustainable product and industrial system by optimizing energy consumption, logistics, and transportation.

Given the complexity and interdependencies of these challenges, the industry recognizes the need for a holistic transformation, encompassing processes, methods, tools, organization, and skills.

This greenfield transformation requires a departure from conventional continuous improvement approaches and necessitates a comprehensive reassessment of existing Extended Enterprise concepts.

In this greenfield transformation, Industries will address the complete scope of their operating model including processes, methods, tools, organization, and skills.

The approach to be used will follow the same phases as for the development of the new product itself.

The transformation process mirrors the phases involved in developing a new product.

After the CONCEPTUAL phase, the focus shifts to DEVELOPING and IMPLEMENTING the identified solution.

This second phase is crucial, as original equipment manufacturers (OEMs) must ensure that the selected companies can effectively operate within the new processes and standards.

Once the concept is validated, key performance indicators (KPIs) are defined and instantiated, at the same time, methods and tools are developed and the system is established for efficient execution.

#3 - NEW SUPPLY CHAIN DESIGN AND IMPLEMENTATION

The following tables provide an overview of the different steps or modules involved in the Extended Enterprise model transformation. The goal is to develop, implement, and optimize a new supply chain model that aligns with the dynamic challenges faced by the Aerospace and Defense sector, promoting adaptability, resilience, and sustainability.

The steps involved in this transformation process are as follows:

- Reassess existing concepts
- Develop a new supply chain model
- Implement the new model
- Optimize the new model

The goal is to develop, implement, and optimize a new supply chain model that aligns with the dynamic challenges faced by the Aerospace and Defense sector, promoting adaptability, resilience, and sustainability.

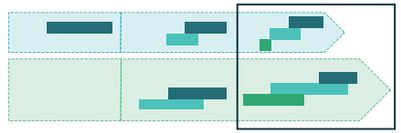
It is important to notice at this stage that the overall approach to be put in place over the time needs to be consistent with the existing launched transformation (like #2 Predictive and Collaborative Supply chain).

However, the journey doesn't end with implementation. Continuous monitoring and improvement are essential throughout the program's lifecycle.

The Execution phase for Industrial, similar to the #1 - optimized execution phase but on a larger scale, involves forecasting the plan, cascading the plan, and monitoring the execution across various aspects like operations, logistics, and data flow.

The different steps or modules of this Extended Enterprise model transformation can be summarized in the chart after, representing the systematic progression from reassessing existing concepts to developing, implementing, and optimizing the new supply chain model. This comprehensive approach aims to align the industry with the dynamic challenges it faces, fostering adaptability, resilience, and sustainability in the Aerospace and Defense sector.

#3 - NEW SUPPLY CHAIN DESIGN AND IMPLEMENTATION



The Execution phase is hence like #2 Predictive and Collaborative Supply chain but on a larger scope than Optimized execution.

#CONCEPT PHASE	
DEFINE and UNDERSTAND the supply chain concepts.	The initial step involves re-evaluating existing supply chain concepts, specifically those related to optimized execution and predictive and collaborative supply chain models (as discussed earlier in chapter 5.2 and 5.3). This process enables the calibration and validation of simulation models essential for designing a new supply chain concept capable of meeting the challenges posed by the overall context.
ASSESS the supply chain SYSTEM	ASSESS the supply chain SYSTEM versus the targeted top-level objectives such as performance and resiliency.
ASSESS the "critical" companies	ASSES the companies of this new Extended Enterprise, the industry is already working with and those that are new comers.
VALIDATE the model	VALIDATE the model • via simulation (digital twins) • calibration on some domains based on existing programs data

#DEVELOPMENT & IMPLEMENTATION PHASE	
DEFINE KPIs	DEFINE operational KPIs
DEFINE and DEVELOP Methods & Tools	To operate the new concept
INSTANTIATE KPIs	Some of them could be instantiated on running/ existing programs or on R&D projects
RUN overall assessment	RUN overall assessment versus the targeted objectives For example: Run At Rate simulation as done in the Automotive industry ….

