



Key Trends In Commercial Aerospace Supply Chains

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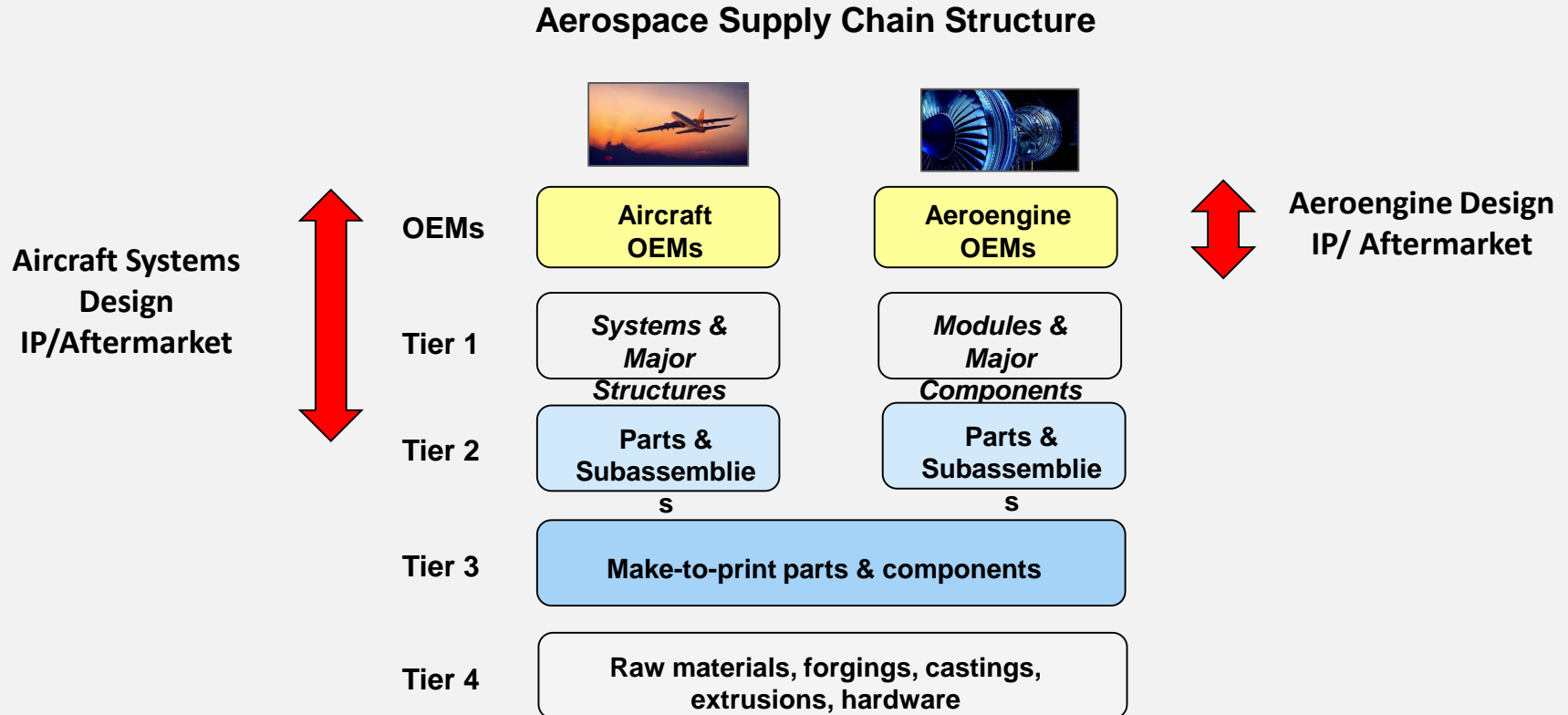


