Supply Chain Ecosystem

for

Urban Air Mobility

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Scalability is Fundamental Need for UAM

- Many pilots (or acceptable and reliable autonomy)
- Spectrum availability
- Airspace operations (e.g., Unmanned Aircraft System Traffic Management type construct)
- Acceptable noise
- **Mass production of electric or hybrid VTOLs**
- **Infrastructure (including recharging systems)**

Mass Production of VTOL Vehicles

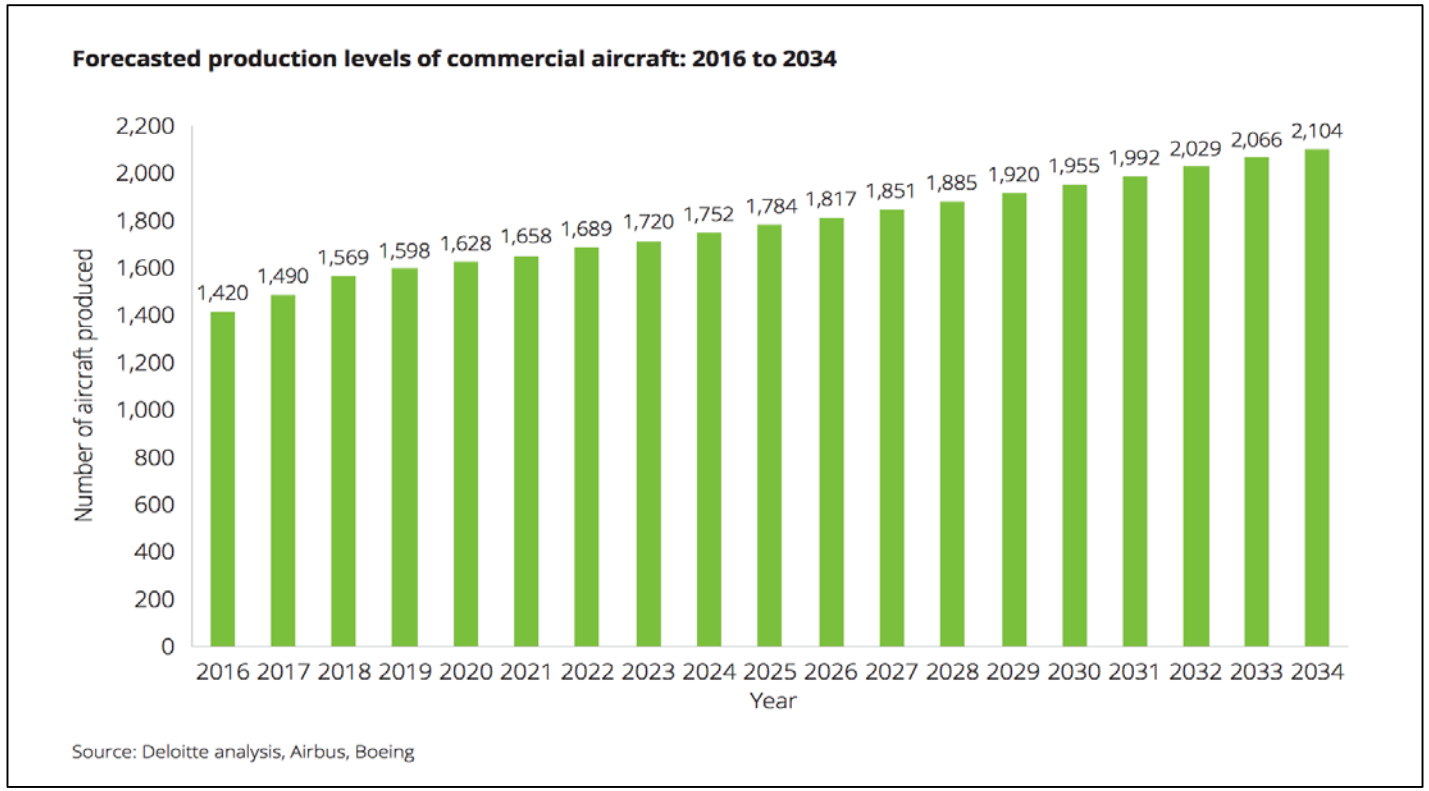
- Production rates need to be closer to cars than conventional aircraft
  - Manufacturing and assembly methods
  - Supply chain network and ecosystem