#EXECUTION PHASE
FORECAST the plan.
CASCADE the plan.
RUN the Methods and Tools.
MONITORING on EXECUTION/OPERATIONS
MONITORING on FLOW/LOGISTIC

ADAPT/UPDATE/CORRECT (if needed) the Extended Enterprise model

CHAPTER

06

The way forward

We must underscore the importance of the CxO agenda in steering the transformative journey of the Aerospace & Defense (A&D) industry's supply chain. The role of C-level executives is paramount in adopting a holistic system approach that encompasses all facets of the supply chain, from the product to the various systems and services that interact directly with organizational structures across the board

KEY AREAS OF FOCUS FOR CXOS INCLUDE:

- **Adopt System approach:** CxOs must consider the supply chain as an integral system that spans the product, industrial, and service systems.
  This broad perspective will directly influence the organization of products, manufacturing, and services, as well as the underlying layers of the supply chain.
- **Be flexible to create a new supply chain** design or reshape it to realize new program ambitions or major system or platform upgrade programs
- **Integrate supply chain by expecting Tier 1 and Tier 2 suppliers to boost their commitment** as a long-term business partner having appetite and ability to increase their accountability.
- **Encourage 'shared responsibility and accountability' from Tier 1 suppliers** for the component turnarounds and pivot to new business models such as performance-based logistics and servitization models that help to meet customer expectations of high levels of fleet serviceability.
- **Incorporate 'Sustainability' in the E2E supply chain framework** including the spectrum from raw material sourcing, material procurements from tiers, aviation fuel, logistics, packaging to decommissioning.

The transformation journey calls for multi-lateral discussions and a collective understanding of benefits among all stakeholders, backed by strong leadership commitment. A narrow, focused scope is necessary at the outset to spark the process of transformation. Starting with one of the key challenges identified – be it Forecasting & Planning, Data Exchange, Supplier Performance, Risk Management, Supplier Dependency, or Sustainability – and approaching it as a system, sets the stage for a comprehensive transformation.

The leaders who act first on these principles will secure a competitive edge, navigating the turbulent supply chain landscape with agility and foresight. The question that remains for every organization is: are you prepared to embark on this transformation journey and emerge as a frontrunner in the A&D industry?

For a successful transformation, we advocate:

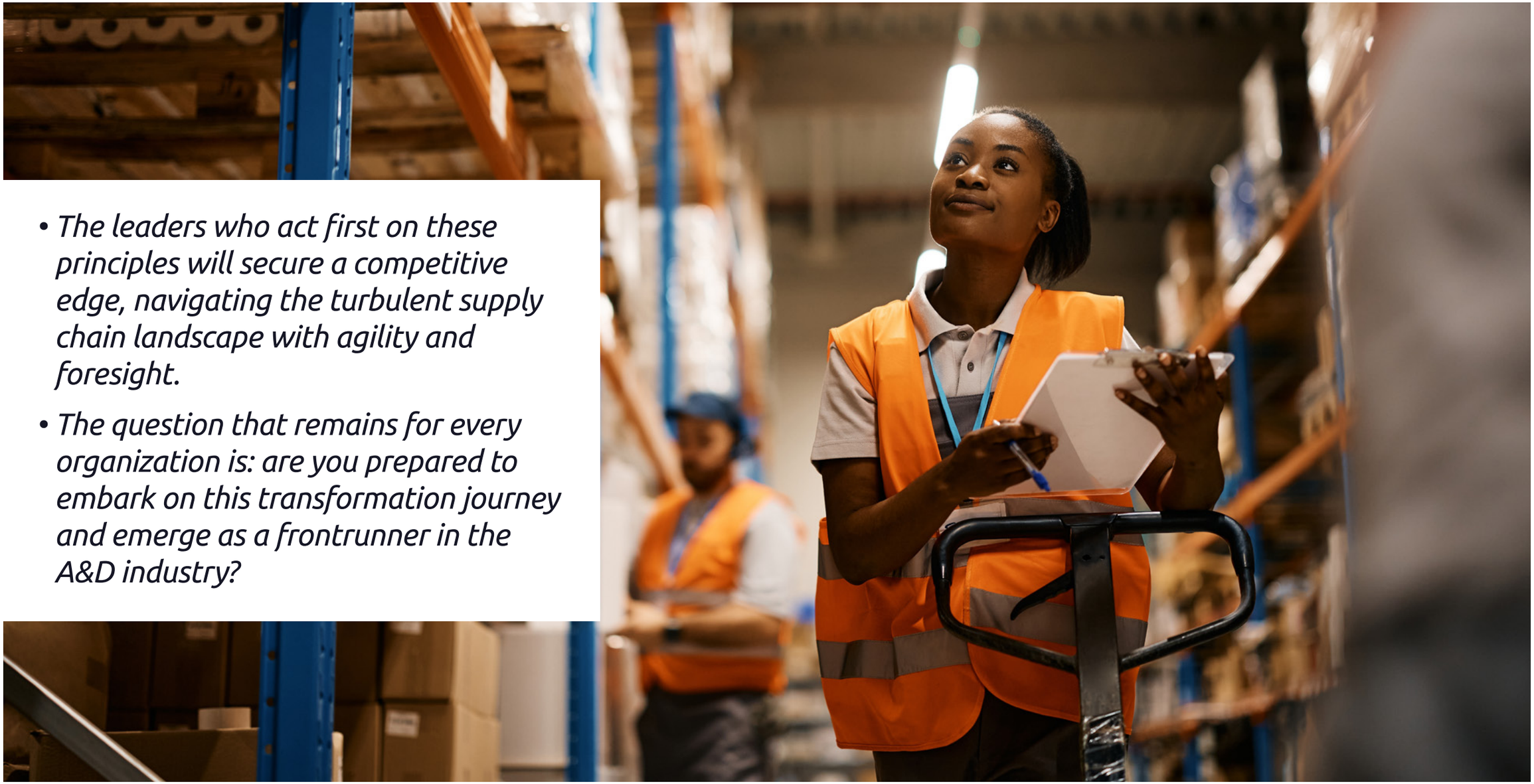
Executive advocacy: Securing buy-in from top-level management is the initial and perhaps the most critical step. Leaders within organizations need to champion the transformation.

Insight and collaboration: Gaining a deep understanding of the challenges and future vision of the supply chain is essential. Building relationships with progressive suppliers who are open to collaboration will be fundamental in reshaping the supply chain.

Value-centric approach: Identifying key drivers and preliminary use cases that demonstrate tangible benefits will be pivotal for ecosystem-wide acceptance of the transformation.

Digital twinning: Developing a digital twin for the ecosystem will enable the simulation of scenarios to anticipate and prevent potential supply chain disruptions.

Governance and operating model: Defining the sub-system, with a focus on the operating model and governance structure, is necessary for the transformation. This includes protocols for data sharing and identifying roles crucial to platform management.



- *The leaders who act first on these principles will secure a competitive edge, navigating the turbulent supply chain landscape with agility and foresight.*
- *The question that remains for every organization is: are you prepared to embark on this transformation journey and emerge as a frontrunner in the A&D industry?*

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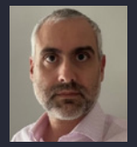

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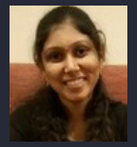

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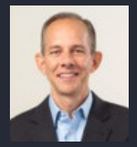

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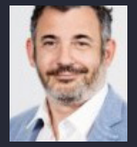