Agenda

Supply Chain - A Brief History

Supply Chain Outlook

The two major aircraft supply chains consist of several tiers



Jetliner supply chains have evolved considerably since the 1970s

Commercial Aerospace Supply Chain Trends

Aircraft



Aeroengines

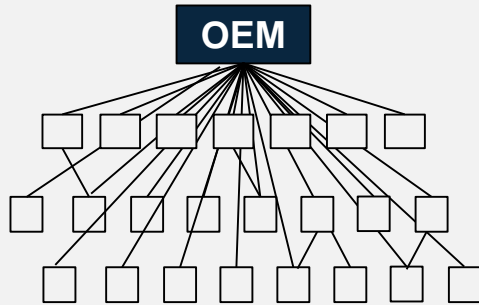


1980s	1990s	2000s	2010s
Self-sufficiency Traditional model	Regional jet OEMs adopt Tier 1 model		
	<i>Global Express</i> <i>First Tier 1 model</i>	<i>EJet</i> <i>Tier 1</i>	Boeing & Airbus Tier 1 1 <i>Power8 787 PFS</i>
Traditional supply chain, risk sharing		Supplier reduction, Tier 1 adoption	
		<i>GTF</i> <i>LEAP</i>	Selective GE vertical integration
		Low cost sourcing	

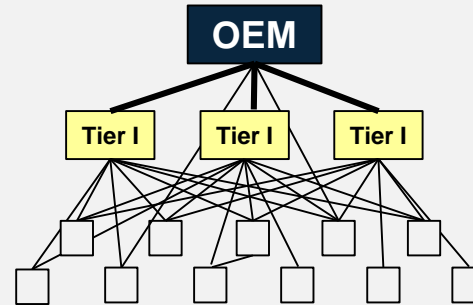
Bombardier pioneered the Tier 1 supply chain model in the 1990s

Aircraft Supply Chain Models

Legacy Model



Tier One Model



Bombardier Global Express – Tier 1 pioneer in early 1990s

- Brought in 10-12 risk sharing partners with large work packages
- Reduced NRE \$1B → \$600 million
- Embraer embraced Tier 1 later in the decade (EJet)

Embraer, Airbus and Rolls-Royce followed with Tier 1 approaches

Number of Major Suppliers

OEM	Model	EIS	Major Suppliers
Airbus	A380	2007	200
	A350XWB	2015	90
Embraer	EMB 145	1997	350
	EMB 170/190	2004	38
Rolls-Royce	Trent 700	1994	~500
	Trent XWB	2015	50 - 75

EJet



- < 40 major suppliers
- 90% reduction compared to ERJ

A350XWB



- 200 major suppliers on A380
- Reduced to ~90 on A350XWB

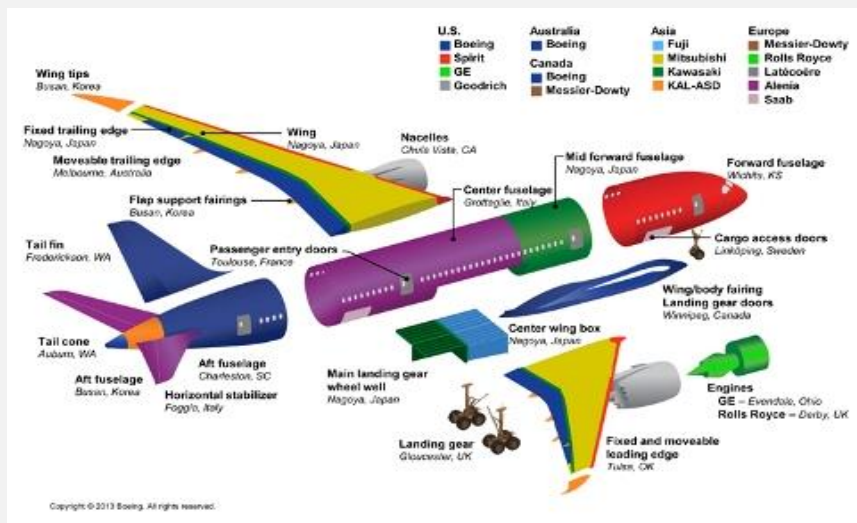
Trent XWB



- Reduced suppliers 80-90%
- Auto supply chain practices

Then Boeing's disastrous 787 supply chain rollout struck

787 Major Aerostructures Suppliers



- Pursued aggressive Tier 1 model while also introducing significant new technology
- Intent was to reduce NRE \$10B → \$6B and development time from six to four years
- Program delayed several years; actual NRE >\$20B
- Deferred production losses reached \$30B
- All of this while many of its suppliers were substantially more profitable