Supply Chain: Basics

- Supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer need
- Aerospace supply chain is an ecosystem of different supplier tiers
- Includes manufacturers, suppliers, transporters, warehouses, etc.
- Supply chain management refers to coordination of all supply chain activities starting with raw materials and ending with a satisfied customer
    - Purpose: Maximize competitive advantage and benefit customer

Current State of the Art in Aero Supply Chain

- Boeing and Airbus have backorders (~5000+, with ~55/month rate)
  - Boeing delivered 806 aircraft and Airbus 800 in 2018
  - In 2016, Boeing had 5715 undelivered orders and Airbus had 6874



Current State of the Art

- Presidential executive order on assessing and strengthening the manufacturing and defense industrial base and supply chain resiliency of the United States (executive order 13806, September 2018)
  - Decline of U.S. manufacturing capabilities and capacities
  - Competitiveness
  - Diminishing STEM and trade skills

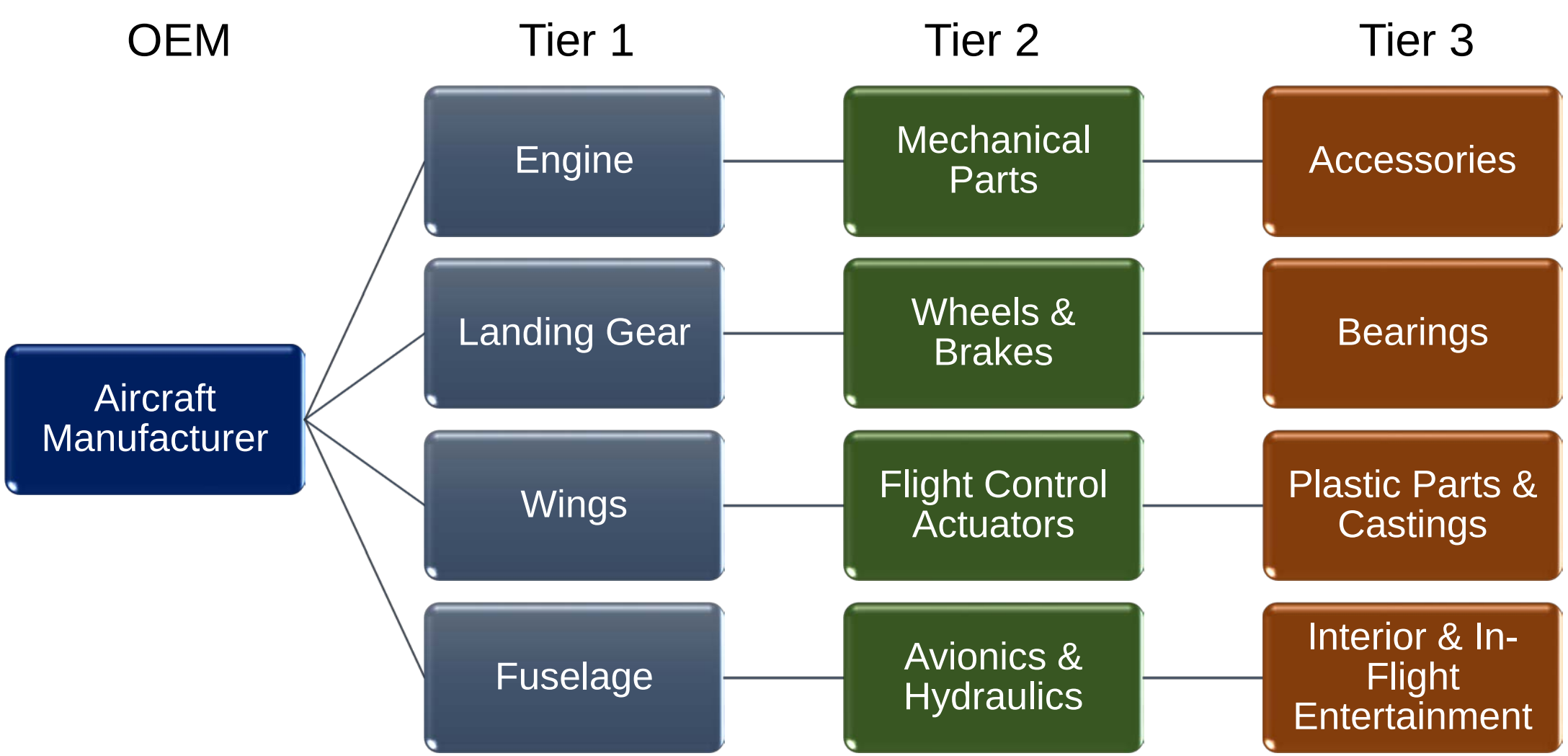
Current State of the Art

- Risk Archetypes
  - Limited/sole sources
  - Fragile supplier and market
  - Capacity constrained supply market
  - Foreign dependency
  - Diminishing manufacturing sources and material shortages
  - Gap in U.S. human capital
  - Product security

