AEROSPACE COMPETITIVE ECONOMICS STUDY 2019

FULL REPORT

Prepared for: International Association of Machinists (IAM)
Society of Professional Engineering Employees in Aerospace (SPEEA)

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TEAL GROUP CORPORATION

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EXECUTIVE SUMMARY

For the second year in a row, the 2019 Aerospace Competitive Economics Study ("ACES") finds that the State of Washington is the most competitive business environment for the manufacture of major aerospace structures. Completing the top five states were Ohio, Utah, North Carolina and Arizona. The second half of the top ten states includes Colorado, Georgia, Texas, Kansas and Alabama.

Washington remains strong across most categories and many individual metrics. It is a top twenty finisher in all categories and a top five finisher in five of the eight categories. Of the 41 metrics reported, the State of Washington ranks in the top ten in 23 of these metrics. This is a very strong showing.

Ohio retains its #2 ranking. While it does well in a number of categories and key metrics, the findings of this year's ACES analysis show that Ohio is well behind Washington in its overall competitive position.

Utah is the surprise of the 2nd Annual ACES. Coming in at #3, Utah moves up sharply from its #7 finish in 2018. The state continues to grow its aerospace sector and has a strong foundation for even more growth. It places in the top ten in half of the categories: Taxes & Incentives, Research & Innovation, Risk to Operations and Economy.

North Carolina drops one spot but is still strong in many categories and metrics. From a category perspective, it is highly ranked in Costs and Industry, with a #1 ranking for the Unit Labor Cost metric.

Arizona is another state that made a major move up in the rankings, going from #9 last year to #5 in 2019. It steadily has added key aerospace companies to its industry profile and thereby developed a growing number of supply chain partners.

In addition to this year's state-level rankings, ACES 2019 examines "aerospace clusters," metropolitan areas in each top ten state with a high concentration of aerospace industrial activity. The report highlights relevant geographic areas and presents key statistics for each state's primary aerospace cluster(s).

ACES 2019 also discusses two important factors affecting the potential for new commercial aircraft manufacturing in these clusters: the presence of a dominant incumbent, and crowding out related to military aircraft production. "Fortress clusters" where one manufacturer already dominates an aerospace cluster make it difficult for another manufacturer to begin operating in that competitive environment. Southwestern Ohio and Savannah, GA are examples of clusters that would be challenging for a new prime contractor to enter.

State	Overall 2019	Overall 2018
Washington	1	1
Ohio	2	2
Utah	3	7
North Carolina	4	3
Arizona	5	9
Colorado	6	5
Georgia	7	6
Texas	8	8
Kansas	9	4
Alabama	10	10
Indiana	11	16
Missouri	12	11
California	13	14
Connecticut	14	24
Florida	15	18
Michigan	16	13
Virginia	17	12
Kentucky	18	21
Oklahoma	19	15
Massachusetts	20	23
Pennsylvania	21	25
Maryland	22	33
Iowa	23	28
North Dakota	24	20
Wisconsin	25	19
Arkansas	26	29
South Carolina	27	22
New Hampshire	28	31
Vermont	29	41
Minnesota	30	30
Wyoming	31	26
South Dakota	32	17
Delaware	33	36
Oregon	34	27
West Virginia	35	32
New York	36	40
New Mexico	37	39
Nevada	38	35
Illinois	39	37
Idaho	40	34
Alaska	41	44
Tennessee	42	43
Nebraska	43	42
Maine	44	46
District of Columbia	45	48
Hawaii	46	38
New Jersey	47	50
Mississippi	48	47
Louisiana	49	45
Montana	50	49
Rhode Island	51	51

Meanwhile, “military clusters” with a large defense presence may experience the crowding out of commercial aircraft production. Military aircraft cost structures conform to government procurement policies, which often include cost-plus provisions that allow for wage increases that outpace productivity and cannot be matched by commercial aircraft programs. This makes it very difficult for states like California and Texas, which have large military aircraft manufacturing programs, to provide cost environments for new commercial aircraft manufacturing that match the productivity of aerospace workers in those states.

Beyond these two issues, this report also addresses the role that Brazil might play in the manufacture of Boeing’s aircraft. Given that Boeing will acquire a major controlling interest in Embraer’s existing manufacturing assets, there is speculation that Boeing plans to move existing aircraft production and design to, or locate new aircraft work in, Brazil. These plans could include a new location for engineering and design work, manufacturing structures and sections for future Boeing jetliners, flight testing and certification work on new aircraft, and conceivably even a new aircraft final assembly line.

After taking a close look at economic factors in Brazil, its aerospace trade balances (exports and imports) and its overall competitiveness against the U.S, we conclude that it would be extremely difficult for Boeing to locate a significant amount of new aircraft work in Brazil. There are too many economic factors arguing against Brazil as a competitive business environment. While it seemingly possesses some cost advantages, these are more than outweighed by lower labor productivity and significant long-term structural problems plaguing the Brazilian economy.

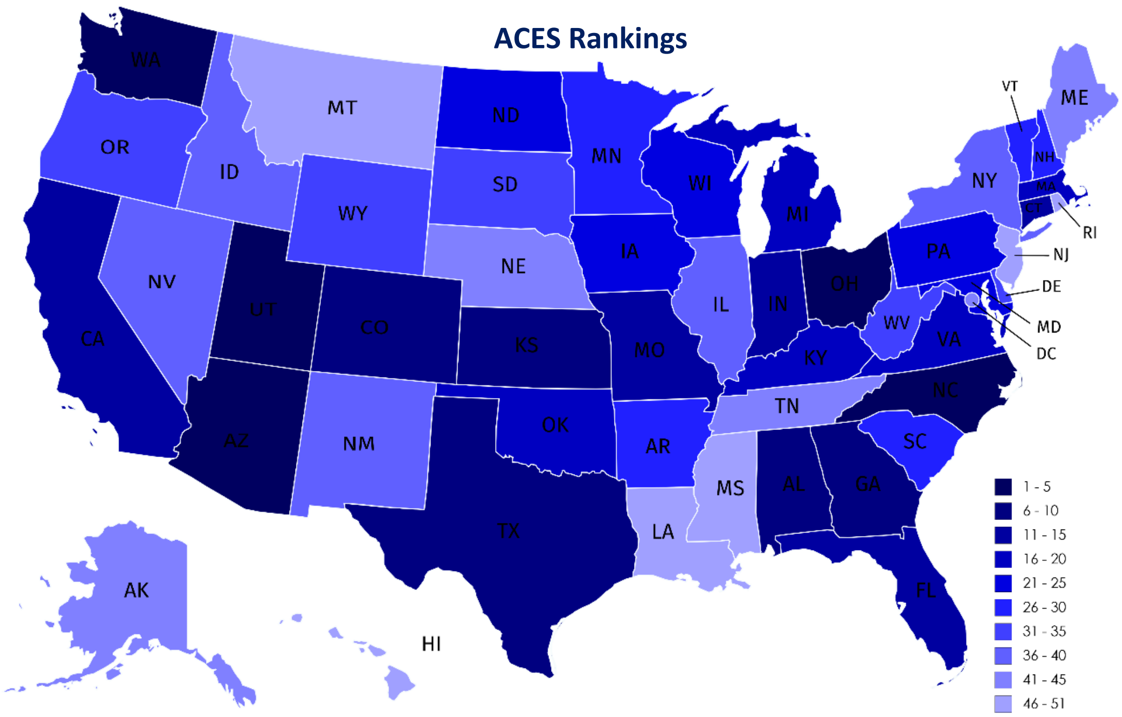
Finally, this year’s report updates the global market outlook for jet aircraft. Several issues weigh heavily on industry conditions and performance. Most notably, the two 737MAX disasters and subsequent grounding have disrupted the civil aircraft market with significant downward pressure on industry output. Beyond 737MAX, problems with other platforms, including 777X program delays, A330neo difficulties, the ending of the A380 and uncertainty with Boeing’s new midsized (or mid-market) airplane (“NMA”), have created headwinds for the industry.

On the demand side, negative factors may limit more robust growth in the near-term. Traffic growth this year has slowed markedly. U.S.-China trade tensions and a slowing of the Chinese economy have constrained demand, contributing to a sharp decline in new aircraft orders. After a long and robust period of orders, we finally may be seeing the emergence of a down cycle that needs to work its way through before orders accelerate again.

Industry uncertainty and 737MAX issues mean that Boeing remains unclear about the introduction of its NMA. As a result, Boeing continues to evaluate its preferred NMA strategy and timing. However, it can only delay the decision so long. Boeing needs to offer something in this segment in order to aggressively compete across the full market and avoid conceding too much ground to Airbus.

TOP 10 MOST COMPETITIVE STATES

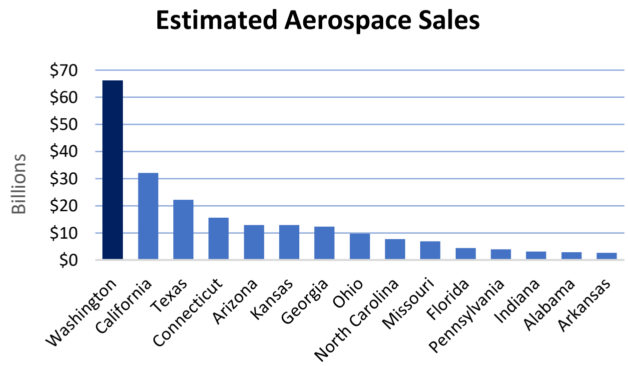
The top performing states are presented in the chart and table below. Based on the various measures included in ACES, these states represent the most competitive business environments for the manufacture or final assembly of large aerospace structures. Each of these ten states incorporates multiple factors that contribute to its competitiveness ranking.



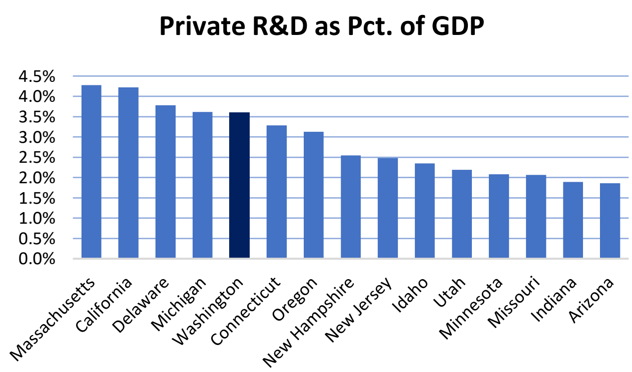
State	Overall Rank	Costs	Labor & Education	Industry	Infrastruc-ture	Risk to Operations	Economy	Research & Innovation	Taxes & Incentives
Washington	1	1	2	1	14	5	1	6	5
Ohio	2	13	9	4	16	7	16	23	17
Utah	3	12	11	16	51	3	8	3	4
North Carolina	4	2	40	7	28	13	27	19	12
Arizona	5	14	8	6	50	1	40	10	16
Colorado	6	24	5	12	45	30	22	5	13
Georgia	7	21	10	14	24	21	14	26	18
Texas	8	30	22	10	33	32	18	22	3
Kansas	9	26	4	3	18	49	15	32	31
Alabama	10	25	12	9	40	24	23	33	8

Washington #1

The State of Washington scores high in most of the categories and many of the individual metrics. It is a solid first place finisher. Washington is at or near the top in four categories: Costs (#1), Industry (#1), Economy (#1) and Labor & Education (#2). It also scores in the top ten in Risk to Operations (#5), Taxes & Incentives (#5) and Research & Innovation (#6).



While other states rank well in a handful of categories and individual metrics, Washington outperforms the competition by ranking extremely high in many measures. Washington is ranked in the top ten in twenty-three individual metrics. This is over half of all the metrics included in the ACES model.

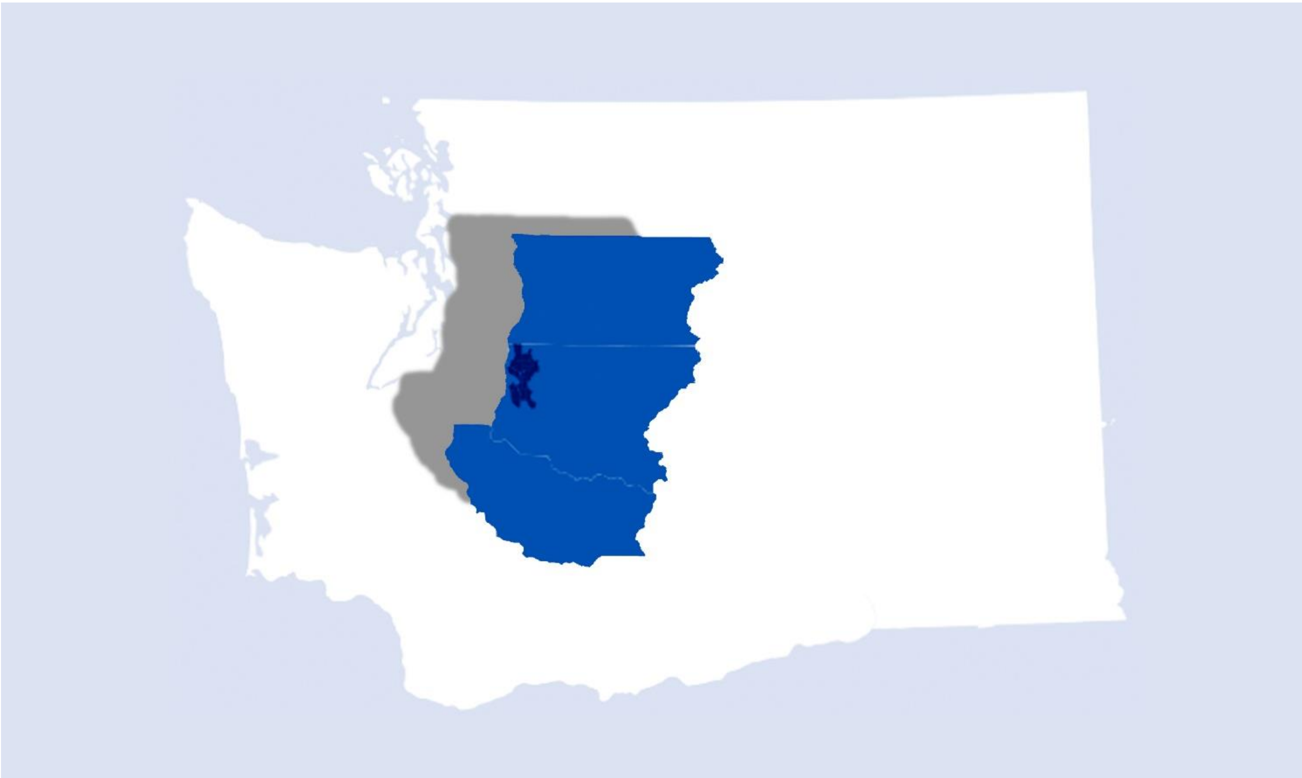


Given its strong presence in aircraft manufacturing, Washington scores high in a number of aerospace-related metrics. But, it also scores well with broader industrial measures, such as Energy Costs, Port Volume, Insurance Losses and Premiums, and multiple tax metrics.

- The FAA grounded Boeing 737MAX aircraft due to a software issue, leading Boeing's Renton plant to cut production from 52 to 42 airplanes per month.
- In May 2019, Web Industries announced a new 84,000 ft^2 facility at the Arlington Marysville Manufacturing Industrial Center which will process carbon fiber into spools of slit tape used to create the wing skins and fuselage sections of the Boeing 787 and 777X.
- The International Association of Machinists and Aerospace Workers District 751 announced a $66 million investment to form the Aerospace Machinist Institute, a center focused on training, skills enhancement, pre-apprenticeship, and apprenticeship for members and the public.
- Boeing took out a lease option for 58 acres of undeveloped land adjacent to Paine Field in Everett "to develop additional aerospace manufacturing facilities to supplement its existing operations."
- Exotic Metals Forming LLC, an aerospace sheet metal fabrication and design firm, plans to build two new manufacturing facilities at its Airway Heights location, adding more than 150 jobs.

Costs	1
Unit Labor Cost	7
Unit Material Cost	6
Energy Cost	1
Construction Cost	32
Labor & Education	2
Aerospace Engineers	2
Aerospace Production Workers	1
Engineering BAs	3
Graduate Degrees	13
High School Degree or More	16
Education Spending	22
Industry	1
Aerospace Sales	1
Aerospace Value Added	1
Aerospace Exports	1
Workforce Growth	26
Supplier Density	3
Crowding Out	22
Infrastructure	14
Airports	24
Freight Railroad	33
Port Volume	4
Road Condition	40
Transportation Funding	11
Risk to Operations	5
Insurance Losses	3
Insurance Premiums	8
Earthquake Premiums	49
Extreme Weather	7
Economy	1
GDP Per Capita	9
GDP Per Capita Growth	3
Manufacturing	15
Global Manufacturing Connectivity	3
Unemployment Rate	12
Research & Innovation	6
Patents per Capita	3
Public R&D	21
Private R&D	5
High Tech Establishments	17
Taxes & Incentives	5
Total Taxes/GDP	9
Workers' Compensation	36
Corporate Income Tax	6
Individual Income Tax	1
Manufacturing Tax	4
Property Tax	17
Sales Tax	48

Seattle Aerospace Cluster



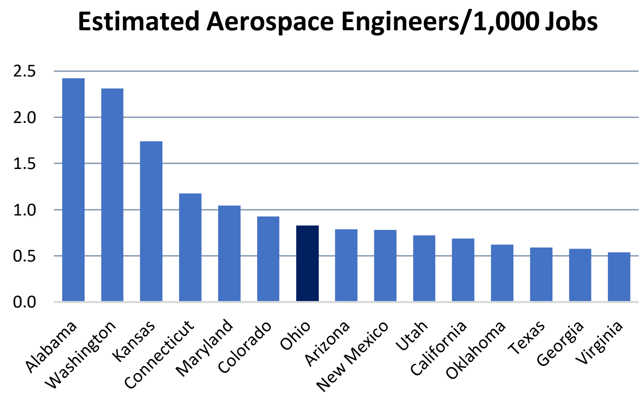
Washington's aerospace production is centered in the Seattle aerospace cluster composed of Snohomish, King and Pierce Counties. Boeing plants in Everett (747, 767, 777, 787 and Everett Composite 777x Wing Center) and Renton (737MAX) anchor the cluster. Dozens of Boeing suppliers like Safran, which builds cabin equipment for the 737, and Aviation Technical Services, which maintains and repairs aircraft components, employ thousands of machinists and engineers. Additionally, Boeing and other aerospace firms partner with Washington high schools on the two-year Core Plus Aerospace education program, and with the University of Washington and other colleges through the Joint Center for Aerospace Technology Innovation to transition technology from academia to industry.