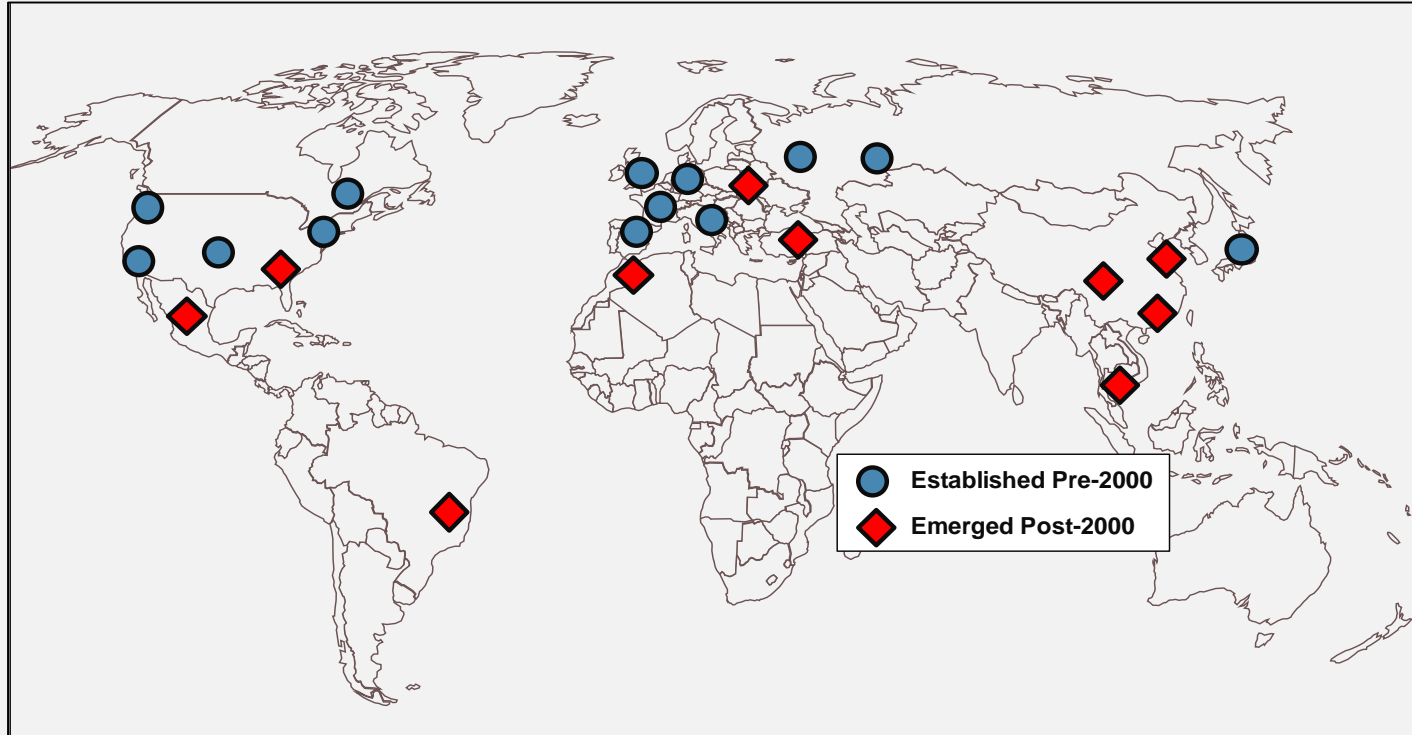


Jim Albaugh – Former Boeing CEO

“On the 787, we outsourced too much. We had five different sections of the fuselage all with their own processes and outsourced the wing...we were driven too much by RONA – we didn’t balance it with risk”