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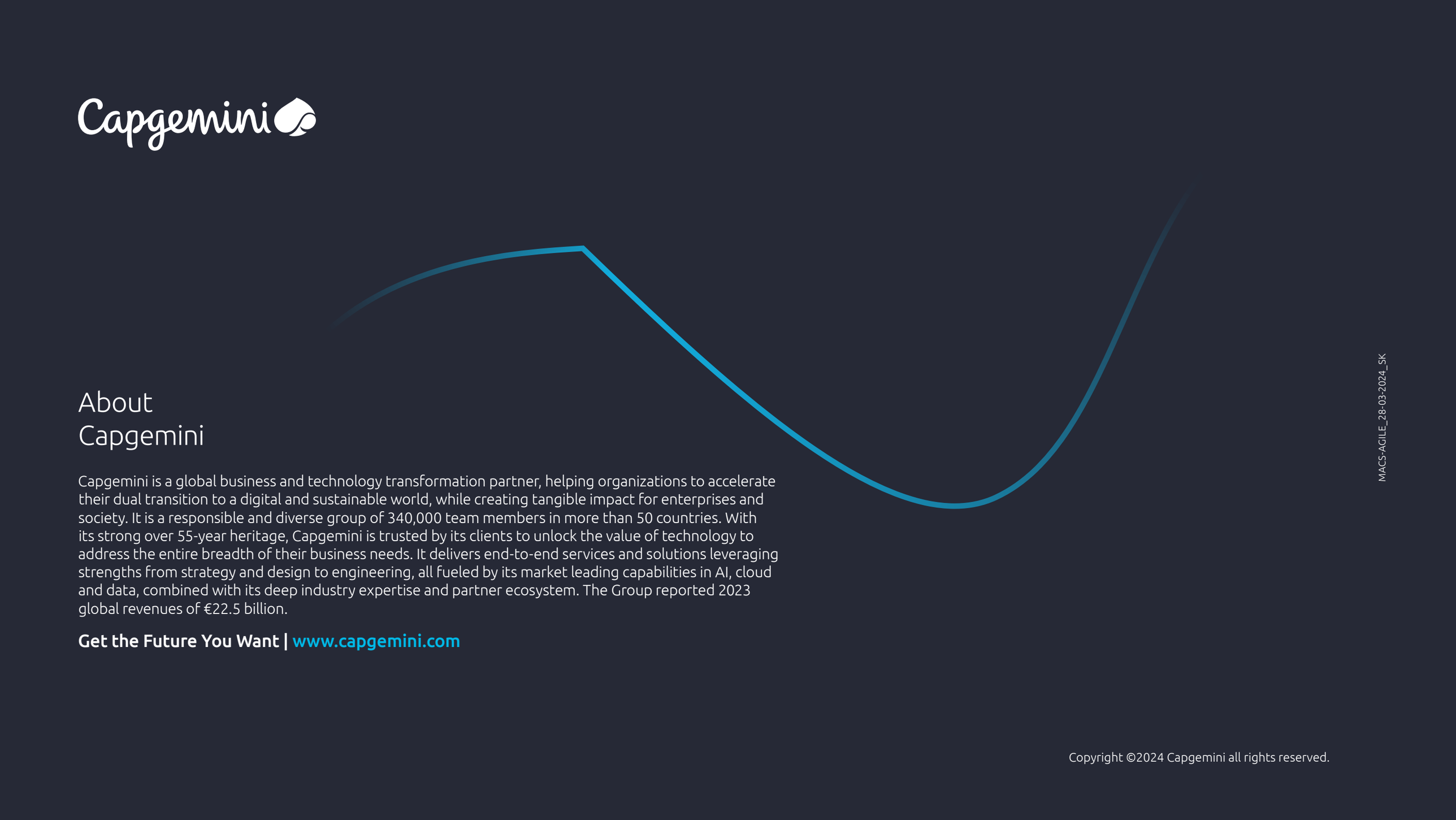
TERMINOLOGY AND SCOPE OF THE EXTENDED ENTERPRISE USED IN THE POV