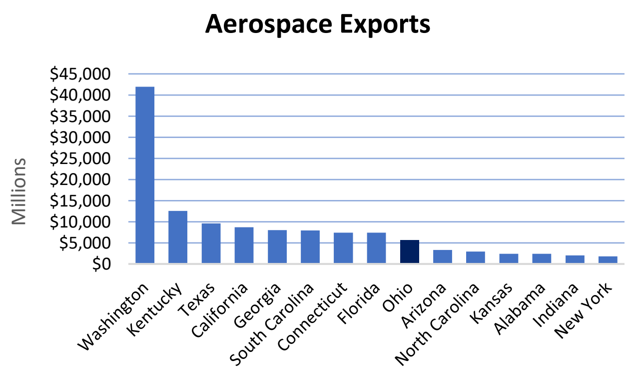
Aerospace Employees	Aerospace Establishments	Advanced Degree Percentage
70,562	153	16.0%
Aerospace Engineers	**Manufacturing GDP**	**Federal Aircraft Contracts**
8,480	$38.8B	$265M

Sources: (Clockwise from Upper Left) QWI (2017/2018); BLS (2018); CPS (2017); USASpending.Gov (2017); BEA (2017); BLS OES (2015).

Ohio #2

Ohio once again finishes in the second highest position. Measures contributing to its position include Industry (#4), Risk to Operations (#7) and Labor & Education (#9). Ohio ranks 13th in the important Costs category and ranks 16th in both Infrastructure and Economy.



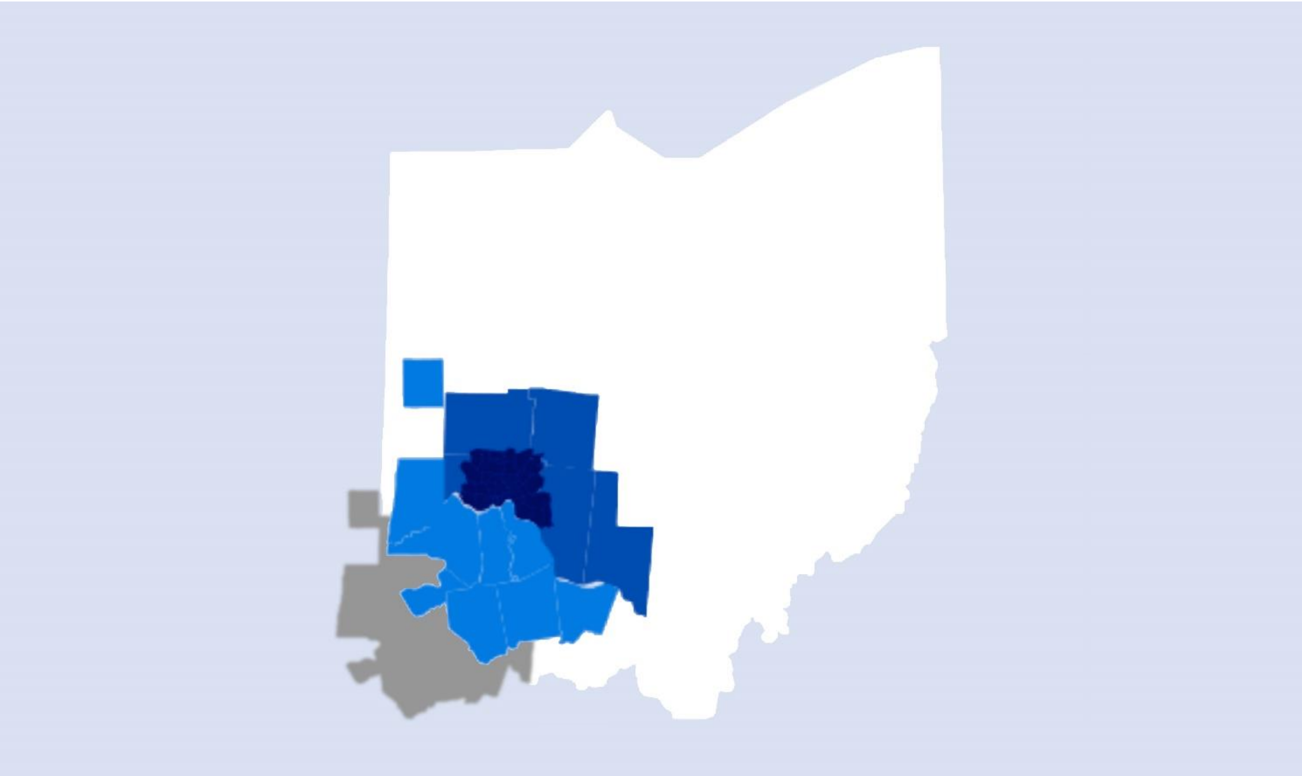


Ohio has a mature and well developed aerospace industry, with leading major government and corporate entitites like GE Aviation in Cincinnati, the NASA Glenn Research Center in Cleveland and the Air Force Research Laboratory in Dayton. The state is ranked in the top ten in Aerospace Engineers, Sales, Value-Added, Exports, Airports, Freight Railroad, Insurance Losses, Manufacturing and Corporate Income Tax. Just outside the top ten it also scores well in Workforce Growth and Supplier Density.

- **Barron Industries based in Oxford, OH partnered with Triumph Group to supply cast and machined stainless-steel components for the GE9X high-bypass turbofan aircraft engine being developed by GE Aviation for Boeing's 777X.**
- **The Air Force announced Wright-Patterson Air Force Base will host an F-35 aircraft support and management program that could create more than 400 jobs. The program called the F-35 Hybrid Product Support Integrator Organization will be part of the Air Force Life Cycle Management Center.**
- **Northrop announced a 35,000 ft^2 building expansion at its Beavercreek, OH facility in support of its $90 million contract to supply high temperature composites for the U.S. military, including the hot trailing edge (HTE) of the B-2.**
- **Consolidated Aerospace Manufacturing unit Voss industries, a manufacturer of clamps and related items for the aerospace industry, announced its relocation to a 95,000 ft^2 modern manufacturing facility in the Cleveland-area, adding up to 60 jobs.**
- **Dupont opened its Aerospace Technology Center, which includes collaborative work spaces for technical training in Valley Dew, a suburb of Cleveland.**
- **StandardAero Component Services Inc., an aerospace maintenance, repair and overhaul provider, announced plans to hire 250 to 300 technicians and other employees after opening its new facility in Sharonville.**

Costs	**13**
Unit Labor Cost	14
Unit Material Cost	16
Energy Cost	24
Construction Cost	26
Labor & Education	**9**
Aerospace Engineers	7
Aerospace Production Workers	17
Engineering BAs	29
Graduate Degrees	32
High School Degree or More	25
Education Spending	20
Industry	**4**
Aerospace Sales	8
Aerospace Value Added	8
Aerospace Exports	9
Workforce Growth	11
Supplier Density	12
Crowding Out	42
Infrastructure	**16**
Airports	5
Freight Railroad	5
Port Volume	22
Road Condition	29
Transportation Funding	39
Risk to Operations	**7**
Insurance Losses	1
Insurance Premiums	9
Earthquake Premiums	31
Extreme Weather	37
Economy	**16**
GDP Per Capita	26
GDP Per Capita Growth	11
Manufacturing	8
Global Manufacturing Connectivity	13
Unemployment Rate	48
Research & Innovation	**23**
Patents per Capita	18
Public R&D	22
Private R&D	19
High Tech Establishments	26
Taxes & Incentives	**17**
Total Taxes/GDP	26
Workers' Compensation	16
Corporate Income Tax	5
Individual Income Tax	18
Manufacturing Tax	30
Property Tax	22
Sales Tax	32

Cincinnati Aerospace Cluster



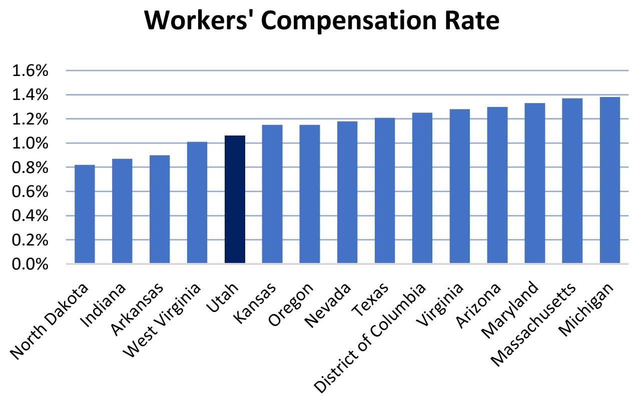
Ohio's largest aerospace cluster is located in Cincinnati and anchored by GE Aviation, the world's leading manufacturer of jet engines with more than 9,000 employees in SW Ohio. GE Aviation engines power the Boeing 747-8, 777, 777x and 787. GE Aviation's CFM International joint venture ("JV") with Cincinnati-based Safran Aircraft Engines produces LEAP engines for the Airbus A320neo, A321neo, and Boeing 737Max aircraft, its GE-Pratt & Whitney JV manufactures engines for the A380, and GE's JV with Honda produces light business jet engines. GE Aviation's GE9X engine for the long-haul 777x will be the world's largest jet engine when it goes into operation in 2020. Wright-Patterson Air Force base is 50 miles north of Cincinnati and aerospace engineers are educated at the University of Cincinnati.

Aerospace Employees	Aerospace Establishments	Advanced Degree Percentage
11,073	45	12.8%
Aerospace Engineers	**Manufacturing GDP**	**Federal Aircraft Contracts**
2,430	$11.4B	$3,676M

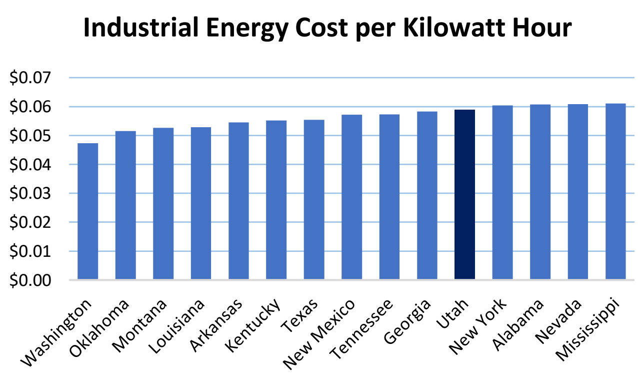
Sources: (Clockwise from Upper Left) QWI (2017/2018); BLS (2018); CPS (2017); USASpending.Gov (2017); BEA (2017); BLS OES (2016).

Utah #3

Jumping four places from last year's 7th place finish, Utah lands in the top five and becomes the 3rd most competitive aerospace manufacturing state. Contributing to its rise, Utah moves up in three key categories: Costs, Labor & Education and Industry. It is a top ten finisher in three categories: Risk to Operations (#3), Research & Innovation (#3) and Taxes & Incentives (#4). Utah fell just outside the top ten in Labor & Education (#11) and Costs. (#12).



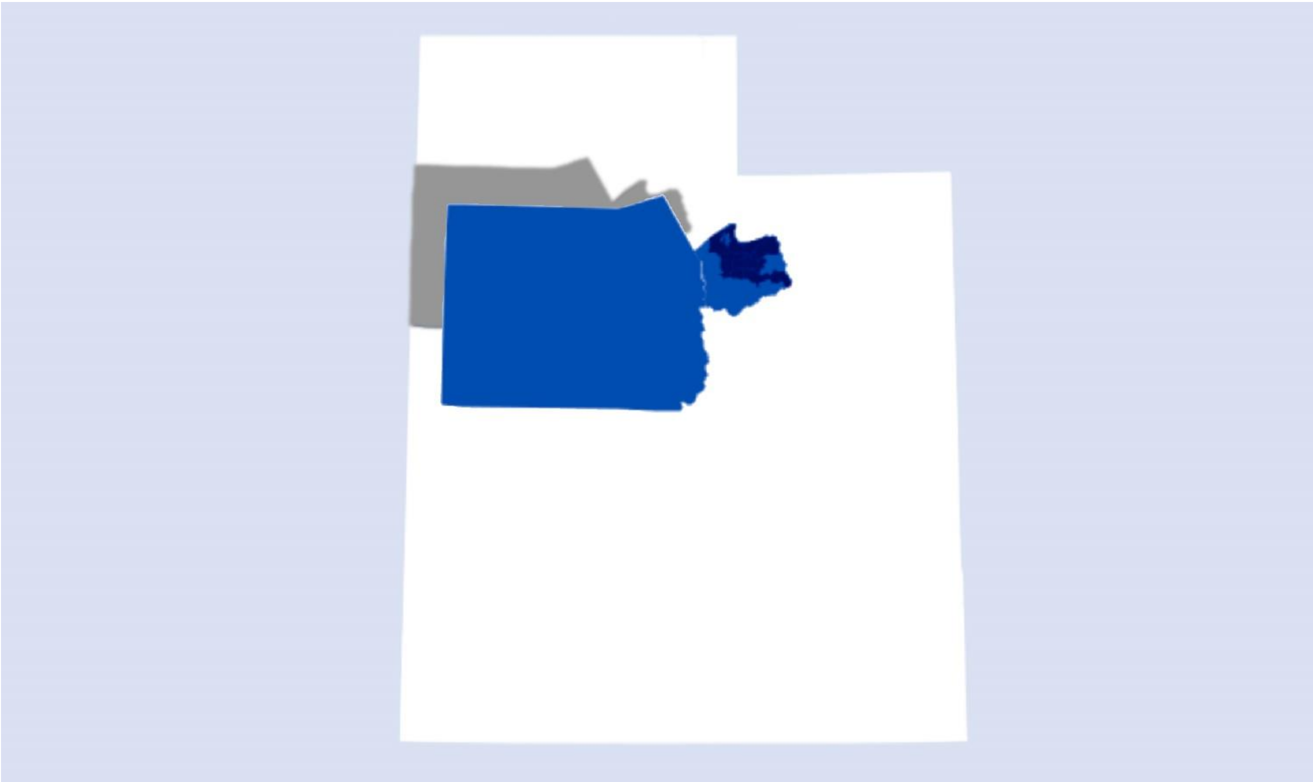
With respect to individual metrics, Utah has the lowest Unit Material Cost of any state and therefore ranks #1. It is at or near the top ten in a number of other metrics: Energy Costs, Aerospace Engineers, Supplier Density, Insurance Losses, Insurance Premiums, Extreme Weather, GDP Per Capita Growth, Global Manufacturing Connectivity, High Tech Establishments, Private R&D, Taxes/GDP and Workers' Compensation.



- L3 Technologies will build a new $50 million manufacturing facility, while adding another 250 jobs to its Salt Lake City-based workforce of 3,500. The company received an incentive to earn up to 20 percent of the new state taxes they will pay.
- Northrop and Airbus agreed to expand their partnership to explore complex composite wing out-of-autoclave technologies. Northrop Grumman is currently producing composite fuselage stringers and frames for the Airbus A350 XWB -900 and -1000 variants at its Aircraft Commercial Center of Excellence facility in Clearfield, Utah.
- RAM Manufacturing Company, a manufacturer of precision products for the commercial, aerospace and space industries, completed its 75,000 ft^2, $11 million expansion in St. George.
- Utah State University received $91.8 million in federal research and development funding for aerospace, aeronautical, and astronautical engineering, the 3rd highest amount of federal funds for a university in the nation.

Costs	12
Unit Labor Cost	42
Unit Material Cost	1
Energy Cost	11
Construction Cost	18
Labor & Education	**11**
Aerospace Engineers	10
Aerospace Production Workers	16
Engineering BAs	21
Graduate Degrees	23
High School Degree or More	10
Education Spending	51
Industry	**16**
Aerospace Sales	26
Aerospace Value Added	17
Aerospace Exports	32
Workforce Growth	10
Supplier Density	9
Crowding Out	25
Infrastructure	**51**
Airports	47
Freight Railroad	46
Port Volume	22
Road Condition	23
Transportation Funding	41
Risk to Operations	**3**
Insurance Losses	6
Insurance Premiums	2
Earthquake Premiums	47
Extreme Weather	4
Economy	**8**
GDP Per Capita	31
GDP Per Capita Growth	10
Manufacturing	20
Global Manufacturing Connectivity	12
Unemployment Rate	10
Research & Innovation	**3**
Patents per Capita	11
Public R&D	13
Private R&D	11
High Tech Establishments	6
Taxes & Incentives	**4**
Total Taxes/GDP	8
Workers' Compensation	5
Corporate Income Tax	11
Individual Income Tax	16
Manufacturing Tax	16
Property Tax	14
Sales Tax	26

Salt Lake City Aerospace Cluster



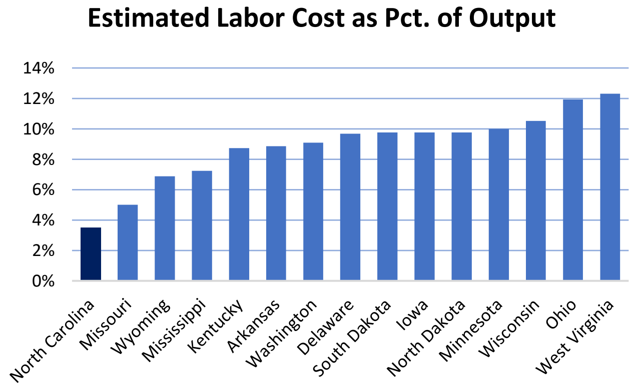
Utah's growing aerospace industry is concentrated in Salt Lake City and centered around advanced composite fabrication and the defense industry. Albany Engineered Composites' Salt Lake City facility manufactures light-weight composites for large OEMs like Boeing and Airbus, while Hexcel's West Valley City carbon fiber and matrix manufacturing plants create carbon fiber and prepreg composite products for Airbus' A350 and the Boeing 787. Northrop Grumman builds ICBM missile systems in the area and broke ground on a new facility adjacent to Hill Air Force base in 2019, while L3Harris Technologies designs and manufactures communications systems for the military. The University of Utah's aerospace engineering college is also based in Salt Lake City.

Aerospace Employees	Aerospace Establishments	Advanced Degree Percentage
6,703	56	12.2%
Aerospace Engineers	**Manufacturing GDP**	**Federal Aircraft Contracts**
180	$10.6B	$4M

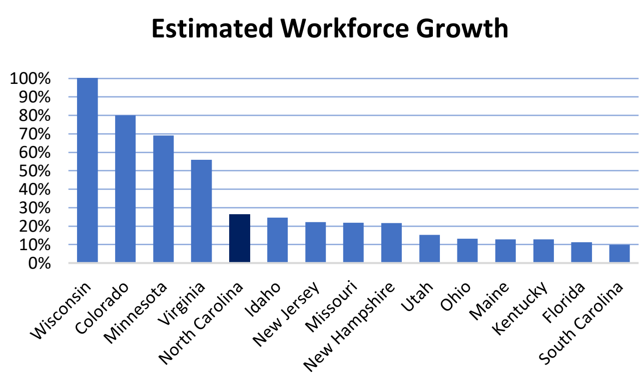
Sources: (Clockwise from Upper Left) QWI (2017/2018); BLS (2018); CPS (2017); USASpending.Gov (2017); BEA (2017); BLS OES (2018).