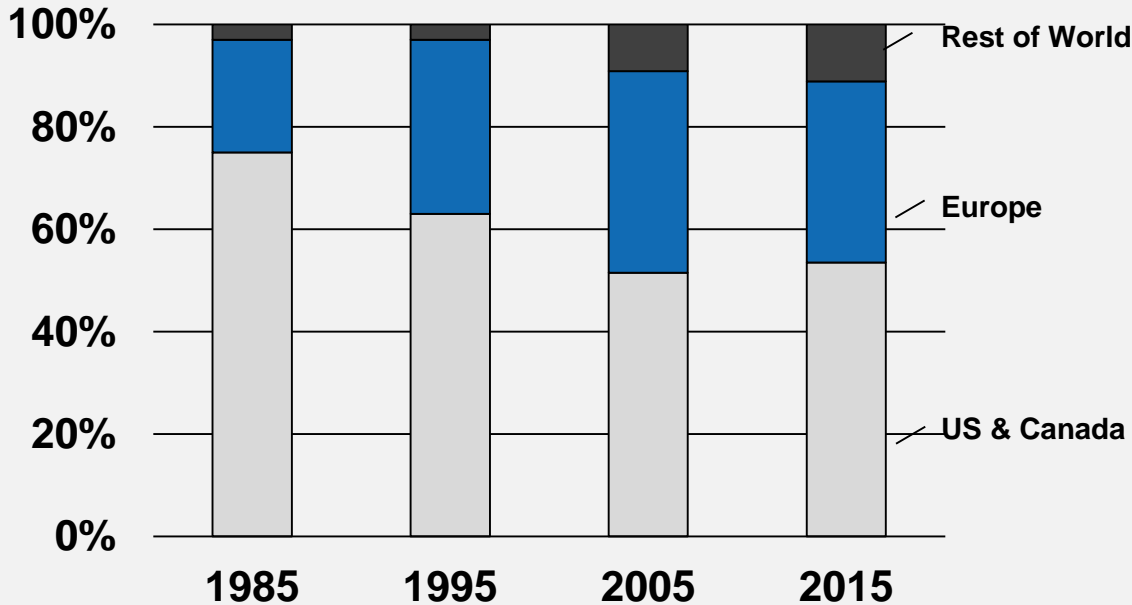
Many new manufacturing clusters emerged in recent years due to globalization and the pursuit of low cost sourcing

Jetliner Manufacturing Activity By Region



...and as a result aerospace manufacturing dispersed

Jetliner Manufacturing Activity By Region



- Jetliner manufacturing was heavily concentrated in North America in the 1980s
- The rise of Airbus, Rolls-Royce and Safran underpinned a shift in activity to Europe
- Rest of World has grown its share since last decade



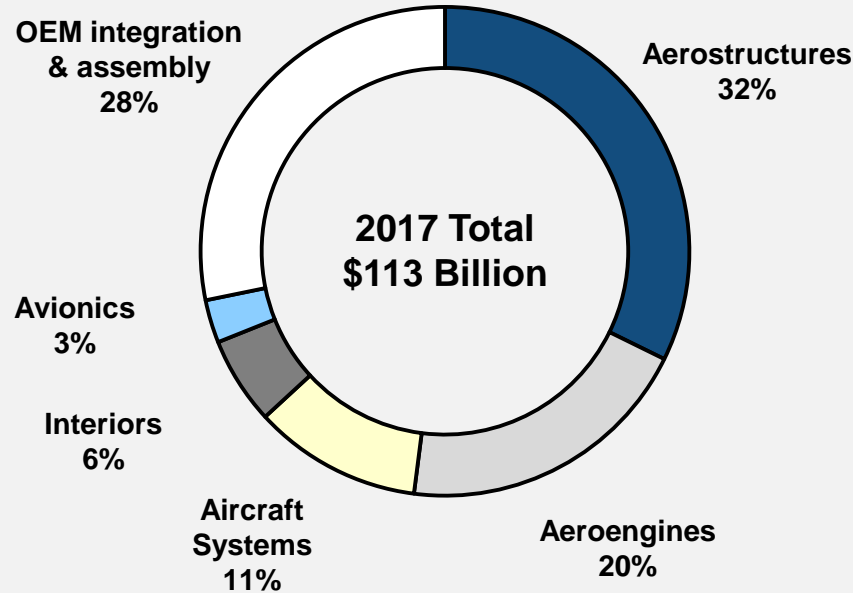
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Supply Chain - A Brief History