S.N	Terminologies	Definitions
1	Supplier	The entity or party that supplies designs, production materials, production/service parts, assemblies, special processes (e.g., heat treatment, welding), services, software or software service to a customer in accordance with contract requirements. The aerospace standards have defined the supplier as the furnisher of articles or related services, at any tier, to an approved manufacturer. [ref. AS9114]
2	Extended Enterprise	Extended enterprise within the A&D industry is a system composed of several sub-systems. We have identified 6 sub-systems to fully categorize the A&D Extended Enterprise. • The Product itself, its Industrial System, and its Services activities • The Product organization, the Manufacturing organization, and the Service organization.
3	System	A system is composed of interconnected processes, parts, components, or elements that collaborate to produce outcomes that individual elements cannot achieve on their own. The interdependence enables the elements to interact and influence each other's behavior.
4	Sub-system	The processes, parts, components, or elements part of a system are the sub-systems
5	Original Equipment Manufacturers	They are from the market segments of civil aeronautics, defence and space (space agencies and space industry players) who are involved in the making of passenger aircraft, business jets, military aircraft, helicopters, aircraft components, missiles, satellites and space vehicles.
6	Tier 1 suppliers	Tier 1 suppliers supply the OEM by obtaining parts or subassemblies from the Tier 2 supply chain and play a major role in the supply chain following 'pull' mechanisms bringing in operational efficiency to the supply chain. They are technically sophisticated and involved in the Design, Industrialization, Manufacturing and support of major components or systems such as Engines, control systems, landing gear, braking systems, flight deck, avionics, aerostructures, hydraulics, electronic warfare systems, weapon systems and interior cabin products.
7	Tier 2 suppliers	Tier 2 suppliers are supplying to Tier 1 and primarily manufacturers of critical parts and subsystems such as aerofoils, tyres, electrical, mechanical and avionics sub-assemblies, missile nose cones, airframe structures, actuators, transmissions and flight controls. Being in the middle of supply network, they carry high responsibility with influence over the flow of material and production.
8	Tier n suppliers (Tiers >2)	Tier n suppliers are more execution-focussed, primarily component manufacturers who help Tier 2 suppliers to make sub-systems. They manufacture components such as Hydraulic fittings, pressure and temperature valves, hydraulic hoses, instrumentation fittings, tubing, high strength fasteners, pins etc, some of them create software for various systems.
9	Direct Procurement/ Flying/ Projects procurement	Direct procurement involves the direct purchase of raw goods, machinery, and wholesale goods that are directly involved in the creation of company's end products like aircrafts, helicopters, spacecrafts, engines, aircraft systems, radars etc generating revenues for the business. Examples: systems or parts such as electrical connectors, cables for wire harnesses, O-rings, valves, line replaceable units as well as production machinery, process tanks, jigs, fixtures etc as well as major capex for infrastructure establishment, refurbishment of facilities for research, production, testing, assembly and overhaul such as hangars, tarmac, ground test centres
10	Indirect Procurement/ Non-Flying/ Non-Projects procurement	Indirect procurement involves the purchasing of goods that don't directly affect the company's end product or bottom line, that are indirectly involved in the final product manufacturing and required for day-to-day operations of the business. Examples: consumables used in production process and MRO process, spares and consumables required for day-to-day operations and maintenance of the industrial plant, machinery and equipment, freight, logistics, travel expenses, office furniture, stationeries and supplies, payment on utilities, training of talent, marketing and advertising expenses, IT hardware and its maintenance etc
11	Engineer to Order (ETO)	Aerospace and defense organization follow ETO approach for manufacturing processes as each end customer has got unique requirements based on their business lines (commercial aviation, Defense, MRO and Space etc). The ETO planning process starts with engineering activities based on the customer orders and transferred manufacturing shopfloor execution. This approach combines engineering and manufacturing activities to meet the customer order requirements and deliver the final product to the customer
12	A&D Extended Enterprise scope	Predominantly covers the spectrum that caters to the design, manufacturing, assembly, integration of finished systems or products (i.e passenger aircraft, business jets, military aircraft, helicopters, aircraft systems, aerostructures, missiles, satellites or space vehicles) and servicing including repair and refurbishing of the systems and airborne platforms during their operations



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Capgemini is a global business and technology transformation partner, helping organizations to accelerate their dual transition to a digital and sustainable world, while creating tangible impact for enterprises and society. It is a responsible and diverse group of 340,000 team members in more than 50 countries. With its strong over 55-year heritage, Capgemini is trusted by its clients to unlock the value of technology to address the entire breadth of their business needs. It delivers end-to-end services and solutions leveraging strengths from strategy and design to engineering, all fueled by its market leading capabilities in AI, cloud and data, combined with its deep industry expertise and partner ecosystem. The Group reported 2023 global revenues of €22.5 billion.

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