North Carolina #4

North Carolina dropped one position from #3 in 2018 but maintained a very strong top five finish in 2019. It is #2 in the all-important Costs category, down slightly from its #1 ranking in the 2018 results. It also dropped one position in the Industry category to #7. Top twenty rankings in Taxes & Incentives (#12) and Risk to Operations (#13) were key contributors to its overall strength.



The state has seen strong growth in the aerospace sector and now ranks as the fifth highest in Workforce Growth. Coupled with the #1 most competitive ranking in Unit Labor Cost, North Carolina presents an attractive location for the industry.



The state perfoms well in most Aerospace Industry metrics, including Sales, Value Added, Exports and Crowding Out. Beyond these, it scores well in Construction Costs, Insurance Losses, Corporate Income Taxes and Property Taxes.

- Oerlikon opened a $55 million Innovation Hub & Advanced Component Production facility in Huntersville, NC. The 125,000 ft² facility serves as Oerlikon's leading additive manufacturing business with a focus on surface solutions, equipment, advanced materials and materials processing.
- GE Aviation in Asheville, NC delivered its 25,000th aircraft engine shroud. GE's two-plant manufacturing site produces ceramic matrix composite (CMC) components for commercial jet engines.
- GE Aviation announced a $105 million investment to increase production capacity for its CMC line of jet engine components built in Asheville.
- Honda Aircraft announced plans to expand its global headquarters in Greensboro, NC, by investing an additional $15.5 million in a new 82,000 ft² facility. This will bring the company's total capital investment in its NC facilities to more than $245 million.

Costs	2
Unit Labor Cost	1
Unit Material Cost	18
Energy Cost	18
Construction Cost	12
Labor & Education	40
Aerospace Engineers	34
Aerospace Production Workers	29
Engineering BAs	27
Graduate Degrees	25
High School Degree or More	37
Education Spending	46
Industry	7
Aerospace Sales	9
Aerospace Value Added	9
Aerospace Exports	11
Workforce Growth	5
Supplier Density	36
Crowding Out	13
Infrastructure	28
Airports	15
Freight Railroad	19
Port Volume	17
Road Condition	24
Transportation Funding	44
Risk to Operations	13
Insurance Losses	7
Insurance Premiums	26
Earthquake Premiums	10
Extreme Weather	34
Economy	27
GDP Per Capita	36
GDP Per Capita Growth	28
Manufacturing	17
Global Manufacturing Connectivity	30
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Total Taxes/GDP	11
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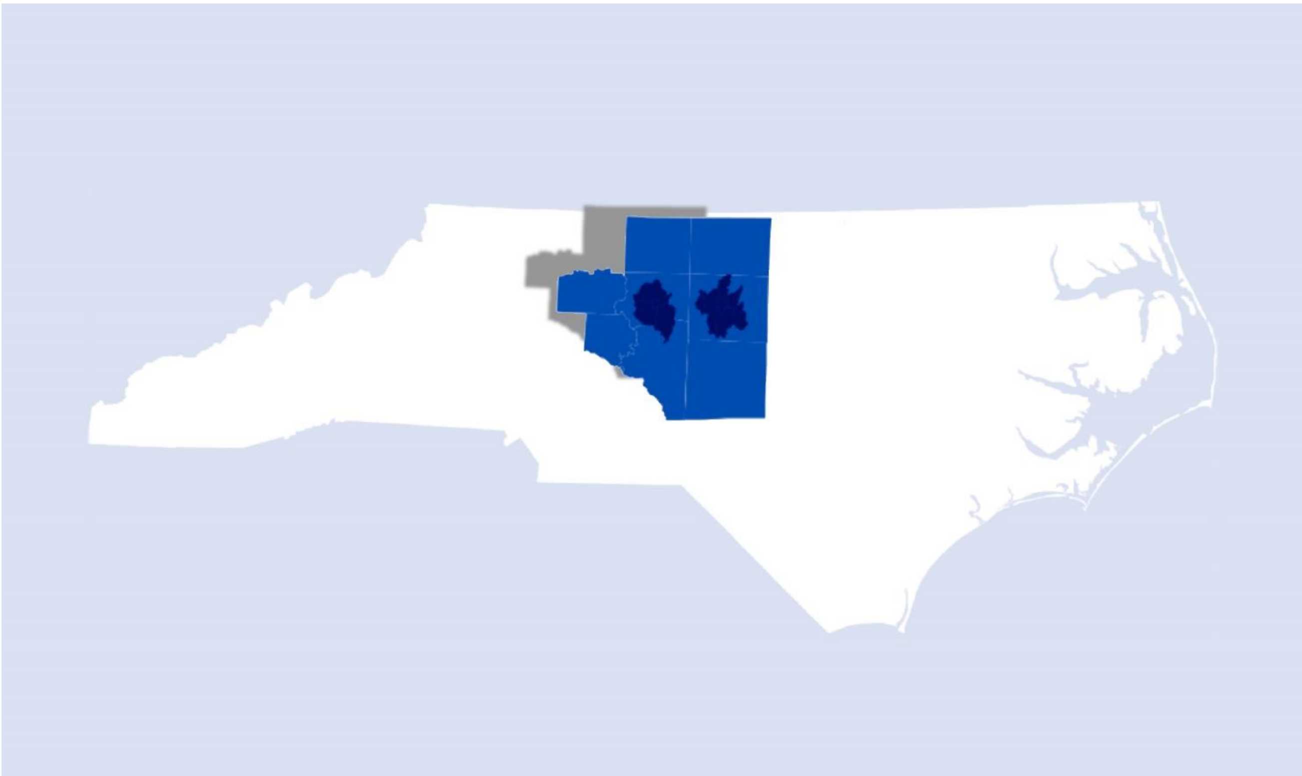
Property Tax	11
Sales Tax	27

Piedmont Triad Aerospace Cluster



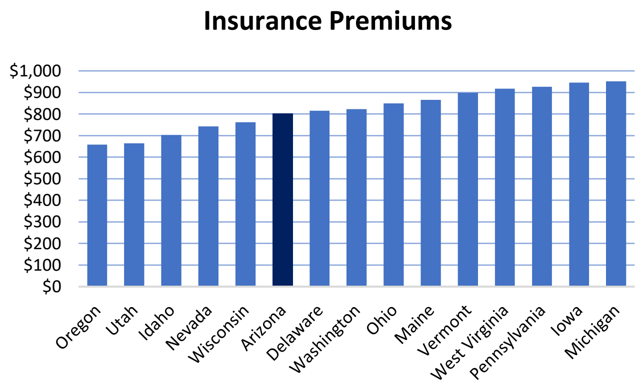
Greensboro, Winston-Salem and High Point form the Piedmont Triad, the densest aerospace cluster in North Carolina. Honda Aircraft Company's global headquarters and 133-acre campus lie adjacent to Piedmont Triangle International Airport ("PTI") near Greensboro, where the company designs and manufactures its HA-420 HondaJet Elite. HAECO Americas, which provides aircraft maintenance, repair and overhaul services, announced an expansion of its composite services operations at PTI in 2019. Collins Aerospace manufactures aircraft interiors out of the former B/E Aerospace headquarters in Winston-Salem. While university-level aerospace education is less developed in the Triad, Wake Forest University launched its first engineering program in 2017.

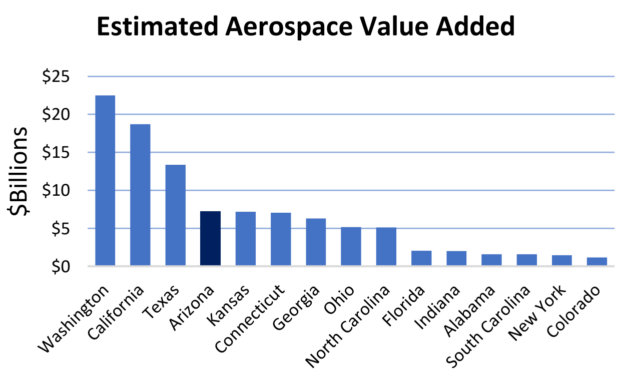
Aerospace Employees	Aerospace Establishments	Advanced Degree Percentage
2,413	10	9.5%
Aerospace Engineers	**Manufacturing GDP**	**Federal Aircraft Contracts**
100	$7.6B	$1M

Sources: (Clockwise from Upper Left) QWI (2017/2018); BLS (2018); CPS (2017); USASpending.Gov (2017); BEA (2017); BLS OES (2018).

Arizona #5

Another state that improves its ranking from last year is Arizona, which climbs from #9 overall in 2018 to #5 in 2019. Strong category rankings include Risk to Operations (#1), Industry (#6), Labor & Education (#8) and Research & Innovation (#10). Improvements in Industry and Infrastructure were important drivers of Arizona's overall rise.



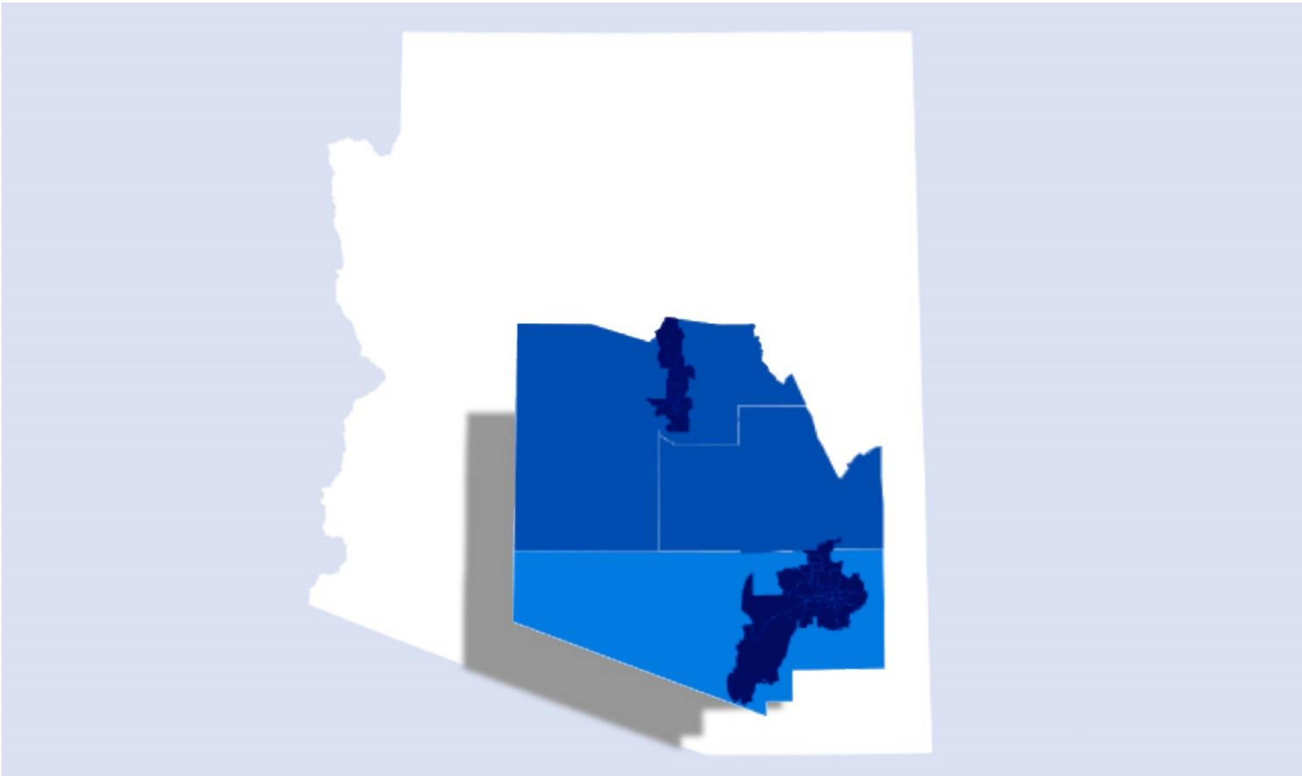


Arizona ranks high in key individual metrics, including Aerospace Production Workers and Engineers, Aerospace Sales, Value Added and Supplier Density.

- Raytheon, which manufactures a variety of missiles in Tucson and employs 13,000 people in Southern Arizona, announced a merger with United Technologies Corporation, potentially creating an aerospace and defense firm with $74 billion in revenue.
- Mitsubishi Heavy Industries announced the $750-million acquisition of Bombardier's Canadair Regional Jet ("CRJ") program and other assets, including the CRJ service center in Tucson.
- Raytheon opened buildings as part of its plan for a major expansion of its facilities in Tucson, AZ. The 559,000 ft^2 expansion will include an advanced testing facility, a multi-purpose building, a customer access center, and several additional buildings. Raytheon will also upgrade infrastructure, installing new laboratories and testing facilities, engineering and manufacturing enhancements, and high-powered computing capability. It is planned for completion in 2020.
- Magellan Aerospace partnered with Pratt & Whitney to manufacture aluminum castings for Next Generation Product Family (NGPF) engines powering the Airbus A320neo, Airbus A220, Embraer E2 and Mitsubishi MRJ aircraft. Magellan's facility in Glendale, AZ will participate in the approximately $62 million project.
- The Whitcraft Group, a Connecticut-based precision manufacturer for the aerospace industry acquired LAI International's operations in Scarborough and Tempe.
- Times Microwave Systems moved into a 63,000 square-foot building in Mesa to design and manufacture coaxial cables, connectors and cable assemblies for the aerospace and defense industries.

Costs	**14**
Unit Labor Cost	24
Unit Material Cost	17
Energy Cost	22
Construction Cost	12
Labor & Education	**8**
Aerospace Engineers	8
Aerospace Production Workers	5
Engineering BAs	14
Graduate Degrees	28
High School Degree or More	39
Education Spending	49
Industry	**6**
Aerospace Sales	5
Aerospace Value Added	4
Aerospace Exports	10
Workforce Growth	32
Supplier Density	4
Crowding Out	35
Infrastructure	**50**
Airports	46
Freight Railroad	47
Port Volume	22
Road Condition	12
Transportation Funding	46
Risk to Operations	**1**
Insurance Losses	14
Insurance Premiums	6
Earthquake Premiums	9
Extreme Weather	6
Economy	**40**
GDP Per Capita	41
GDP Per Capita Growth	31
Manufacturing	19
Global Manufacturing Connectivity	17
Unemployment Rate	46
Research & Innovation	**10**
Patents per Capita	17
Public R&D	15
Private R&D	15
High Tech Establishments	15
Taxes & Incentives	**16**
Total Taxes/GDP	19
Workers' Compensation	12
Corporate Income Tax	10
Individual Income Tax	13
Manufacturing Tax	29
Property Tax	23
Sales Tax	41

Phoenix and Tucson Aerospace Clusters



Arizona has two primary aerospace clusters centered in Phoenix and in Tucson. In Phoenix, Honeywell Aerospace produces aircraft engines, cockpit and cabin electronics, wireless connectivity services and auxiliary power units at four facilities, including its global headquarters, while Boeing produces AH-64 Apache attack helicopters in nearby Mesa. Tucson's aerospace sector is anchored by Raytheon Missile Systems, with 13,000 employees manufacturing missiles in Southern Arizona. The city is also home to Davis-Monthan Air Force Base, which employs thousands of airmen and support personnel and hosts a massive aircraft "boneyard." The University of Arizona in Tucson provides a robust aerospace engineering degree program.

Aerospace Employees
13,533 (PHX) / 13,295 (TUS)

Aerospace Establishments
91/16

Advanced Degree Percentage
11.2%/14.0%

Aerospace Engineers
1,980/220

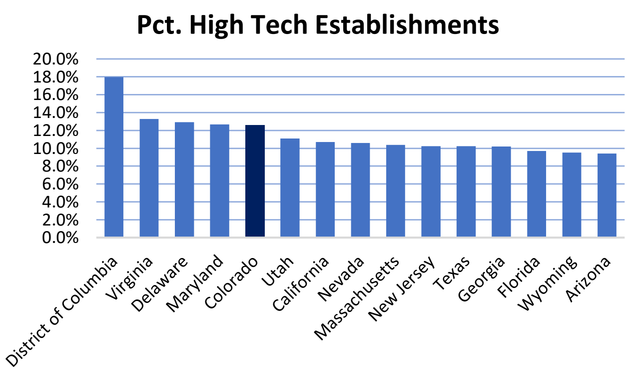
Manufacturing GDP
$15.8B/$4.1B

Federal Aircraft Contracts
$798M/$8M

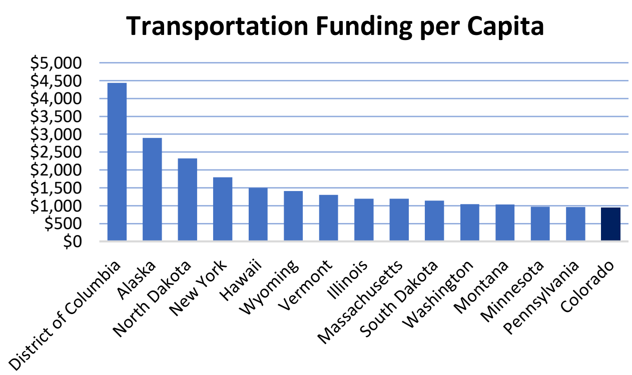
Sources: (Clockwise from Upper Left) QWI (2017/2018); BLS (2018); CPS (2017); USASpending.Gov (2017); BEA (2017); BLS OES (2018).

Colorado #6

Coming in at #6 and down one position from a year ago, Colorado remains a solid top ten performer. Helping it maintain a leading position are #5 rankings in two categories: Labor & Education and Research & Innovation. An Industry rank of #12 and Taxes & Incentives rank of #13 are two other factors contributing to its overall strong performance. Colorado also jumps eight places in the Costs category.