Supply Chain Outlook

Aircraft OEM typically source 65% or more of jetliner content

The 2017 Air Transport Sector



Regional Jet OEM appear committed to the Tier 1 model

Regional Jet OEMs – Supply Chain Strategies

BOMBARDIER
the evolution of mobility



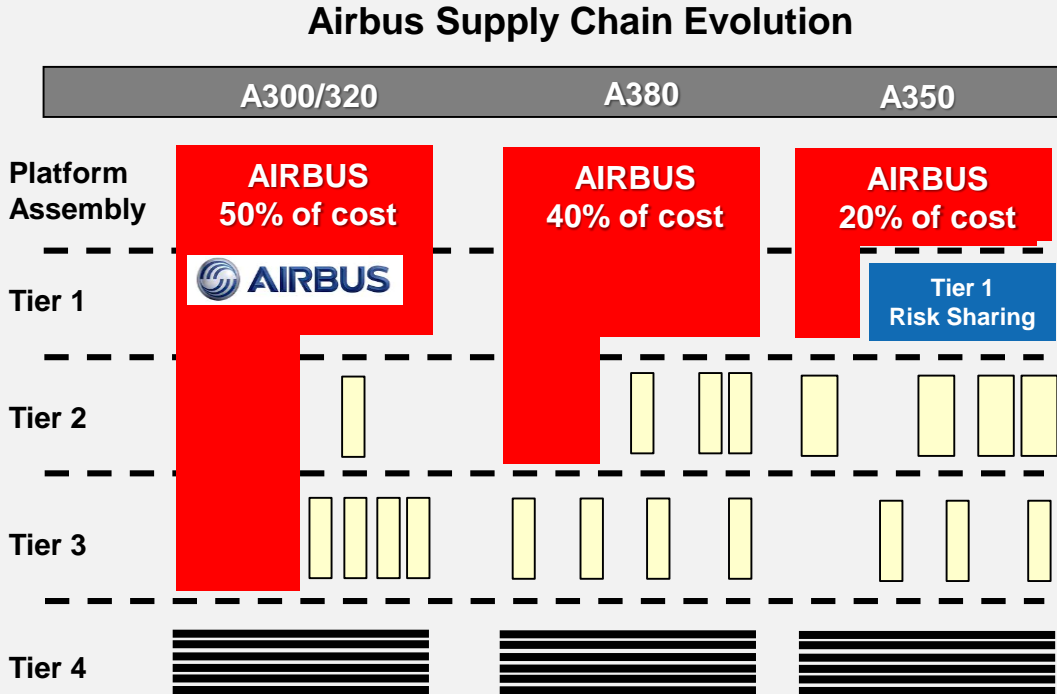
- Remains committed to Tier 1 model – worked well on CSeries and past development programs
- Targeted aerostructures insourcing on CSeries – composite wings in house
- Remains capital constrained – must determine optimal outsourcing mix for future programs

← EMBRAER



- Like Bombardier, remains committed to Tier 1 model
- Brought in some aerostructures content on E2 – insourcing wings
- Unlikely to insource aircraft systems but does retain landing gear capability through ELEB

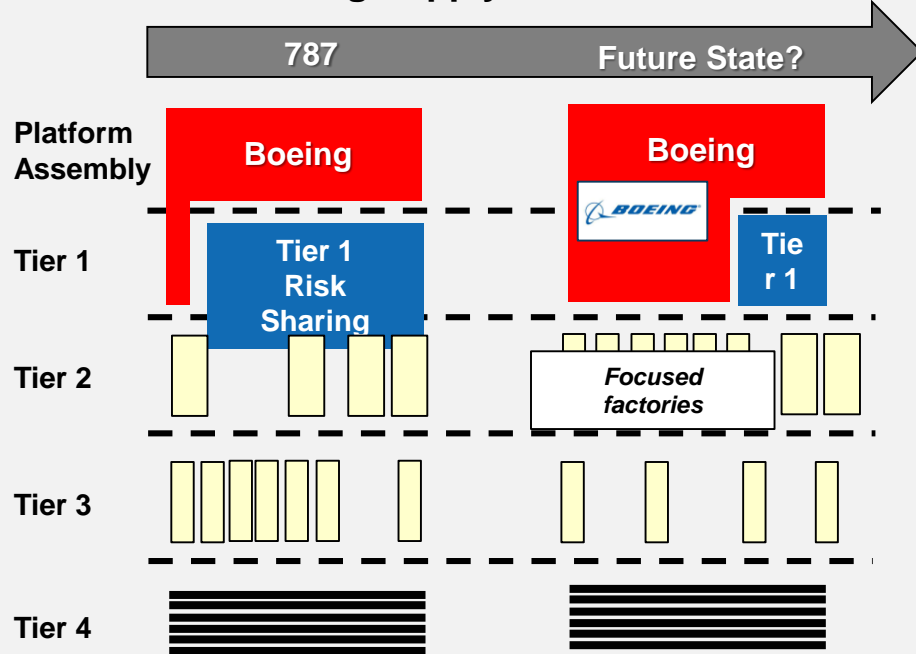
Airbus is also committed to Tier 1 but is pursuing aggressive price reductions