Supply Chain Strategies

Reference: Operations Management, Heizer et al (2016)

- Many suppliers
- Few suppliers
- Vertical Integration
- Joint Ventures
- Horizontal Integration
- Keiretsu Networks (part collaboration, part few suppliers, part vertical integration)
- Virtual Companies



- **OEM** – Control design, manufacturing and assembly function, the most critical component of value chain
- **Tier 1** – Support Primes by providing them with equipments and systems like engines, Wings, Fuselage
- **Tier 2** – Manufacture and develop parts as per the specifications provided by primes and Tier 1 suppliers
- **Tier 3** – Responsible for supplying basic products, components and other non-core value added services

Source: https://www.tresvista.com/wp-content/samples/landscaping/Research%20Report_Aerospace%20-%20Supply%20Chain%20Overview.pdf

Known Aero Supply Chain Related Issues

- Sourcing of raw materials – aluminum, steel, copper, etc.
- Mitigating supply disruption risks (e.g., geopolitical considerations)
- Coping with Modernization and Emerging Technologies (e.g., wiring problems, software issues)
- Shortage of skilled workers (Tim Cook’s view on outsourcing)

Supply Chain Considerations and Challenges

(Credit: EY – A&D Edge, Supply Chain Management in Aerospace and Defense, Feb 2018, slides 8-9)

	Design and Engineering	Planning	Procurement	Manufacturing	Aftermarket
Considerations	• Timeline • Cost • Quality • Margin • IP • Efficiency	• Forecast accuracy • Supply disruptions • Demand shifts • Inventory • Supply chain visibility • Lead times	• Supplier performance • Price volatility • Cost and prices • Lead times • Supplier due diligence	• Quality • Stock-outs • Waste • Capacity • Cost • Contract • Safety	• Ground time • On-time delivery • Network • Safety
Challenges	• Dependence on large number of sole-source suppliers • Long lead time • Financial challenges across the supply chain for new programs • Large inventory needs • Collaboration across complex supply chain • Cyber and security				

Recommendations: Supply Chain for Urban Air Mobility Vehicles *(Drones and VTOLs)*

- Time to start building an entire new eco-system
- Take advantage of other manufacturing (e.g., auto)
- Rebuild/train auto, heavy industries, traditional aerospace suppliers to consider VTOL
- Get regional manufacturing and supply chain associations exposed to emerging aero needs

Recommendations: Supply Chain for Urban Air Mobility Vehicles *(Drones and VTOLs)*

- Build an electronic exchange platform to connect VTOL customers with suppliers
  - Prototypes
  - Job production
  - Mass production
  - Quality management based on FAA production need
- Training workforce: curriculum, skills, and entrepreneurs

Recommendations: Supply Chain for Urban Air Mobility Vehicles *(Drones and VTOLs)*

- Build a robust maintenance and reconditioning network and reliable authenticated parts supplier base
- Need global network to address MRO considerations related to operations – cycle time is critical

Summary

- Real need to build supply chain–drones are already here
- Global supplier base for OEMs and MROs is needed
- Rate of production and delivery needs to be significantly different than today's aerospace manufacturing and assembly
- Parts access will need to be rapid for MROs
- Time to rebuild skills, talents, digital enterprise and attract new manufacturers to scale deliveries

BACKUP

Strategy	Dependence on sole source suppliers	Long lead time	Financial challenges	Large inventory	Collaboration across supply chain	Cyber threats
Adoption of digital technologies	Moderate	High	Low	High	High	High
Risks-sharing partnerships	Low	High	High	High		
Integration	High	High	Moderate	High	High	Moderate
Monitor security	Low				Moderate	High
Cross-sourcing	Low	High		High	Moderate	
Multiple sourcing	High	Moderate			High	
Readiness assessment		High		High	Moderate	
Local players in supply network		High		Moderate	Moderate	Low

Credit: EY – A&D Edge, Supply Chain Management in Aerospace and Defense, Feb 2018)