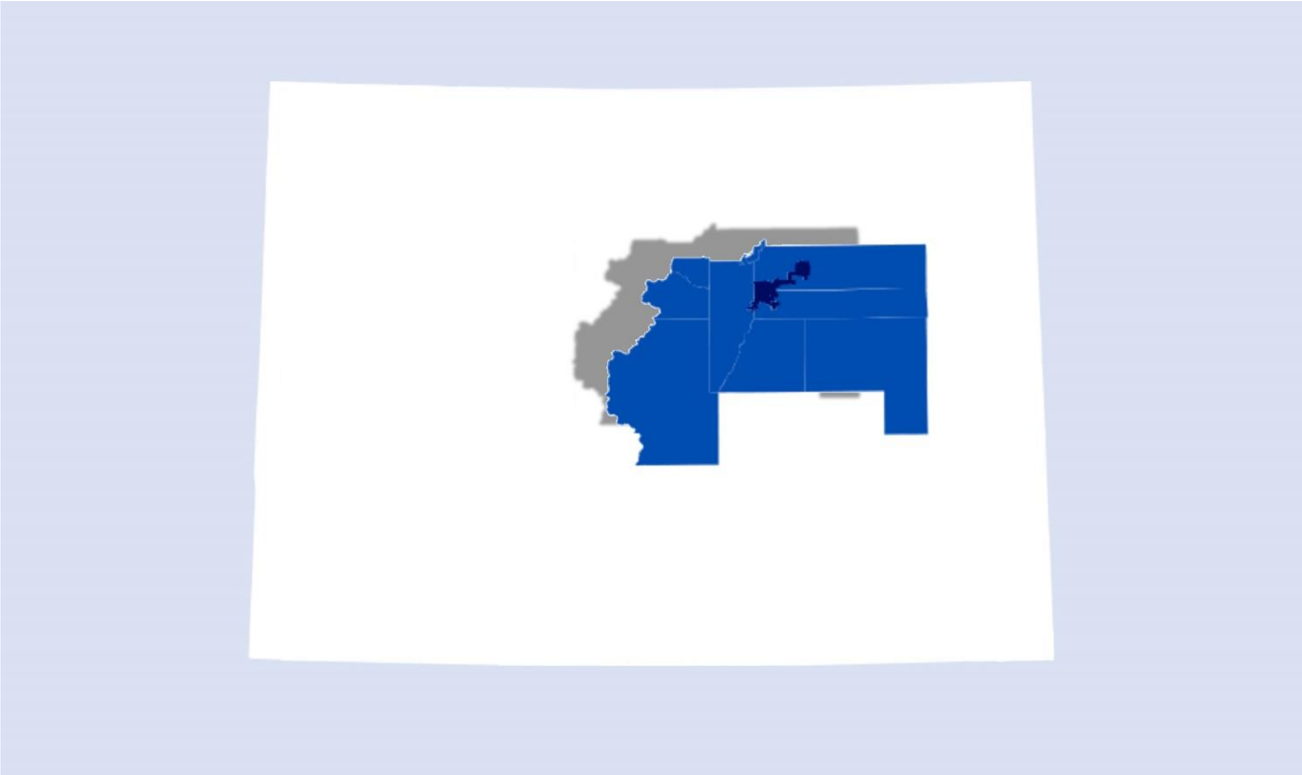
Within the Research & Innovation category, Colorado holds very strong positions in High Tech Establishments, Public R&D Spending and Patents. Also impressive are the state's rankings with respect to Aerospace Workforce Growth, Crowding Out and Aerospace Engineers. Key Aerospace companies located in the state include Raytheon, Northrop Grumman, Lockheed Martin, Harris Corporation, United Launch Alliance, Ball Aerospace, Sierra Nevada Corporation and Boeing.



- NASA selected Maxar Technologies of Westminster, CO to build the power and propulsion element for The Gateway, a space station that will orbit around the moon.
- Sierra Nevada Corp, in Louisville, CO passed a series of key NASA milestone tests in preparation for an early 2021 mission to bring supplies, science experiments and other cargo to the International Space Station with its Dream Chaser spacecraft.
- Bye Aerospace of Englewood, CO nears 300 orders for its all-electric eFlyer aircraft. Deliveries are scheduled to begin in 2020. The aircraft was originally intended as a solar powered platform, but was redesigned as electric and is targeting the low-cost segment of the pilot training market.
- The FAA granted Spaceport Colorado its operator license to launch satellites and private space-vehicles into orbit from the Colorado Air and Space Port located at Front Range Airport near Denver.
- The University of Colorado, Boulder received $35.2 million in federal research and development funding for aerospace, aeronautical, and astronautical engineering, the 4th highest amount of federal funds allocated to universities in the nation.

Costs	**24**
Unit Labor Cost	17
Unit Material Cost	21
Energy Cost	30
Construction Cost	35
Labor & Education	**5**
Aerospace Engineers	6
Aerospace Production Workers	15
Engineering BAs	2
Graduate Degrees	9
High School Degree or More	14
Education Spending	39
Industry	**12**
Aerospace Sales	16
Aerospace Value Added	15
Aerospace Exports	34
Workforce Growth	2
Supplier Density	29
Crowding Out	7
Infrastructure	**45**
Airports	43
Freight Railroad	43
Port Volume	22
Road Condition	45
Transportation Funding	15
Risk to Operations	**30**
Insurance Losses	29
Insurance Premiums	42
Earthquake Premiums	22
Extreme Weather	13
Economy	**22**
GDP Per Capita	15
GDP Per Capita Growth	8
Manufacturing	36
Global Manufacturing Connectivity	44
Unemployment Rate	21
Research & Innovation	**5**
Patents per Capita	10
Public R&D	6
Private R&D	24
High Tech Establishments	5
Taxes & Incentives	**13**
Total Taxes/GDP	18
Workers' Compensation	17
Corporate Income Tax	9
Individual Income Tax	14
Manufacturing Tax	17
Property Tax	25
Sales Tax	36

Denver Aerospace Cluster



Colorado's aerospace industry is centered in Denver with large concentrations of space and defense firms. Boulder-based Ball Aerospace builds spacecraft and satellites for NASA, while Centennial-headquartered Sierra Nevada Corporation's Dream Chaser cargo spacecraft is preparing to deliver supplies to the International Space Station on a United Launch Alliance Vulcan Centaur rocket designed near Denver. The region also has a large defense presence. Lockheed Martin designs unmanned airborne systems for the military in Littleton, while Northrop Grumman, Raytheon and Boeing also operate in the area. Nearby University of Colorado - Boulder and the U.S. Air Force Academy in Colorado Springs both have nationally ranked aerospace engineering programs.

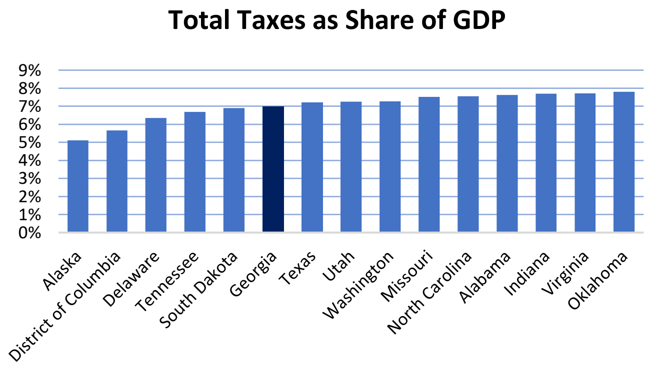
Aerospace Employees	Aerospace Establishments	Advanced Degree Percentage
8,570	17	15.8%

Aerospace Engineers	Manufacturing GDP	Federal Aircraft Contracts
1,040	$7.0B	$0M

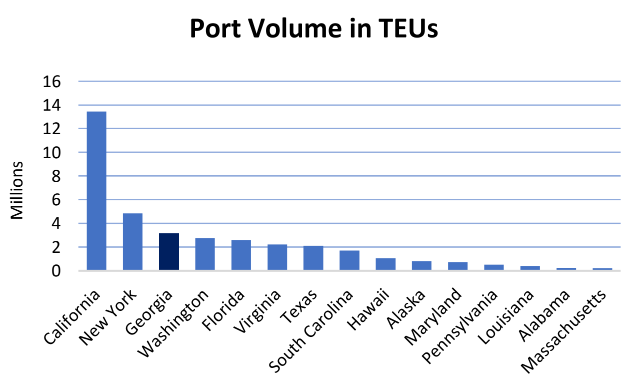
Sources: (Clockwise from Upper Left) QWI (2017/2018); BLS (2018); CPS (2017); USASpending.Gov (2017); BEA (2017); BLS OES (2018).

Georgia #7

Also dropping one spot is Georgia at #7. It has several top twenty category finishes: Labor & Education (#10), Industry (#14), Economy (#14) and Taxes & Incentives (#18). Georgia rises nine positions in the Economy category while dropping eight positions in the Taxes & Incentives category.



Contributing to Georgia's strength in Labor & Education was its #6 ranking for the Aerospace Production Worker metric and it's #14 ranking for the Aerospace Engineers metric.

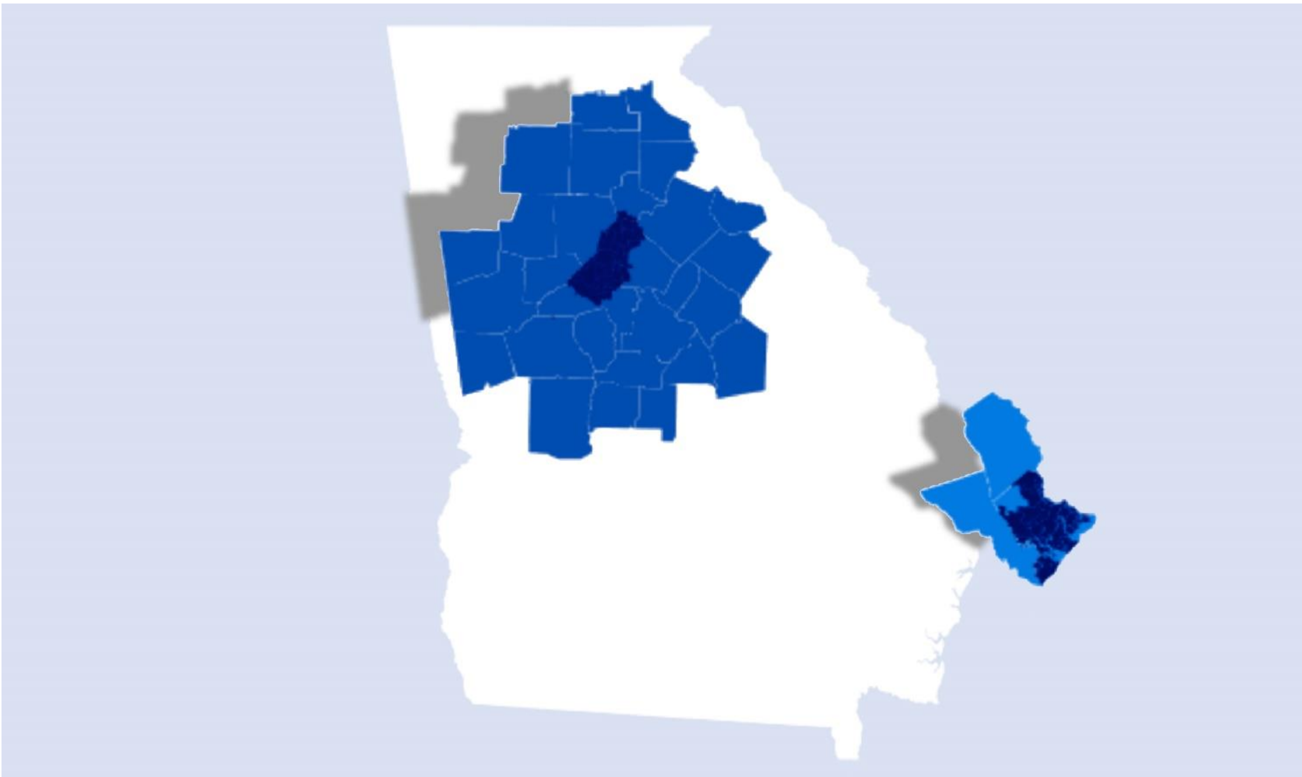


Other impressive rankings include the metrics for Total Taxes/GDP, Port Volume, GDP Per Capita Growth, Aerospace Exports, Aerospace Sales and Aerospace Value Added.

- Element Materials Technology opened a 30,000 ft² aerospace testing laboratory in Piedmont, GA. The facility will work in partnership with Element's Connecticut location to support its main customer in the area, GE.
- Gulfstream Aerospace, headquartered in Savannah, GA, completed certification of the all-new G500 in mid-2019 and then delivered the first aircraft to a North American customer. The G500 is a technologically advanced, clean-sheet aircraft.
- Lockheed Martin delivered the 52nd C-5M Super Galaxy strategic transport to the U.S. Air Force's Reliability Enhancement and Re-engining Program (RERP) at the company's Marietta, GA facility. The aircraft is the largest strategic airlifter in the Air Force's fleet.
- The FAA approved Gulfstream Aerospace Corporation's G600 type and production certificates in June 2019, "clear[ing] the way for the first G600 deliveries to customers as scheduled."
- Preci-Dip announced a new $13.6 million plant in Bryan County to produce electronic connector pins with the potential to create 100 new jobs.
- The Georgia Institute of Technology ("Georgia Tech") received $116.4 million in federal research and development funding for aerospace, aeronautical, and astronautical engineering, making it the largest recipient of aerospace university and college R&D funds in the nation.

Costs	**21**
Unit Labor Cost	19
Unit Material Cost	39
Energy Cost	10
Construction Cost	12
Labor & Education	**10**
Aerospace Engineers	14
Aerospace Production Workers	6
Engineering BAs	22
Graduate Degrees	21
High School Degree or More	41
Education Spending	37
Industry	**14**
Aerospace Sales	7
Aerospace Value Added	7
Aerospace Exports	5
Workforce Growth	36
Supplier Density	25
Crowding Out	30
Infrastructure	**24**
Airports	20
Freight Railroad	11
Port Volume	3
Road Condition	28
Transportation Funding	47
Risk to Operations	**21**
Insurance Losses	19
Insurance Premiums	32
Earthquake Premiums	15
Extreme Weather	27
Economy	**14**
GDP Per Capita	29
GDP Per Capita Growth	4
Manufacturing	31
Global Manufacturing Connectivity	20
Unemployment Rate	12
Research & Innovation	**26**
Patents per Capita	28
Public R&D	36
Private R&D	29
High Tech Establishments	12
Taxes & Incentives	**18**
Total Taxes/GDP	6
Workers' Compensation	46
Corporate Income Tax	16
Individual Income Tax	28
Manufacturing Tax	20
Property Tax	18
Sales Tax	33

Atlanta and Savannah Aerospace Clusters



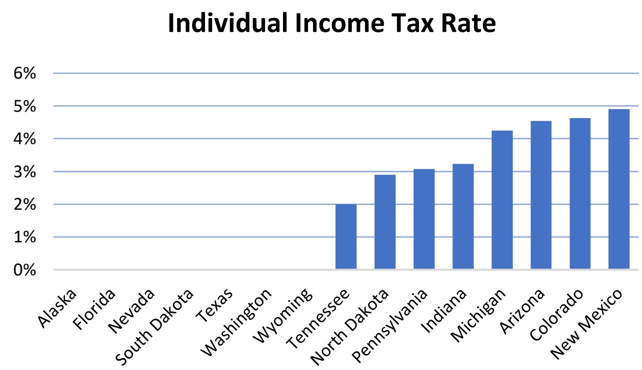
Georgia's aerospace industry is concentrated in two distinct clusters in Atlanta and Savannah. Lockheed Martin Aeronautics assembles the C-130 Hercules military transport plane in Marietta, GA near Atlanta, the longest continuous military aircraft program in history. Delta Airlines also employs almost 35,000 Atlanta-based workers at its global headquarters and at Hartsfield-Jackson Atlanta International Airport. Meanwhile, the Georgia Institute of Technology ("Georgia Tech") in Atlanta has the nation's 4th ranked aerospace engineering program. Savannah-headquartered Gulfstream Aerospace, a subsidiary of General Dynamics, dominates the city's aerospace landscape, employing over 10,000 workers to manufacture the G280, G500, G550, G650 and recently certified G600.

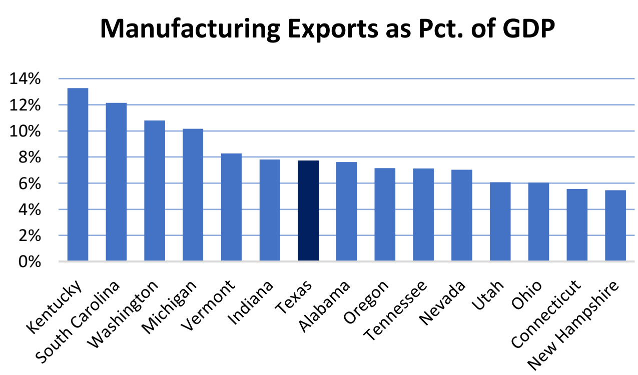
Aerospace Employees	Aerospace Establishments	Advanced Degree Percentage
6,216(ATL)/8,126(SAV)	40/16	14.3%/12.2%
Aerospace Engineers	**Manufacturing GDP**	**Federal Aircraft Contracts**
980/1,080	$13.2B/$2.5B	$255M/$0M

Sources: (Clockwise from Upper Left) QWI (2017/2018); BLS (2018); CPS (2017); USASpending.Gov (2017); BEA (2017); OES (2018/2015).

Texas #8

Texas remains in the top ten and stays at #8 in the overall rankings. Categories that contribute to its finish include Taxes & Incentives (#3), Industry (#10) and Economy (#18). While Texas saw year-over-year gains in Industry and Infrastructure, it dropped in Costs, Economy and Risk to Operations.





Tax policy in Texas is highly attractive with top ten rankings in Individual Income Tax, Corporate Income Tax, Manufacturing Tax, Workers' Compensation and Total Tax/GDP. Other top ten finishes include Aerospace Sales, Value Added, Exports, Energy Cost, Earthquake Premiums and Global Manufacturing Connectivity.

- Triumph's Technology and Engineering Center in Arlington, TX is partnering with Mitsubishi Aircraft Corporation to support the design and development of the Mitsubishi SpaceJet M100. Triumph Aerospace Structures will design major structures of the aircraft optimizing weight, cost, and producibility in support of the program.
- Lockheed Martin of Fort Worth, TX delivered the 400th production F-35 with a full-year plan to deliver over 130 of the aircraft for all of 2019. The Initial Operational Test and Evaluation phase of the F-35 is expected to end this year and the System Development and Demonstration phase will begin and enter into full rate production.
- Solvay Composite Materials expanded it resin mixing capacity by locating in Greenville, TX. Solvay serves the growing demand for out-of-autoclave technologies.
- Web Industries announced a $1.5 million, 20,000 ft^2 facility to create new multi-layer insulation (MLI) for satellites and rockets, and composite ply cutting production cells for aerospace engines.
- Aeromax Industries, Inc., a manufacturer of parts and assemblies for military aircraft, plans to relocate its headquarters from Canoga Park, CA to a 12,000 ft^2 facility in the Aledo Industrial Park near Fort Worth.
- Private equity firm Arlington Capital Partners acquired Triumph Group's four fabrication businesses to create Radius Aerospace Inc., which operates a 145,000 ft^2 plant in Fort Worth.