- Appears committed to Tier 1 model
- Increasing procurement from North American suppliers with Mobile production facility
- Launched A320 Scope+ cost optimization program in 2014 – pursuing price reductions >10%
- Also exploring dual-sourcing of certain components
- Publicly contemplated insourcing seats

Boeing appears to be shifting away from the Tier 1 model...

Boeing Supply Chain Evolution



- Boeing's 787 experience and desire to earn greater profits is driving a shift in supply chain strategy
- Boeing appears to be going “back to the future” and pursuing a pre-787 supply chain model
- It is interested in “focused factories” that produce low cost “make to print” products
- It is in the second phase of Partnering for Success initiative
 - Additional price concessions
 - Extended payment terms
 - More aggregation of supplier purchasing
 - Aftermarket revenue & royalties



...and there are several recent examples of Boeing vertical integration and focused factories



Boeing's propulsion center of excellence



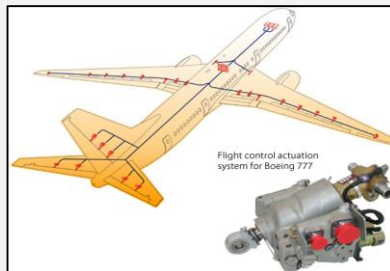
Landing gear deals with Heroux Devtek



New supplier for 737 economy seats – now SFE



777X wing fabrication Facility in Everett



Taking on 777X flight control system integration



Taking control of legacy aircraft parts distribution

Norsk Titanium broke ground on two major additive manufacturing facilities...

Plattsburg, New York – Industrial



Oslo - European Assembly & Test Center



- Norsk focuses on aerospace-grade, additive manufactured, structural titanium components
- Its New York investment will be the world's first Rapid Plasma Deposition™ factory; it will open in 2017
- It also broke ground on a new European assembly & test center
- The upshot: additive manufacturing is being capitalized

...and GE doubled down on additive manufacturing in purchasing two leading European suppliers

Arcam AB



- Based in Mölndal, Sweden
- Invented electron beam melting machining for metal-based additive manufacturing
- \$68 million in revenue with 285 employees