Costs	**30**
Unit Labor Cost	23
Unit Material Cost	29
Energy Cost	7
Construction Cost	42
Labor & Education	**22**
Aerospace Engineers	13
Aerospace Production Workers	20
Engineering BAs	11
Graduate Degrees	37
High School Degree or More	50
Education Spending	42
Industry	**10**
Aerospace Sales	3
Aerospace Value Added	3
Aerospace Exports	3
Workforce Growth	37
Supplier Density	18
Crowding Out	45
Infrastructure	**33**
Airports	21
Freight Railroad	36
Port Volume	7
Road Condition	32
Transportation Funding	34
Risk to Operations	**32**
Insurance Losses	31
Insurance Premiums	50
Earthquake Premiums	7
Extreme Weather	16
Economy	**18**
GDP Per Capita	17
GDP Per Capita Growth	33
Manufacturing	27
Global Manufacturing Connectivity	7
Unemployment Rate	26
Research & Innovation	**22**
Patents per Capita	20
Public R&D	27
Private R&D	26
High Tech Establishments	11
Taxes & Incentives	**3**
Total Taxes/GDP	7
Workers' Compensation	9
Corporate Income Tax	4
Individual Income Tax	1
Manufacturing Tax	9
Property Tax	39
Sales Tax	40

Dallas-Fort Worth Aerospace Cluster

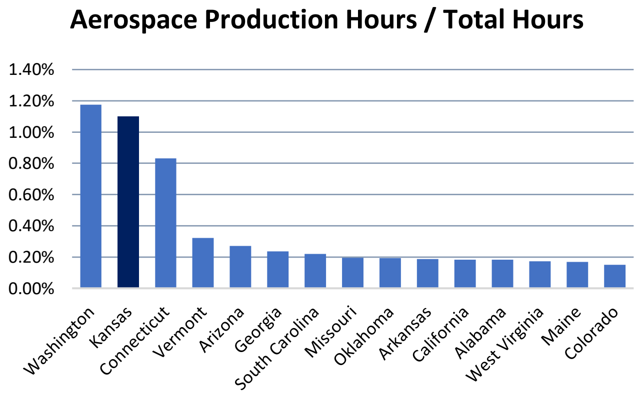
Dallas-Fort Worth ("DFW") is Texas' primary aerospace cluster and is dominated by the defense industry. Lockheed Martin Aeronautics, headquartered in Fort Worth, operates a 16,400-employee factory in the city constructing 130 F-35 fighter jets per year as part of the largest military program of all time. Raytheon employs 8,000 people in the DFW region and announced construction of a 200,000-square-foot manufacturing plant in McKinney set to open in 2020. Bell Helicopter Textron is headquartered in DFW, while Triumph Group's flagship plant in Red Oak will build the wing, vertical tail and horizontal tail structures for Boeing-Saab's T-X trainer jet. The University of North Texas is based in Denton, while the University of Texas operates satellite campuses in Arlington and Dallas.

Aerospace Employees	Aerospace Establishments	Advanced Degree Percentage
32,990	107	12.0%
Aerospace Engineers	**Manufacturing GDP**	**Federal Aircraft Contracts**
3,140	$43.2B	$16,816M

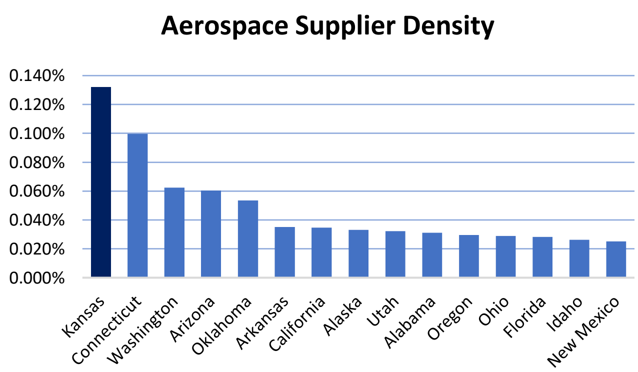
Sources: (Clockwise from Upper Left) QWI (2017/2018); BLS (2018); CPS (2017); USASpending.Gov (2017); BEA (2017); BLS OES (2018).

Kansas #9

Kansas at #9 drops five spots in this year's rankings. The state is particularly strong in two categories, Industry (#3) and Labor & Education (#4); and achieves two other top twenty finishes in Economy (#15) and Infrastructure (#18). Kansas experienced a sharp drop in the Costs and Research & Innovation categories rankings, while its position in the Economy category rose.



With major aerospace companies like Spirit, Boeing, Airbus, Cessna, and Raytheon, Kansas has a strong industry presence and ranks high in a number of metrics: Aerospace Sales, Aerospace Value Added, Aerospace Exports, Supplier Density, Aerospace Engineers and Aerospace Production Workers.

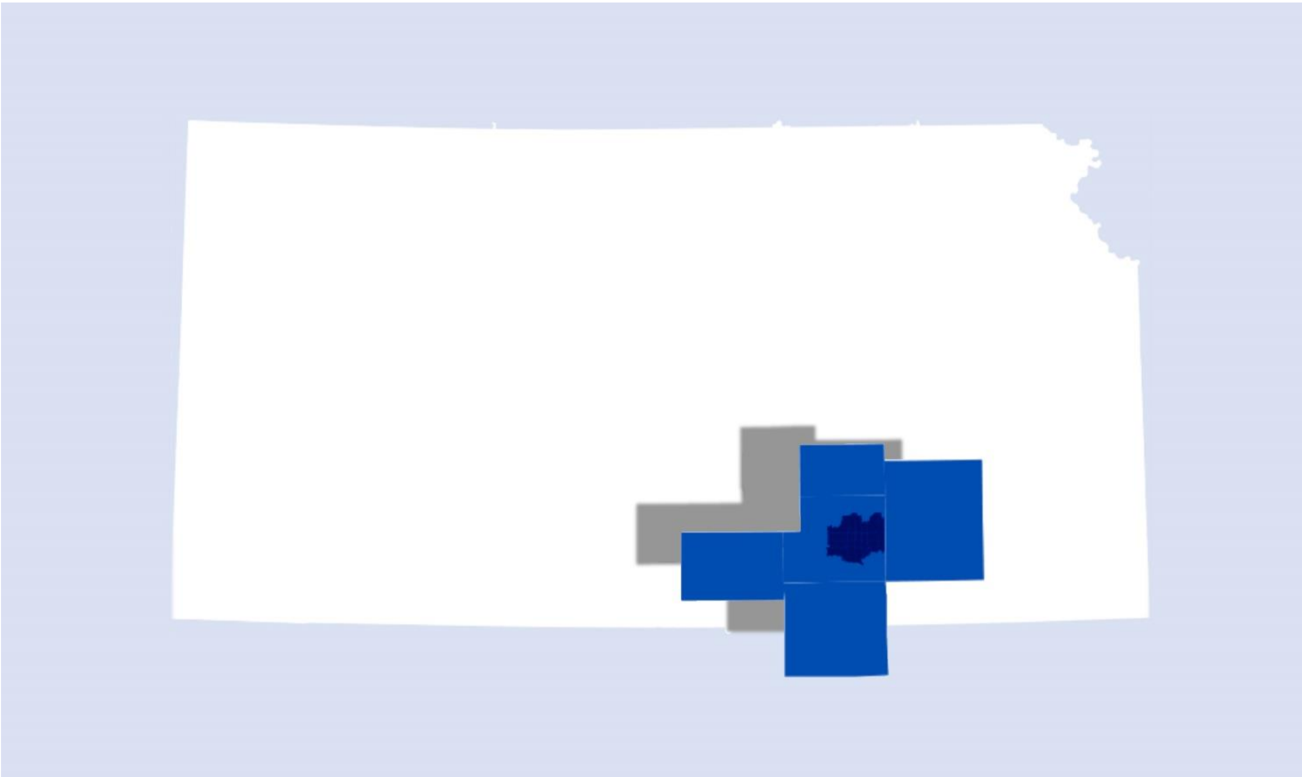


The drop in the state's overall ranking was primarily due to a less competitive cost position. All of the individual cost metrics experienced a decline in rank from a year ago.

- The FAA certified Textron's Citation Longitude, the largest and most ambitious business jet built by the company so far. Textron (and its predecessor companies) have built over 7,500 Citation business jets over a 50-year period.
- Spirit AeroSystems of Wichita, KS launched its new composites manufacturing technology designed for the next-generation, high-volume, single-aisle fuselage production. It is projected to generate a 30% reduction in cost and yield substantially higher production rates.
- Spirit AeroSystems announced that it plans to add 1,400 additional employees to its Kansas-based commercial and defense aerospace businesses. Spirit will build a new 150,000 ft^2 Global Digital Logistics Center at its Wichita campus, housing the Raw Material Cutting Center of Excellence, and a 150,000 ft^2 Global Digital Logistics Center in Wichita.
- Park Aerospace, developer and manufacturer of advanced composite materials for the aerospace industry, announced construction of a $19 million, 90,000 ft^2 facility at its current site in Newton, KS outside of Wichita, potentially adding 73 new jobs.

Costs	**26**
Unit Labor Cost	26
Unit Material Cost	19
Energy Cost	32
Construction Cost	24
Labor & Education	**4**
Aerospace Engineers	3
Aerospace Production Workers	2
Engineering BAs	28
Graduate Degrees	17
High School Degree or More	17
Education Spending	33
Industry	**3**
Aerospace Sales	6
Aerospace Value Added	5
Aerospace Exports	12
Workforce Growth	33
Supplier Density	1
Crowding Out	20
Infrastructure	**18**
Airports	30
Freight Railroad	24
Port Volume	22
Road Condition	10
Transportation Funding	30
Risk to Operations	**49**
Insurance Losses	43
Insurance Premiums	47
Earthquake Premiums	29
Extreme Weather	30
Economy	**15**
GDP Per Capita	24
GDP Per Capita Growth	24
Manufacturing	14
Global Manufacturing Connectivity	27
Unemployment Rate	12
Research & Innovation	**32**
Patents per Capita	27
Public R&D	50
Private R&D	22
High Tech Establishments	21
Taxes & Incentives	**31**
Total Taxes/GDP	27
Workers' Compensation	6
Corporate Income Tax	31
Individual Income Tax	27
Manufacturing Tax	25
Property Tax	36
Sales Tax	44

Wichita Aerospace Cluster



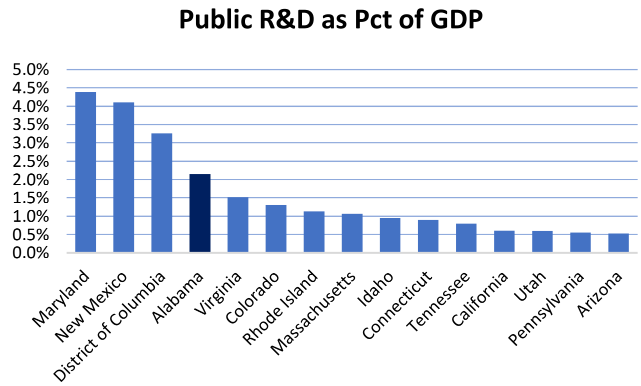
Kansas' largest aerospace cluster is centered in Wichita and anchored by Spirit AeroSystems. Wichita-based Spirit, the world's largest aerostructures supplier, employs roughly 11,000 primarily union workers to manufacture Boeing 737 fuselages, 747, 767, 777 and 787 forward fuselages, 737 thrust reversers and other major aircraft components. A number of aerospace companies also produce smaller planes in the area. Textron Aviation is headquartered in Wichita and produces Cessna and Beechcraft business jet single-engine piston and turboprop aircraft, while Bombardier's Learjets are manufactured at a Wichita facility. Wichita State University's National Institute for Aviation Research tests aerospace technology, conducts aerospace research and educates aerospace engineers.

Aerospace Employees	Aerospace Establishments	Advanced Degree Percentage
28,971	126	11.0%
Aerospace Engineers	**Manufacturing GDP**	**Federal Aircraft Contracts**
1,800	$6.5B	$78M

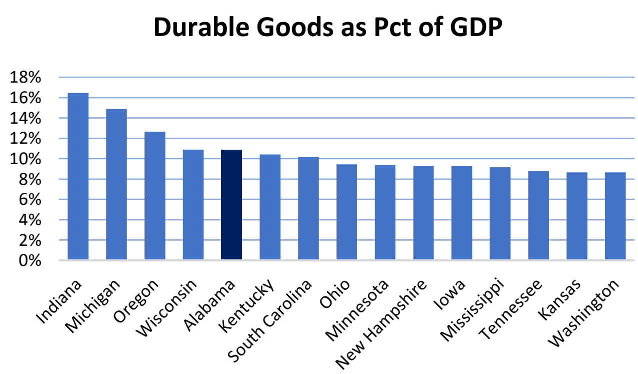
Sources: (Clockwise from Upper Left) QWI (2017/2018); BLS (2018); CPS (2017); USASpending.Gov (2017); BEA (2017); BLS OES (2018).

Alabama #10

Completing the top ten is Alabama. Key contributing categories include Taxes & Incentives (#8), Industry (#9) and Labor & Education (#12). Alabama retained the #10 overall ranking from 2018 to 2019. Its year-over-year performance saw a strong improvement in the Costs category. However, this was offset by drops in Economy, Taxes & Incentives and Infrastructure.



With major industry companies like Lockheed Martin, Boeing, Airbus and United Technologies, Alabama has a highly technical aerospace presence. It is number one in the Aerospace Engineers metric and performs well in Aerospace Sales, Aerospace Value Added, Aerospace Exports and Supplier Density.



It also ranks high with low Manufacturing Taxes, Property Taxes, Energy Costs and Construction Costs.

- Airbus is close to beginning assembly for the A220 jetliner (formerly Bombardier's CSeries) at its Mobile, AL facility. Major components began arriving in the first half of 2019 and the first wave of A220 employees is being trained in Canada. A220 deliveries are scheduled to begin in mid-2020.
- The A220 line will join Airbus's first jetliner assembly line in Mobile. In December, the 100th A320 series aircraft was delivered from this line, going to Frontier Airlines. A320 deliveries at Mobile are running at four per month.
- Defense contractor BAE Systems announced a $45.5 million expansion in Huntsville, including a new 83,000 ft² state-of-the-art manufacturing and office space facility.
- United Launch Alliance made significant progress in the manufacture of its Vulcan Centaur launch vehicle, scheduled for launch in 2021. It is being manufactured in Decatur, GA and will be powered by Blue Origin engines built in Huntsville, AL.
- Blue Origin broke ground on a $200-million rocket engine production facility in Huntsville to manufacture the BE-4 engine used to power the Vulcan rocket.
- Carpenter Technology, a maker of specialty alloys, announced construction of a $52-million Emerging Technology Center focused on additive manufacturing (AM) technology development in Limestone County.

Category	Rank
Costs	**25**
Unit Labor Cost	22
Unit Material Cost	43
Energy Cost	13
Construction Cost	12
Labor & Education	**12**
Aerospace Engineers	1
Aerospace Production Workers	12
Engineering BAs	32
Graduate Degrees	41
High School Degree or More	45
Education Spending	40
Industry	**9**
Aerospace Sales	14
Aerospace Value Added	12
Aerospace Exports	13
Workforce Growth	19
Supplier Density	10
Crowding Out	39
Infrastructure	**40**
Airports	36
Freight Railroad	20
Port Volume	14
Road Condition	17
Transportation Funding	43
Risk to Operations	**24**
Insurance Losses	21
Insurance Premiums	40
Earthquake Premiums	17
Extreme Weather	19
Economy	**23**
GDP Per Capita	46
GDP Per Capita Growth	37
Manufacturing	5
Global Manufacturing Connectivity	8
Unemployment Rate	29
Research & Innovation	**33**
Patents per Capita	47
Public R&D	4
Private R&D	31
High Tech Establishments	40
Taxes & Incentives	**8**
Total Taxes/GDP	12
Workers' Compensation	23
Corporate Income Tax	24
Individual Income Tax	19
Manufacturing Tax	3
Property Tax	2
Sales Tax	47

Huntsville Aerospace Cluster

Huntsville, once known as "Rocket City," is the center of Alabama's aerospace industry. Home to NASA's Marshall Space Flight Center with almost 6,000 employees conducting rocketry and spacecraft propulsion research, Huntsville also hosts 2,900 Boeing employees working on NASA's Space Launch System, as well as air and missile defense. Aerojet Rockedyne opened its rocket propulsion Advanced Manufacturing Facility in 2019, and Jeff Bezos' Blue Origin's BE-4 rocket engine plant is set to open in 2020. Northrup Grumman, Dynetics, Inc., Lockheed Martin Corporation and Teledyne Brown Engineering also have significant operations in Huntsville, while Alabama A&M University and the University of Alabama in Huntsville train the next generation of aerospace engineers.

Aerospace Employees	Aerospace Establishments	Advanced Degree Percentage
5,164	26	14.8%
Aerospace Engineers	**Manufacturing GDP**	**Federal Aircraft Contracts**
3,310	$3.2B	$355M

Sources: (Clockwise from Upper Left) QWI (2017/2018); BLS (2018); CPS (2017); USASpending.Gov (2017); BEA (2017); BLS OES (2018).

Other Results

In addition to the top ten, a number of other states score well in individual categories. However, in order to rank highly overall, a state must score fairly high in a number of categories and not rank near the bottom in multiple categories.

The Infrastructure category is interesting in that not one of the overall top ten aerospace manufacturing competitiveness states appears in the top ten for Infrastructure. Of the overall top ten states only Washington, Ohio and Kansas rank in the top twenty in the Infrastructure category.

Category Rank	Costs	Labor & Education	Industry	Infrastructure	Risk to Operations	Economy	Research & Innovation	Taxes & Incentives
#1	**Washington**	Connecticut	**Washington**	Massachusetts	**Arizona**	**Washington**	Massachusetts	South Dakota
#2	**North Carolina**	**Washington**	California	Illinois	Michigan	New Hampshire	California	Indiana
#3	Missouri	Vermont	**Kansas**	Vermont	**Utah**	Massachusetts	**Utah**	**Texas**
#4	Iowa	**Kansas**	**Ohio**	Dist. of Columbia	Oregon	Wisconsin	Connecticut	**Utah**
#5	South Dakota	**Colorado**	Connecticut	New York	**Washington**	Oregon	**Colorado**	**Washington**
#6	Arkansas	Maryland	**Arizona**	Pennsylvania	Maine	Iowa	**Washington**	North Dakota
#7	West Virginia	California	**North Carolina**	Maryland	**Ohio**	Minnesota	New Hampshire	Nevada
#8	Kentucky	**Arizona**	Florida	Connecticut	New Mexico	**Utah**	Maryland	**Alabama**
#9	Wyoming	**Ohio**	**Alabama**	North Dakota	Nevada	Indiana	New Jersey	Oklahoma
#10	Indiana	**Georgia**	**Texas**	Florida	Wisconsin	Michigan	**Arizona**	Tennessee

Note: Overall top ten states are **bolded**.

Another category of note is Industry. Seven overall top ten performing states appear in the category. The three other Industry top ten states (California, Connecticut and Florida) are clearly top aerospace producing states (but, not necessarily for large aircraft structures), yet they do not have sufficient strength across enough other categories to propel them into the overall top ten. A number of states moved up or down by a significant amount in this year's rankings.

Winners

State	Overall Rank (2019)	Overall Rank (2018)	Gain
Vermont	29	41	+12
Maryland	22	33	+11
Connecticut	14	24	+10
Arizona	4	9	+5
Indiana	11	16	+5
Iowa	23	28	+5
Utah	3	7	+4
Pennsylvania	21	25	+4
Arkansas	25	29	+4
New York	36	40	+4
New Jersey	46	50	+4

Losers

State	Overal l Rank (2019)	Overall Rank (2018)	Loss
South Dakota	32	17	-15
Hawaii	49	38	-11
Wisconsin	26	19	-7
Oregon	34	27	-7
Idaho	40	34	-6
Kansas	9	4	-5
Virginia	17	12	-5
South Carolina	27	22	-5
Wyoming	31	26	-5
Oklahoma	19	15	-4
North Dakota	24	20	-4

Indiana almost moved into the top ten. Finishing at #11 overall, Indiana is strong in Taxes & Incentives (#2), Economy (#9) and Costs (#10). Contributing to its rise were solid improvements in Labor & Education, Costs, Taxes & Incentives and Risks to Operations.

Connecticut finished at #14, moving up ten positions from its 2018 finish at #24. It is very strong in Labor & Education (#1), Research & Innovation (#4), Industry (#5) and Infrastructure (#8). However, Connecticut also performs poorly in two key categories: Costs (#48) and Taxes & Incentives (#43).

ACES Results 2019 vs. 2018

Several states made substantial gains or suffered significant declines in their index value and relative ranking.

A state's index value is the sum of its weighted ranking (category weight x metric weight x rank) for all 41 metrics in the ACES rankings. It can be thought of as a state's weighted average rank. The lower the index value the better a state's overall competitiveness. Each state's movement in the rankings between 2018 and 2019 is noted with an arrow.

State	2019		Rank Change	2018	
	Index Value	Rank		Index Value	Rank
Washington	11.79	1	↔	11.60	1
Ohio	18.85	2	↔	19.00	2
Utah	19.52	3	↑	20.34	7
North Carolina	20.54	4	↓	19.48	3
Arizona	20.55	5	↑	20.61	9
Colorado	20.79	6	↓	20.25	5
Georgia	21.23	7	↓	20.31	6
Texas	21.67	8	↔	20.52	8
Kansas	21.68	9	↓	19.53	4
Alabama	22.06	10	↔	21.36	10
Indiana	22.11	11	↑	23.73	16
Missouri	22.16	12	↓	22.63	11
California	23.45	13	↑	23.63	14
Connecticut	23.87	14	↑	25.03	24
Florida	23.97	15	↑	24.53	18
Michigan	24.11	16	↓	23.59	13
Virginia	24.25	17	↓	23.46	12
Kentucky	24.27	18	↑	24.93	21
Oklahoma	24.39	19	↓	23.67	15
Massachusetts	24.41	20	↑	24.99	23
Pennsylvania	24.71	21	↑	25.38	25
Maryland	24.97	22	↑	26.52	33
Iowa	25.03	23	↑	25.71	28
North Dakota	25.07	24	↓	24.92	20
Wisconsin	25.43	25	↓	24.58	19
Arkansas	25.45	26	↑	25.73	29
South Carolina	25.78	27	↓	24.98	22
New Hampshire	25.82	28	↑	26.17	31
Vermont	26.22	29	↑	28.42	41
Minnesota	26.39	30	↔	26.04	30
Wyoming	26.67	31	↓	25.66	26
South Dakota	26.69	32	↓	24.48	17
Delaware	26.71	33	↑	28.05	36
Oregon	26.79	34	↓	25.69	27
West Virginia	27.12	35	↓	26.33	32
New York	27.26	36	↑	28.40	40
New Mexico	27.65	37	↑	28.36	39
Nevada	27.73	38	↓	27.74	35
Illinois	27.96	39	↓	28.24	37
Idaho	28.03	40	↓	26.85	34
Alaska	28.92	41	↑	29.38	44
Tennessee	29.49	42	↑	29.07	43
Nebraska	29.64	43	↓	28.53	42
Maine	30.00	44	↑	30.74	46
District of Columbia	30.62	45	↑	31.70	48
Hawaii	31.23	46	↓	28.27	38
New Jersey	31.27	47	↑	32.84	50
Mississippi	31.30	48	↓	31.26	47
Louisiana	31.77	49	↓	30.65	45
Montana	33.16	50	↓	32.06	49
Rhode Island	36.69	51	↔	37.17	51

AEROSPACE CLUSTER DYNAMICS

ACES 2019 defines aerospace clusters as metropolitan areas with a high level of concentrated aerospace industrial activity. In addition to the ACES state-level rankings, this year's report drills down to identify, analyze, and consider factors affecting the most important aerospace clusters for each top ten state. Two factors play an outsized role in determining whether these clusters are suitable for placement of a production site for new commercial aircraft: the presence or absence of a dominant incumbent prime contractor, and the relative concentration of military production in the cluster. The presence of "fortress clusters" with a strong existing incumbent, or "military clusters" with a heavy defense contracting presence crowding out commercial investment, present challenges for the placement of new commercial aircraft manufacturing

Fortress Clusters and Incumbent Primes

Fortress clusters are aerospace clusters dominated by a single prime contractor, or by another systems contractor (usually engines), as opposed to a region where multiple contractors play important roles. This distinction is important. If a prime contractor effectively dominates a cluster, the cluster's suppliers are heavily tied to that prime. Suppliers have an economic incentive to gear production toward meeting the financial terms, material specifications and manufacturing priorities of the prime contractor, which make it hard for a new entrant to establish a presence in the market. Additionally, the prime may shape the cluster's labor market to meet its specific business needs, leaving newcomers with an absence of workers with appropriate skill sets.

Examples of fortress clusters, ones that are heavily dominated by one large aerospace company, include:

- Southern Ohio (General Electric)
- Central Connecticut (Pratt & Whitney)
- Sao Jose Dos Campos, Brazil (Embraer)
- Savannah, Georgia (Gulfstream)

The Puget Sound area fits the description of a fortress cluster in many ways. But the region's very large aerospace labor force makes it a reasonable option for newcomer firms, despite Boeing's dominance. Tax incentives can further increase the appeal for any newcomer seeking to locate in Puget Sound, or any other fortress cluster that chooses to offer these incentives.

Examples of clusters that are less dominated by a single contractor:

- Dallas/Fort Worth (although the F-35 ramp-up is coming to play a growing, and perhaps eventually dominant role in local aerospace economic conditions and labor markets, perhaps creating a de facto Lockheed Martin fortress cluster).
- Southern California
- Montreal, Canada
- Wichita, Kansas
- Western North Carolina
- Huntsville, Alabama

It is not terribly unusual, at least in the past decade, for contractors with a fortress cluster to set up production lines elsewhere, but they are almost always secondary lines. This means they are either moved to these new locations after the primary line provides the company with the necessary experience to mature a new program,

or, alternatively, the company decides to establish secondary lines in the new location without abolishing the original location.

An example of the first would be Embraer's business jet production lines in Florida. An example of the second would be Airbus's single aisle jetliner facilities in Alabama and China. Sometimes, as with Boeing's second 787 line in Charleston, there's a mix of both. Boeing learned important lessons about building the 787 in Everett, then migrated this knowledge to Charleston, but has since kept both lines going.

By contrast, it is very unusual, if not unprecedented, for a firm to bring a new production line into another company's fortress cluster. If someone were to build a new civil program in Savannah, for example, they would find the local aerospace supply chain and labor market heavily dominated by Gulfstream.

The newcomer company might be able to find trained aerospace talent and other attractive features at this other company's cluster, but they'd need to time their arrival carefully. If they showed up at a fortress cluster at a time of prosperity for the incumbent contractor, they'd find that worker skill sets and working conditions were effectively determined by that incumbent contractor. The newcomer company would also find it difficult to determine terms and conditions for local suppliers, since they'd already be enjoying prosperity by catering to the incumbent firm.

For this reason, these fortress clusters would be very unlikely sites for a new aircraft production line. However, it should be noted that Boeing's 80% acquisition of Embraer's jetliner unit means that Sao Jose Dos Campos is no longer out-of-bounds for Boeing, as it is effectively their fortress cluster.

While the authors of this report do not believe that the economics (or politics) of this site lend themselves to a new aircraft line, the acquisition has led some observers to conclude that Sao Jose Dos Campos is now in play as a possible future site for Boeing.

Military Clusters and Crowding Out

The nature of aerospace clusters also illustrates the impact and threat of crowding out in military clusters dominated by defense manufacturing. Crowding out is a term we use to describe military investment that makes commercial manufacturing economics, particularly the ratio of wages to productivity, more challenging for manufacturers. Aerospace clusters with a significant defense industry footprint ("military clusters") may see their costs driven up for commercial aerospace manufacturers, crowding out existing and future commercial aerospace production, including a potential NMA production line.

The process of crowding out occurs because defense contracts allow for a degree of cost inflation above and beyond productivity levels, particularly for wages. Cost-plus procurement contracts, which are still largely the norm in defense, reimburse contractors for all costs. Thus, in any area where there is competitive tension between companies (and a high level of demand due to strong markets), the company working on a defense contract will have a strong economic advantage over a commercial company. The latter needs to keep costs as low as possible, because their customer simply expects a low, fixed-price. In fact, the commercial jetliner world not only disallows inflation, but in terms of realized price, it has become deflationary in real terms.

Crowding out mostly occurs in regions with a very high level of defense work, and usually in a time of key defense program ramp-up. Since the US defense budget is at a very high level in historical terms, with plans for even higher levels in the coming years, it represents an issue that civil contractors need to deal with in particular regions.

Sometimes, crowding out can even be "weaponized." According to several sources, McDonnell's 1967 acquisition of Douglas Aircraft was accompanied by a deliberate threat to inflate labor rates. At a high point in military aircraft procurement due to the Vietnam War, McDonnell had a great deal of latitude in raising labor rates, which would have put Douglas's largely commercial programs at a disadvantage. The threat, or likely imminent practice, of doing this played a role in convincing Douglas's ownership to sell to McDonnell.

The Dallas-Fort Worth aerospace cluster provides a good example of crowding out. During the 1980s, Bell Helicopter expected the V-22 tiltrotor, and other key company military programs, to ramp up at a fast pace, along with military programs at other contractors in the region. In particular, the General Dynamics/McDonnell Douglas A-12 US Navy stealth attack jet was supposed to produce considerable work for the cluster.

This anticipated regional military ramp-up, along with its expected cost inflation, was one of several factors that led Bell to relocate its civil helicopter programs to Canada in 1988. Mirabel, and the greater Montreal aerospace cluster, has very little military work, and thus is subject to much lower levels of cost inflation. It could be said that Bell's Model 206 and 212/412 civil helicopters were crowded out by an anticipated avalanche of military work.

Ultimately, the V-22 program was hit by technical delays and the post-Cold War budget downturn, and the A-12 was canceled outright. As a result, the Dallas-Fort Worth area spent the 1990s in something of an aerospace slump, particularly as the General Dynamics (later Lockheed) F-16 program ramped down as well. Additionally, Bell decided to put the V-22 line in Amarillo rather than Dallas-Fort Worth as a further cost-control measure. Bell's civil departure didn't help either.

By the late 2000s, the defense sector began growing again as Lockheed Martin's F-35 program ramped up in Fort Worth. Deliveries rose from 6 aircraft in 2008 to 91 in 2018. They are scheduled to rise above 160 aircraft per year by the middle of the next decade. This represents a major source of demand for aerospace workers, supplier companies and supplier company workers located in the region.

Each F-35 has a higher unit price than the likely commercial cost of an NMA, and it should be noted that the F-35's customers are far less cost-sensitive than airlines and thus willing to reimburse higher manufacturing costs. Clearly, Lockheed will set the price, terms and conditions for aerospace work in the Dallas-Fort Worth area for years to come.

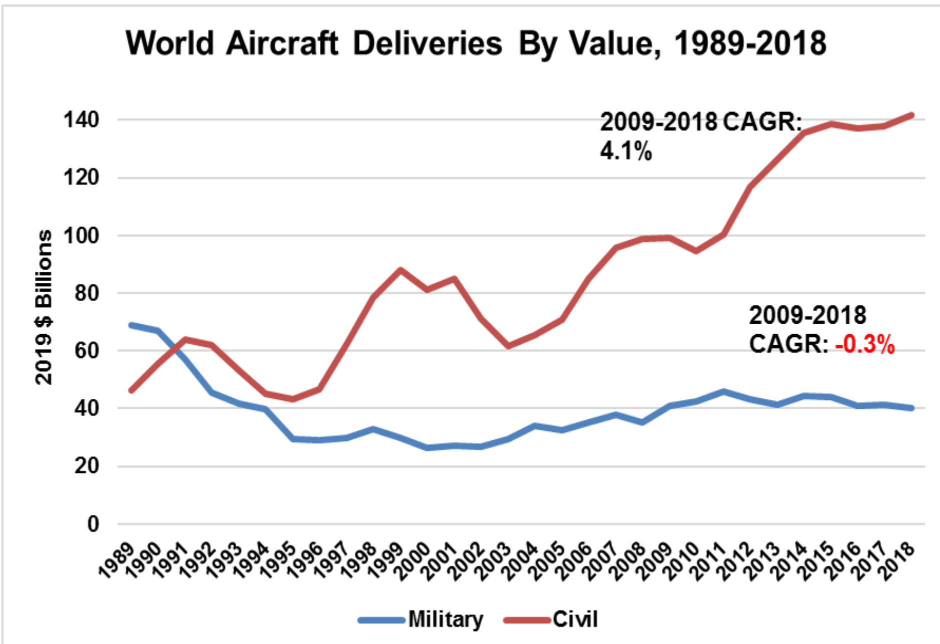
Crowding out is also more of a problem in regions where the ratio of wages to productivity is already high. Southern California has done reasonably well with defense projects – Northrop Grumman's new B-21 stealth bomber will be built there – because regional wage rates are driven by cost-plus contracts. By contrast, the civil aircraft industry, with a few small exceptions, has largely been dead since the last McDonnell Douglas commercial jet (under Boeing ownership) was built there in 2006.

In terms of Boeing's NMA decision, concerns about crowding out will likely rule out any region with a high concentration of military work, and any region with fast-growth military programs. In particular, Southern California and Dallas-Fort Worth are almost certainly out of the running for the NMA.

GLOBAL AIRCRAFT MARKET FORECAST AND ANALYSIS

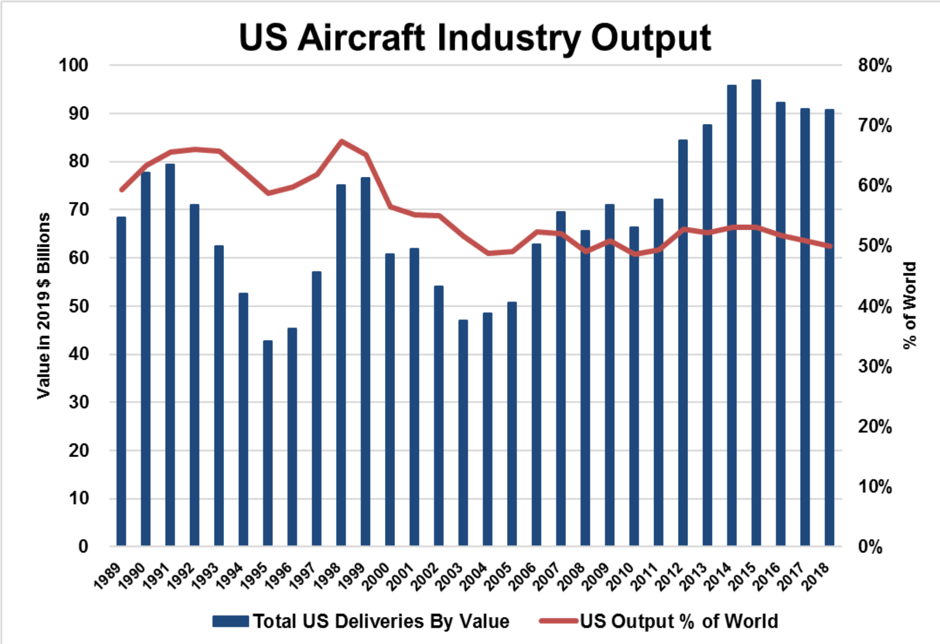
The World Aircraft Market: Still Growing, And More Concentrated

The World aviation market has slowed in recent years. The Civil market has enjoyed a respectable 4.1% Compound Annual Growth Rate in deliveries by value over the last ten years, as seen in our Aircraft Deliveries Chart. But this growth story is complicated by the divergent fortunes of the various civil segments; jetliners have enjoyed ten great years, but all the others are weak. The Military aviation segment, by contrast, has been flat for some time, although it is poised for renewed growth.



At the start of the year, single aisle jetliners and fighter aircraft were the only two aviation segments driving aircraft market growth. Every other industry segment was either flat or down. Unfortunately, after the second 737MAX disaster, the deliveries halt and production cut for this series means single aisles won't contribute to growth this year, despite the A320 and A220 output increases.

As our US Output Chart indicates, US primes' share of this industry has remained relatively steady at about 50% by value of deliveries for the last two decades. As the industry topline has grown, so has US output. While this chart measures output solely at the prime level, US industry continues to do very well at the subcontractor level, exceeding the 50% mark in most key segments (engines, avionics, etc.) and equaling the 50% level in others (aerostructures, control systems, etc.).



The primary drivers of US industry at the prime level include Boeing jetliners and fighters, Lockheed Martin fighters, Gulfstream business jets, and rotorcraft from all three primes (Boeing, Textron/Bell, and Lockheed Martin/Sikorsky). Many other smaller manufacturers play a supporting role.

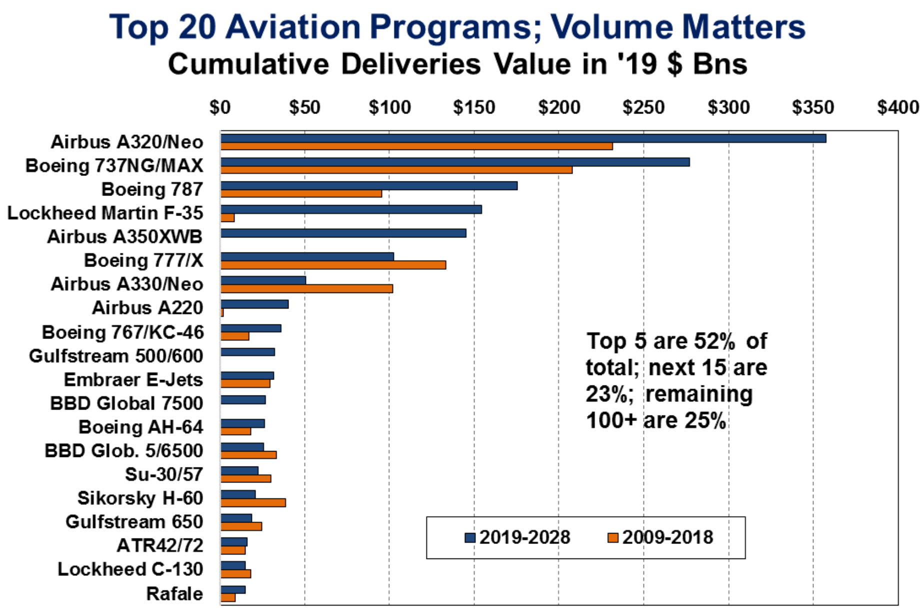
Given the relatively steady state nature of this industry, where there are few major disruptions and product life cycles are measured in decades, it isn't surprising that the US's aerospace trade surplus is relatively steady. The US has enjoyed a roughly 2.5-1 aerospace trade advantage by value with the rest of the world for decades. This higher ratio of recorded exports (compared with 1-1 output at the prime level, shown in the previous chart) reflects US industry's success at the subcontractor level, along with success in space systems, missiles, and in other markets.