Concept Laser

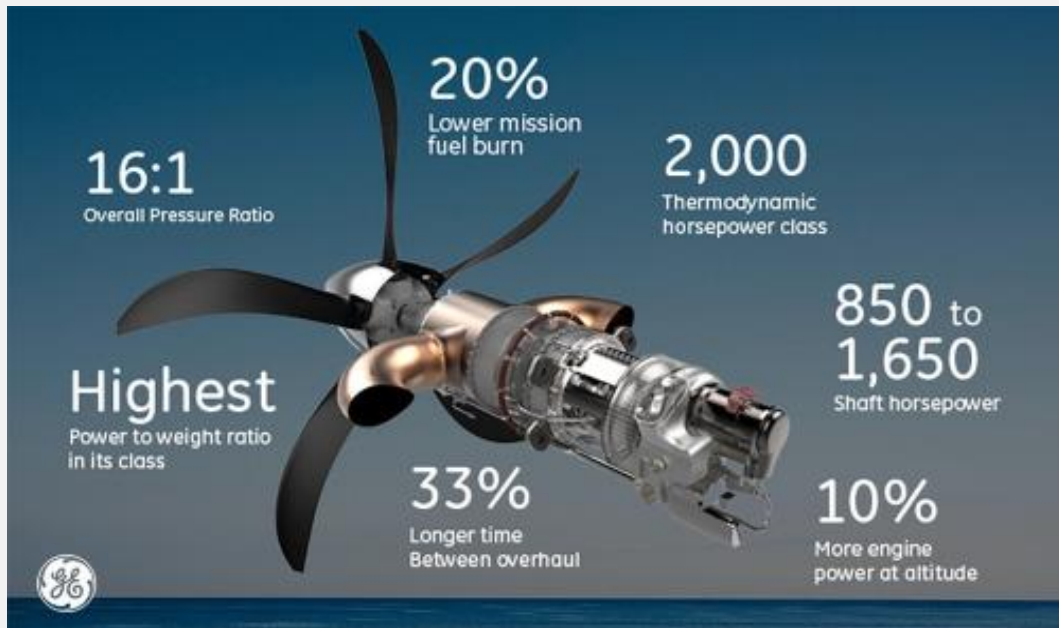


- Based in Lichtenfels, Germany
- A pioneer in powder-bed-based laser melting technology – printed first Ti part for A350XWB
- GE acquired 75% stake for \$599 million

GE also unsuccessfully bid for SLM Solutions

GE will print up to 35% of its new ATP aeroengine

Advanced Turboprop



- The Advanced Turboprop (ATP) engine powering the Cessna Denali will be made from 35% printed parts
- Additive manufacturing will eliminate 845 parts
- Leveraging additive manufacturing in a white sheet design will drive weight reduction and fuel efficiency improvement




GE is vertically integrating with advanced technology

Air Transport Aeroengine Parts – Make/Buy Behavior

Engine OEM	Cases & Rings	Disks & Blisks	Shrouds	Supports	Shafts	Fan Blades	HPT/LPT Airfoils	Compressor Airfoils	Bearings	Fuel Nozzles	Combustor Liners
GE			CMC on Leap-X			CFAN JV with Snecma for GE90 and GE9X	Developing CMC blade capability			Bringing in house via additive mfg. - Parker JV	Bringing in house CMC capability
P&W		Makes powder metallurgy disks				In-house for GTF					
RR						Hollow Ti blades in house					
Snecma						Out-sourcing LEAP blades					

Sources: OEM interviews, AeroDynamic Analysis

Refers to finished part capability including machining and other finishing processes; not limited to forging or investment casting

Make/Buy
 Insourced  Partially Outsourced  Outsourced 

2016 was a clear policy inflection point in the UK and US

BREXIT



June 2016

Donald Trump



November 2016

COMPLETED

- *Pulled US out of Trans-Pacific Partnership*

POTENTIAL

- 
- *Renegotiate NAFTA*
 - *45% tariff on Chinese goods*
 - *20% tariff on Mexican goods*
 - *Reduce corporate taxes and regulation*
 - *Border adjustment tax*

Has low cost sourcing peaked?

A proposal for a Border Adjustment Tax is under consideration

Border Adjustment Tax



- A proposal for a “Border Adjustment Tax” is under consideration by the Trump Administration
 - 20% tax on all imports
 - Profits from exports are not taxed
 - Could fund a reduction in corporate taxes from current 35% -- the highest amongst advanced economies
- An “American Made” coalition of more than 25 major companies dependent on exports – including Boeing, UTC and GE – support the concept in principle if it results in reduced corporate taxes
- An opposing coalition of companies dependent on imports, including Target and Best Buy, oppose the proposal

The \$80B positive US aerospace trade balance is at risk

US Aerospace Industry – 2015 Balance of Trade

Top Export Markets (\$B US)

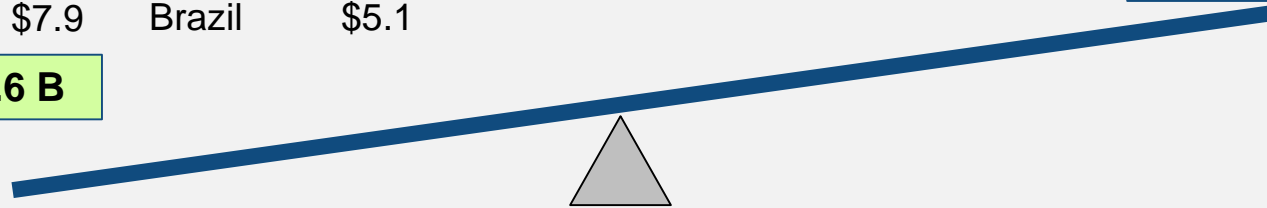
China	\$15.9	Germany	\$7.2
UK	\$10.5	Singapore	\$6.2
France	\$9.9	UAE	\$6.0
Canada	\$8.9	Mexico	\$5.6
Japan	\$7.9	Brazil	\$5.1