The world aircraft industry today is increasingly controlled by Airbus and Boeing. First, large commercial jets are now about 60% of total industry output by value, not just at the final delivery level but through most of the component and structures supply chain, too. Our deliveries chart in the previous section indicates the growing dominance of civil aircraft in the industry; our Top 20 Aviation Programs chart, below, shows the overwhelming dominance of jetliners within the civil business."

Second, Airbus and Boeing dominate because they are absorbing a greater share of the industry. The acquisition of Bombardier's CSeries, now known as the Airbus A220 family, gives Airbus a new line of 110/130-seat jets. Meanwhile, Embraer and Boeing are moving towards creating a joint venture – to be controlled by Boeing – covering Embraer's E-Jet series, spanning 75-120 seats (discussed later in the Brazil section of this report).

Therefore, in a year, the entire jet transport industry will be controlled by just two companies. And barriers to entry remain extremely high, as evidenced by China's multi-decade effort to break into the market, with few signs of success. Russia is trying to re-enter this industry, but it also faces a long and difficult road, particularly with Western sanctions hobbling development efforts.

This industry is not just protected by high entry barriers; it also features extreme concentration at the top, in terms of major revenue-producers. Just a small number of jetliner models play a pivotal role in driving the market. Our Top 20 Aviation Programs Chart shows revenue from deliveries over the past ten years and Teal Group's forecast for the next ten. The two major single aisle programs – Airbus's A320 series and Boeing's 737 family – constitute 25% of industry revenue.



Of the top five programs (which represent half the aircraft industry in revenue) just one, Lockheed Martin's F-35 Joint Strike Fighter, is not a jetliner. Jetliners comprise eight of the top ten aviation manufacturing programs. As discussed directly below, this market has enjoyed very strong growth, but has now entered uncertain territory.

The Difficult Jetliner Market

Jetliner news this year has been dominated by bad program headlines. The 737MAX disaster, along with 777X program delays, A330neo problems, doubts about Boeing's NMA, and of course the long-awaited death of the A380, have cast shadows over the industry.

But market demand developments are actually more concerning. After years of above-trend air traffic growth, air travel demand has slowed markedly this year.

The industry has long regarded 5% as the long-term sustainable annual growth rate for air travel demand in revenue passenger kilometers. But we've enjoyed a decade of nicely above-trend growth, averaging 6-7%, with 7.6% in 2017 and 6.5% last year (according to the International Air Transport Association). Yet starting in February, this important metric downshifted noticeably. Through July, year-to-date growth has been 4.7% over the same period last year (which saw 6.9%), and July itself was a meager 3.6%.

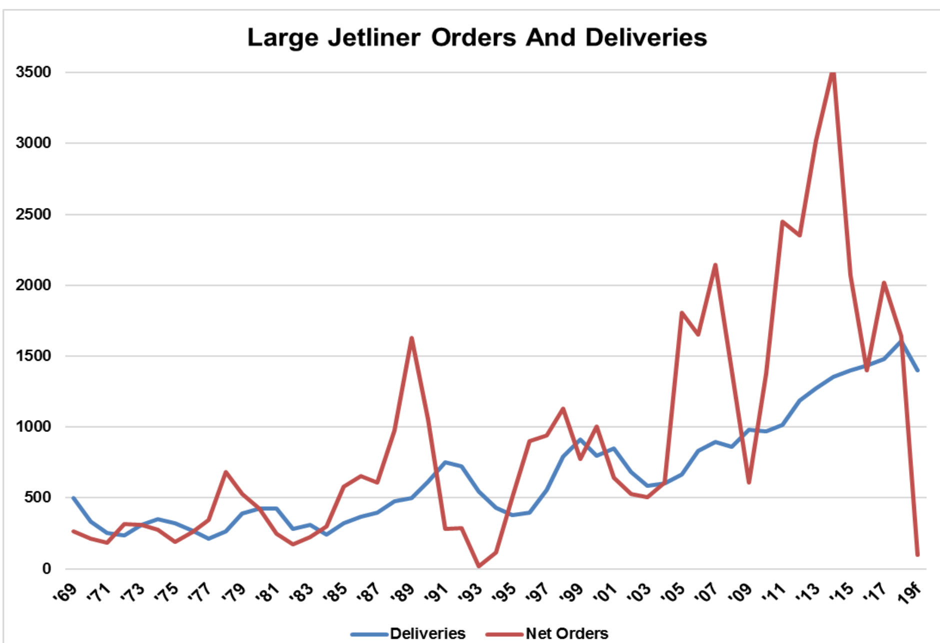
This six-month market drop might be a temporary slowdown, or it might presage a global economic recession. The latter would likely see a sustained decline in air travel demand, lasting a year or longer.

The good news is that traffic is just one of three primary drivers behind jetliner market growth. The ratio between the price of fuel and the cost of capital, and China, are the two other big drivers. Right now, interest rates are relatively low, so jetliner finance terms are reasonable too. Fuel prices are near perfect at around $60/bbl – neither too high for airlines to make money, nor too low to keep airlines hanging on to older equipment. So, this fuel-to-cash indicator is in good shape.

China is a more complicated story. Last year the country took 23% of world jetliner deliveries, a record. China is also a relatively bright spot for travel demand, still growing at around 10% annually. Chinese money continues to play a large role in world jetliner finance. But the US-China trade war could easily impact sales, at least from Boeing.

Despite the current health of the other two market indicators, ultimately, passenger travel demand is the single best jetliner market driver. Airlines have been matching this demand growth drop with an even sharper capacity growth drop, which has helped to maintain airline industry profitability. Passenger load factors in July have hit yet another record high, 85.7%.

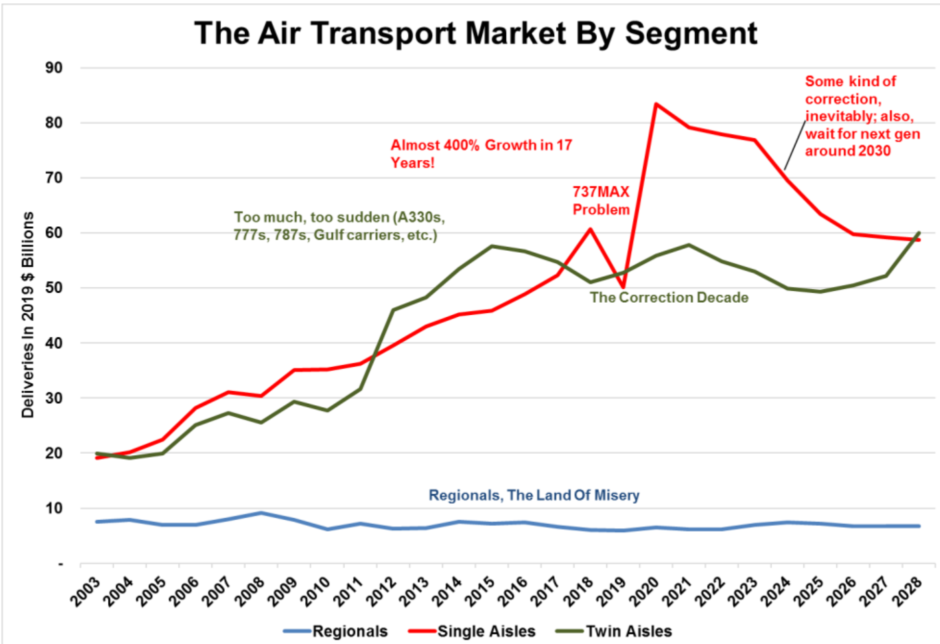
The airlines' efforts to keep a lid on capacity also means that orders have fallen to levels unseen in over 25 years. Through August, Airbus has received a mere 95 net orders this year. Boeing, through August, has recorded negative 85 orders. As the Large Jetliner Orders and Deliveries Chart shows, the book-to-bill ratio this year looks set to collapse (we have forecasted 100 net orders this year, which may be optimistic).



One silver lining in this difficult outlook is the backlog, which remains quite large at over 12,000 jets. But there are two problems with this. The first is that history shows that if there's a serious and prolonged demand

drop, backlogs provide limited insulation. Deliveries fell 29% by value between 2001 and 2003, but the backlog stayed largely intact – above 2,500 jets at the lowest point of the downturn.

The second problem is that much of the backlog is for single aisles. As the death of the A380 shows, a large backlog can coexist with weak programs. Right now, both the 777X and A330neo backlogs can be termed weak. The A350XWB and 787 are in better shape, but with very high output rates both types will see serious production drops after 2021, unless orders come back. The Air Transport Market Chart shows the divergence in market performance between single and twin aisle jetliners.



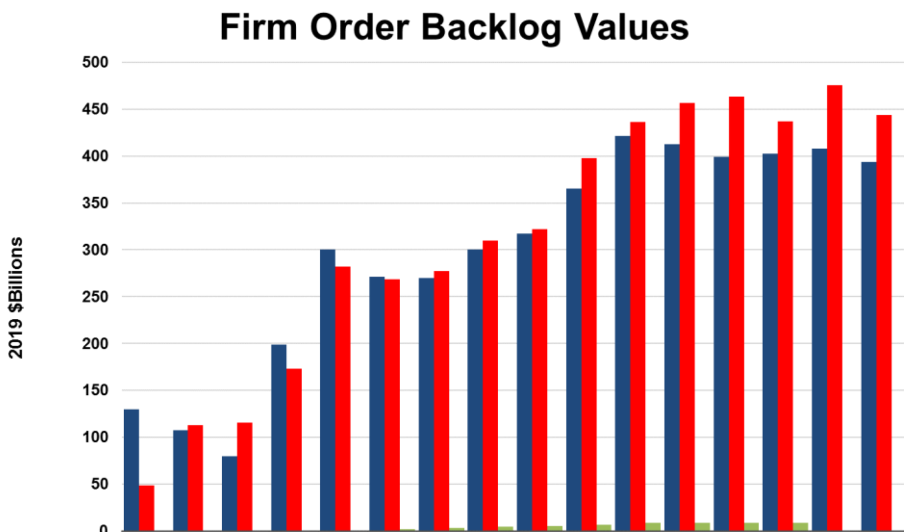
Forecasting jetliner output is complicated further by the market's extraordinary performance since the last downturn. Since the jet age began, the market has seen a recurring pattern of roughly seven good years followed by three bad years, with deliveries in the bad years falling by 30-40%, or more, by value. But the industry has enjoyed strong growth since 2004, with the exception of the 2016-2017 hiatus (due largely to the single aisle deliveries pause before A320neo and 737MAX deliveries ramp up).

That means the industry is in a double cycle. Will a traffic downturn, accompanied by the 737MAX situation, mean that output will plateau, or perhaps even decline? Or, will the 737MAX return next year, accompanied by renewed demand, lead to an unprecedented triple cycle?

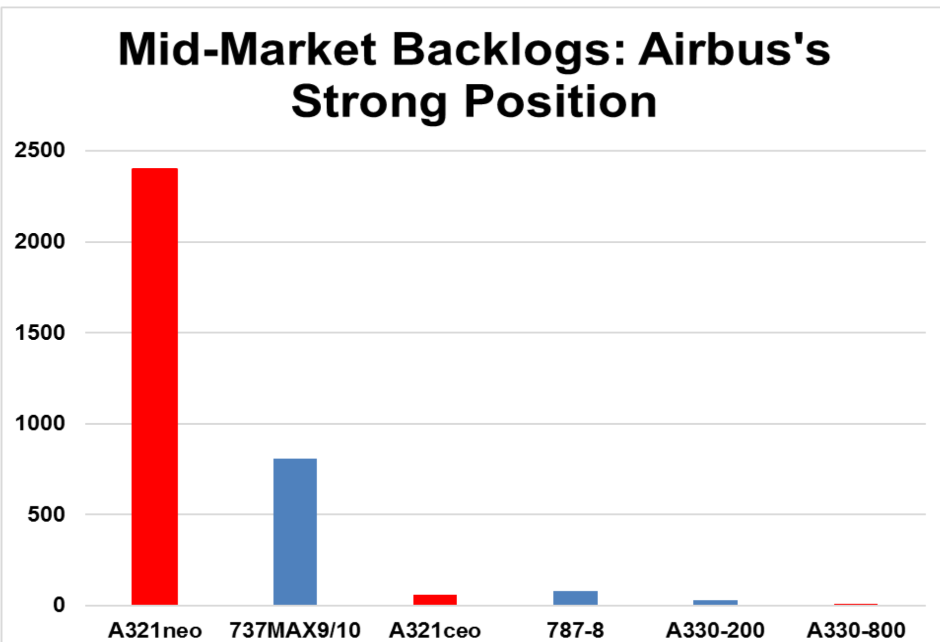
The answer largely depends on traffic, and therefore on the world economy. The coming few months will be crucial.

Boeing And the Middle Market

In most jetliner market segments, Boeing is ahead of Airbus in deliveries and backlog. Yet in aggregate, as indicated in our Firm Order Backlog Chart, Airbus is ahead by value of backlog. This is because Airbus enjoys a commanding lead in exactly one segment: the 190/250-seat middle market. Our Mid-Market Backlogs Chart shows the state of play in mid-market backlogs.



	1h 1997	1h 2001	End 2004	End 2006	End 2008	End 2009	End 2010	End 2011	End 2012	End 2013	End 2014	End 2015	End 2016	End 2017	End 2018	Mid 2019
Boeing	130.0	107.8	79.5	199.1	300.4	271.1	270.0	300.1	317.0	365.3	421.2	412.9	398.9	402.1	408.0	393.6
Airbus	48.6	112.9	115.5	173.0	281.8	268.2	277.6	309.5	321.6	397.4	436.3	456.7	463.0	436.8	475.7	444.0
Bombardier	—	—	—	—	—	1.9	3.3	4.9	5.5	6.7	9.0	9.0	8.7	8.5	—	—



Just below the middle market, the 737MAX8 and A320neo look evenly matched. Just above the middle market, in twin aisles, the 787-9/10 are generally doing better than the A350-900 and A330-900. Above that, the 777X is well ahead of the A350-1000. The 747-8 and A380 have ceased to be major factors in the market.

But in between the first two of these two segments, the largest 737MAXs – 9 and 10 – are being outgunned by the A321neo. The latter has about 2,400 orders on backlog, while there are just around 800 known MAX 9/10 orders (more may come from the "undetermined" group of MAX orders, but this would be at the expense of the MAX8). The current state of 190/250-seat backlogs can be seen in our chart, which clearly shows that if it weren't for this segment Boeing's overall backlog would be well ahead.

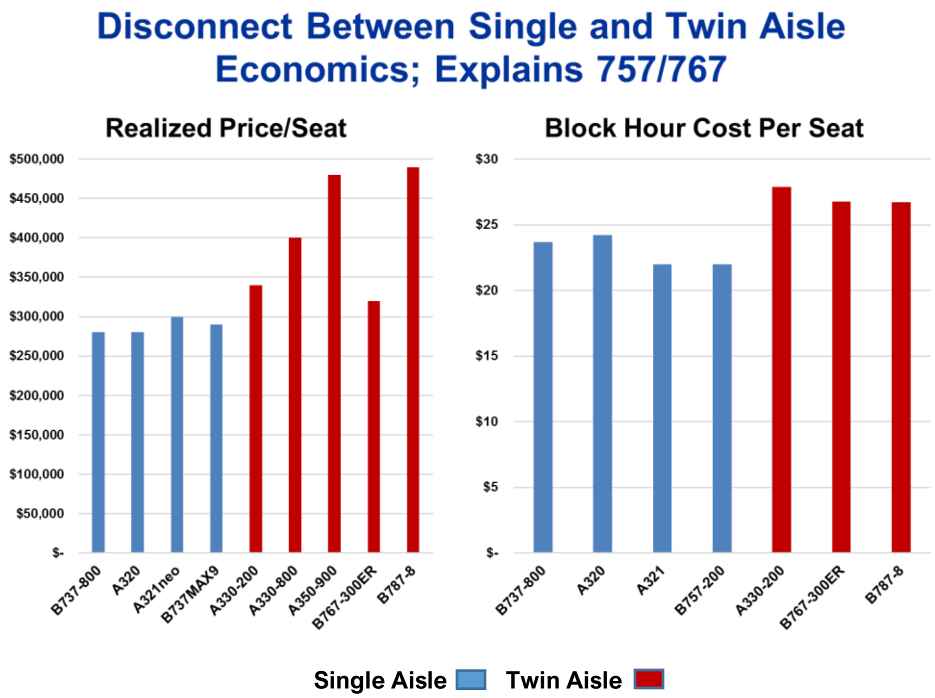
Boeing's response to this challenge is the proposed NMA, a clean-sheet twin aisle design which will seat 220-260 passengers with 5,000-5,500-nm range. Air Lease Corp. Executive Chairman Steven Udvar-Hazy even gave it a proper Boeing designation: the 797.

The NMA concept has been around at least five years, with plenty of anticipation and discussion. Yet Boeing's January 2019 announcement that it would defer a firm industrial launch decision to 2020 – with an Authorization to Offer possible this year – clearly indicated that this program is far from certain. This long and uncertain run-up is highly unusual for a new Boeing project.

Yet these NMA delays are understandable. As a business case, this is not a slam-dunk, as most of the company's past jet launches have been. To understand why Boeing is taking so long to decide, and to understand the risks involved, consider the two primary sources of NMA demand.

The first source is upgauging from single aisle routes and replacements for current single aisle jets. As our chart indicates, A321neo orders strongly dominate the backlog picture for all jets in the 180-250-seat midsized segment. The likely launch of a longer-range A321neo XLR, and the prospect of an A322neo growth model, would further cement Airbus's lock on this segment. Thus, Airbus is aggressively capturing the 757 and A321 replacement market, plus demand from upgauging routes served by the A320 and 737-800.

The problem for NMA here is that in terms of operating economics and manufacturing costs, there remains a significant gap between single aisles and twin aisles. A glance at operating and production economics (block hour cost per seat and realized price per seat, respectively, illustrated in our Disconnect Between Single and Twin Aisle Economics Chart) clearly shows this gap. A single-aisle product is inherently cheaper to buy, build and fly. Low-cost carriers seeking fast turnaround times may like the idea of two aisles, in theory. But if twin-aisle operating economics remain distinctly higher than single-aisles', it is unlikely that faster turnaround times will actually trump lower operating costs.