Exports \$134.6 B

Top Import Markets (\$B US)

France	\$12.5	Mexico	\$2.4
Canada	\$11.1	Italy	\$1.7
Japan	\$7.9	Singapore	\$1.2
Germany	\$7.2	Korea	\$1.1
UK	\$4.8	China	\$1.1
Brazil	\$3.1		

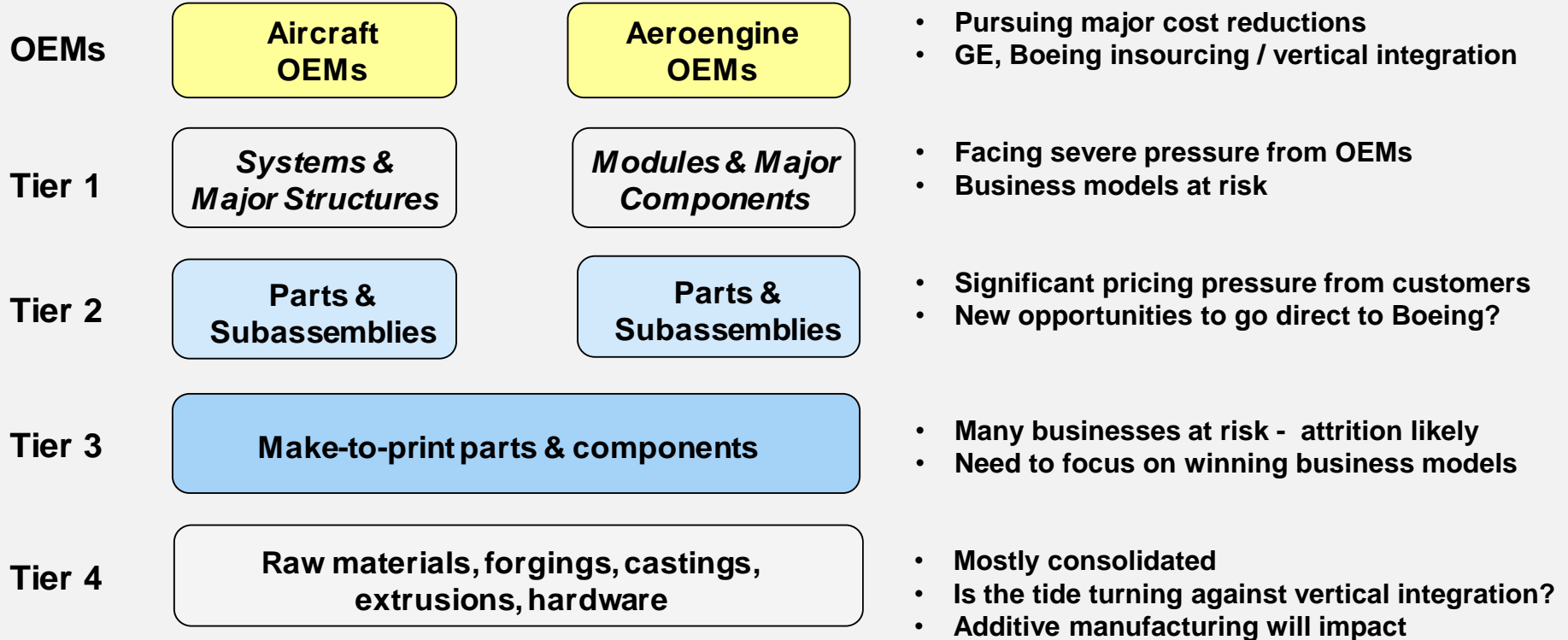
Imports \$54.9 B



- **China and Mexico – two of Trump’s favorite targets -- are worth \$21.5B in exports and support >120K jobs**
- **Canada has a \$2B positive trade balance with the US**

The implications of these trends for suppliers is significant

Commercial Aircraft Supplier Outlook



THANK YOU!



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