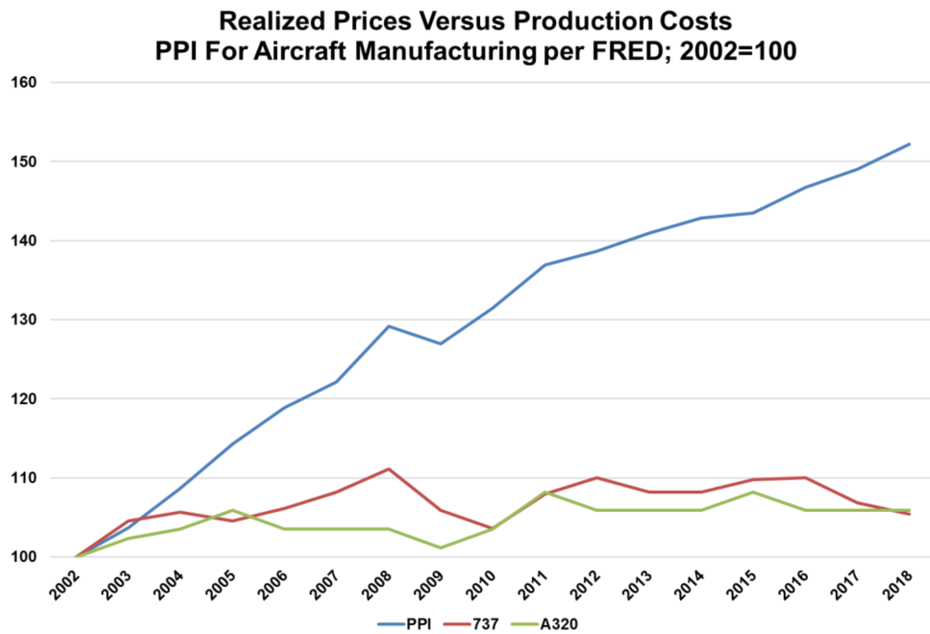


Price negotiations with NMA suppliers are key to bridging this gap, as are all design considerations that impact seat mile costs. If Boeing can't get its costs for a new twin aisle closer to current and future single aisle costs, it might be forced to cede much of this single aisle replacement and growth market to Airbus.

But there are no guarantees that Boeing will be able to bridge the cost gap between single- and twin-aisle jets with the NMA. And new technologies developed for the NMA—particularly new engine technologies—could be used to help lower single-aisle operating costs, too, keeping the gap in place.

Meanwhile, single aisle production costs are a moving target. As our Realized Price chart clearly shows, the price (and therefore production costs, since profit margins have been relatively consistent) of a single aisle jet has badly trailed the producer price index ("PPI"), which measures the average change in selling price received by domestic producers for their output.

The chart highlights an interesting (and concerning) phenomenon: a stable rise in overall aircraft pricing as measured by output against flat prices in the single aisle segment of the market. In real value, parts of the market may in fact be experiencing deflationary pressures, given increasing costs associated with production inputs (components, labor, etc.) and flat prices. It is reasonable to conclude that some aircraft could be losing 1-2% of real value per year. Creating a new jet that competes with these deflating products is an even greater challenge.



Boeing has been in this position before. In the late 1970s, it bifurcated its middle market product launch decision, creating the single-/twin-aisle 757/767 family. This was seen as a necessary response to the clear line between single and twin aisle market requirements, and ultimately both products succeeded. But these are different times in terms of new product development spending levels and company tolerance for risk. If NMA is launched as a twin aisle, there wouldn't be a new single aisle counterpart launched for at least another 6-10 years.

Boeing could accept that Airbus would simply continue to capture the lion's share of the large single aisle market, and focus on the second mid-market source. This would entail taking demand away from larger twin aisle jets. This involves the very hard work of talking with individual airlines to understand how they can use a new 225/265-seat jet with 4,000-5,000 nmi range to create new city pair opportunities, beyond their current route networks. Since airlines generally get better pricing with direct flights, particularly between business centers, there are many opportunities here. But again, identifying these city pairs is a hard process, with few certainties.

One big complication with this concerns product line cannibalization. Creating new point-to-point routes generally involves taking international traffic growth away from larger planes. This means replacing existing 767s, A330s, and other twin aisle jets. But in terms of new production aircraft, the 787 is easily the most popular and successful twin aisle jet directly above the NMA.

Boeing wants to maintain 787 output at 14 aircraft per month, largely since this high rate helps build-down the program's large pool of deferred production costs. The company needs to understand to what extent the NMA's arrival would disrupt this process.

There are many other challenges. In addition to the usual design considerations – airframe materials, fuselage shape, the belly cargo issue, and whatever else – there's also the question of whether the three engine primes can have one or more turbofans ready by the stated in-service goal of 2025. None of them have built an engine

in the 50,000 lbs size class in decades, and all are coping with current program technology and production ramp issues.

Even with these challenges, it's clear that Boeing needs to do something in the mid-sized segment. Given the growth prospects, abandoning this segment to Airbus for a decade or longer is an undesirable option. The alternative to NMA – launching a new, larger single aisle family – would make the 737MAX a ten year or less program, clearly an unpalatable decision. And despite Boeing's desire to return a very high percentage of its cash to shareholders, it certainly has the resources needed to launch the NMA. The company's engineers will also need to work on something after the 777X development program winds down, in the early 2020s.

So, despite the difficulties complicating the NMA decision, the new jet remains in Teal Group's forecast. However, if there is no Authorization to Offer this year or in the first half of 2020, Boeing would clearly be saying that the NMA's challenges outweigh its opportunities.

Production Site Factors

Boeing's need for an ironclad NMA business case relies on many factors on the supply side. Supplier costs, aftermarket rights, and technology and materials decisions all play key roles. But the economics associated with site selection will play a role too, both for final assembly and any separate fuselage or wing manufacturing location.

An aerospace company's need to looking at production site options as part of establishing a business case for a new program is a relatively recent development in the jetliner industry. Historically, most jetliners have been built at legacy production sites. Given very high barriers to entry in this business, and given very long product life cycles (the 737 in 2017 set a record at 50 years in production), this is not surprising.

This means aircraft have been produced where successful companies themselves were established, usually many decades ago. Sometimes, these companies were established in places for relatively arbitrary reasons, such as Boeing's original start in a wooden shipyard in Seattle, largely for its utility for wooden seaplanes. Often, aerospace companies were located in places far from an enemy threat, such as Russia's Siberian-based aircraft factories, or almost all of France's aerospace industry.

Until the 1990s, this reliance on legacy manufacturing sites didn't change very much. Successful companies turned their legacy sites into industrial powerhouses; unsuccessful companies reduced their legacy sites to museums. In 2016, the final C-17 rolled off the line in Long Beach. This represented the last jet built in California, the last of thousands of aircraft, at least until Northrop Grumman starts building B-21s in the 2020s.

Today, state and regional competitiveness matters, but in the first decades of the jet age success was determined by company success or failure and the attributes of the sites themselves seldom played much of a role. McDonnell Douglas failed as a jetliner prime not because Long Beach was a terrible place to build planes; rather, it just systematically underinvested in new technology and products. If Boeing had been located in Long Beach, and McDonnell Douglas had been located in the Puget Sound, it's quite likely that the fortunes of these two regions as aerospace manufacturing centers would have been reversed. But Boeing invested in the future, which helped create and maintain a skilled workforce, and contributed to many other attributes that make the Puget Sound a great place to build aircraft.

While manufacturers generally stayed in their legacy regions, two other trends had a material impact on the evolution of aircraft production. The first was outsourcing. Although Boeing regrets going too far in outsourcing design and integration work on the 787, the idea of spreading production to risk-sharing partners

has been around for half a century, or longer. The entire body of the 747 was outsourced to Northrop in the 1960s.

Increasingly, this outsourcing went global, largely as a result of much broader macroeconomic trends. As borders and governments gave ground to multinational enterprises and economic liberalization, international trade grew at a record pace. Container boxes and ships, air cargo, CAD/CAM, the internet and logistical software provided tools to accelerate globalization. Distance became less relevant. Manufacturing became less vertical, creating global supply chains and industrial arrangements. US manufacturers have been transformed by this new paradigm, enjoying remarkable profitability over the past few decades.

Meanwhile, as noted above, Boeing is pursuing vertical integration opportunities. In the case of the 777X wing, this work will indeed be located near the final assembly line. But in the case of other systems, most notably propulsion systems, the work will be placed away from final production. For example, Boeing's propulsion unit is building 737MAX engine nacelles in South Carolina, across the country from Renton. It might be part of Boeing, yet it still represents distributed manufacturing.

The idea of a "supersite," where all components and structures for a given aircraft are built in the same region, is generally not regarded as a valid approach. In good times, such a supersite would see very high wage inflation for engineers and manufacturing workers, with Boeing and its contractors all poaching employees from each other. And in a bust cycle, the region would be hit hard by very high unemployment rates.

The second aircraft industry trend over the past few decades has been the establishment of secondary final assembly lines, or, as they are sometimes termed today, Final Assembly and Check Out (FACO) lines. Military programs have relied upon FACOs since before World War One. But with its China facility constructed to build MD-80s, McDonnell Douglas extended the concept to jetliners.

Airbus has further led the way in adapting this idea for jetliners. At first, the European company used the concept to establish a secondary single aisle line, in Germany, at a member company facility. But today, it has transplant lines in Mobile, Alabama, and Tianjin, China. It will also use its Mobile facility to build the A220 in a secondary line now that this acquisition has been completed.

This second trend, of secondary assembly lines, was enabled by the first trend. Basically, with sections of the aircraft built elsewhere, it became less expensive to establish secondary final assembly lines, because they didn't need to have a heavy level of local production.

Inevitably, this led to a move away from legacy sites for final assembly lines on new programs. One of the first abortive instances of this took place on the MD-95, later designated the Boeing 717. In November 1994 McDonnell Douglas announced that it had signed up Dalfort Aviation, a Texas-based overhaul company, to handle final assembly of the aircraft. However, this was later cancelled, and the 717 was built at Long Beach.

The 787 was the first Boeing aircraft which involved a very active manufacturing site selection process. After surveying numerous alternatives in the US, including South Carolina, Texas, and Alabama, Boeing selected Everett, Washington in December 2003. However, Boeing later decided to establish a second production line in Charleston, South Carolina.

The 787 was followed by the 737MAX. As a derivative rather than a clean-sheet design, the incumbent 737 production site had an advantage. Even though Boeing executives said they would look at alternative sites, Boeing management worked with labor and other parties, under Project Pegasus, to come to mutually agreeable terms to keep the line in Washington.

This was followed by the 777X site selection process, which also involved a derivative jet. While this was a far more contentious process, which, in theory, involved a much closer look at alternative sites, Boeing kept the line in Everett.

So far, Airbus has yet to look at alternatives to Toulouse and Hamburg for its primary jetliner final assembly lines. Embraer has not looked outside of Sao Jose Dos Campos for jetliner final assembly, but has moved business jet production lines to Florida. Additionally, Bombardier investigated alternatives to Mirabel for CSeries jetliner production at the start of the program.

Boeing, of course, will continue its stated policy of examining many alternatives for future jetliner programs. And to summarize, the success of Boeing's NMA will depend on choosing the optimal site, or sites, for manufacturing and final assembly. The changing nature of aviation manufacturing means that this plane could be built anywhere, but top states maintain competitive advantages outlined in the ACES rankings discussed in this report.

BOEING AND EMBRAER: CROSS-COUNTRY MANUFACTURING COMPETITIVENESS

Over the past few years, Boeing has moved to take control of Embraer's jetliner unit. Boeing and Embraer confirmed a firm plan in late 2017 and signed a Memorandum of Understanding in July 2018, outlining a "strategic partnership" in which Boeing will own 80% of the joint venture.

Embraer shareholders approved the deal in February 2019 and in May, the companies named the new entity Boeing Brasil–Commercial, conspicuously dropping the Embraer name (which will be retained for the remaining non-jetliner company). The E-Jet series may or may not receive new Boeing designations. After final antitrust reviews, the deal is expected to close later this year.

There are two schools of thought about this acquisition, which are not completely exclusive. The first holds that this joint venture constitutes a relatively straightforward acquisition by Boeing of a successful and respected aircraft manufacturer, designed to give Boeing a series of 75/120-seat jetliners that help expand the company's commercial transport waterfront.

Some believe that Boeing's desire to add this capability was a reaction to Airbus's earlier acquisition of Bombardier's 100/130-seat CSeries (now known as the Airbus A220). Others maintain that the company wanted to grow its capabilities with smaller jets, particularly since the larger and heavier engines added to the 737MAX make the smaller versions somewhat less competitive.

The second school of thought is that Boeing has grand strategic plans for its Brazil unit that extend beyond merely adding to its product portfolio. These plans could include relocating engineering and design work, producing manufacturing structures and sections for future Boeing jetliners, flight testing and certification work on new aircraft, and conceivably even placing a new aircraft final assembly line. To analyze the evidence supporting this second rationale, it's important to first examine the broader macroeconomics of manufacturing in Brazil.

As the 8th largest economy in the world, Brazil is a significant player in the global economy and should present substantial opportunity for collaborative growth between its domestic aircraft manufacturer, Embraer, and a global leader like Boeing. It remains rich in natural resources and other key fundamentals of economic development. Yet, Brazil has a long history of underperforming relative to its economic potential. Any attempt to aggressively expand Boeing's manufacturing operations in Brazil will present risks to Boeing, at a time that is already full of challenges to its U.S.-based operations and market position.

Brazil felt the negative effects of the Great Recession more than many other countries. It is still dealing with the aftermath and trying to regain sustained economic growth. As recently as the first quarter of 2019, Brazil's GDP fell by 0.2%, signaling a new economic contraction. Given the weakness of the county's finances and its powerless monetary policy, the only path to real, sustainable growth is through economic reforms. It will take powerful political will and time to make the needed changes.

As a World Bank report recently stated, "Restoring fiscal sustainability is the most pressing economic challenge for Brazil". Driving this assessment are a number of key factors:

- Broad lack of consumer and investor confidence
- Unsustainable debt
- Strong need for infrastructure investment

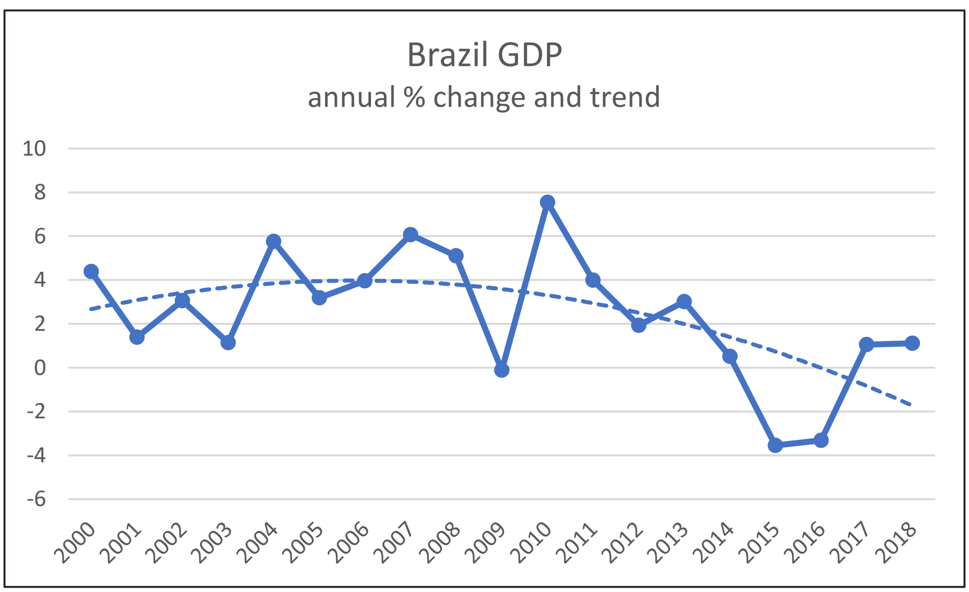
- Flat productivity
- High unemployment and inefficient labor markets
- Complex tax system
- Grossly underfunded pension system

Brazil's industrial and manufacturing sectors face stagnant productivity, which according to the World Bank "can be attributed to the absence of an adequate business environment, distortions created by market fragmentation, several support programs for companies that have yet to yield any results, a market that is relatively closed to foreign trade and little domestic competition." As a result, Boeing enters the Brazilian economic landscape at a difficult time, with long-term limits on growth and productivity.

Economic Conditions and Underlying Challenges

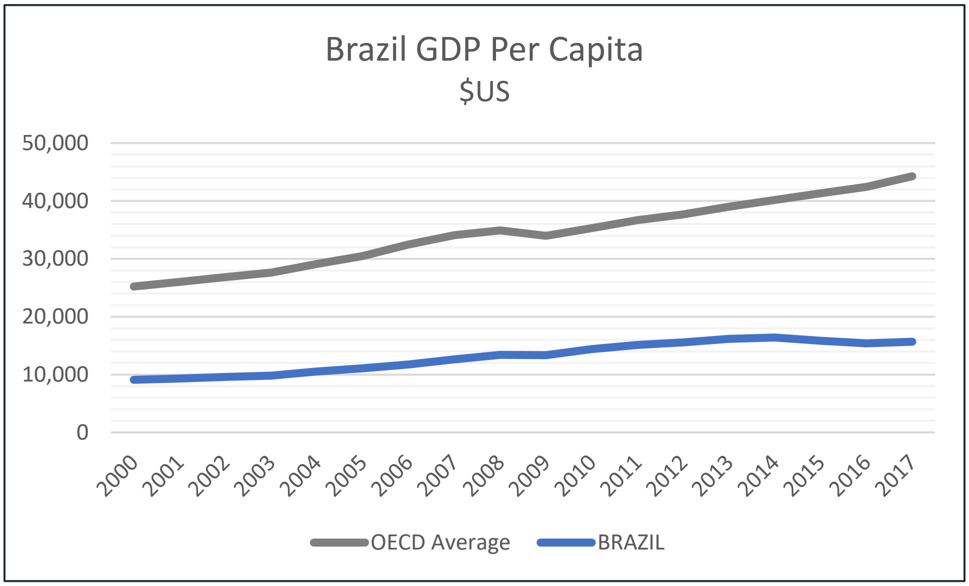
This report focuses primarily on U.S. competitiveness. However, given Boeing's interest in Embraer it makes sense to evaluate Brazil's competitiveness as an alternative manufacturing location. Based on key economic factors and general business conditions, Brazil is not a good option at present.

Brazil's current economic environment is weak. Basic economic indicators suggest that Brazil is a long way from major improvement and that downward pressures will continue to plague business fundamentals. Nominal GDP growth, which was on an upward trajectory prior to the recession starting in late 2007, has since reversed and now continues on a problematic downward path. After two years of decline in 2015-2016, GDP growth returned to positive territory in 2017-18, before showing renewed signs of weakness in early 2019.



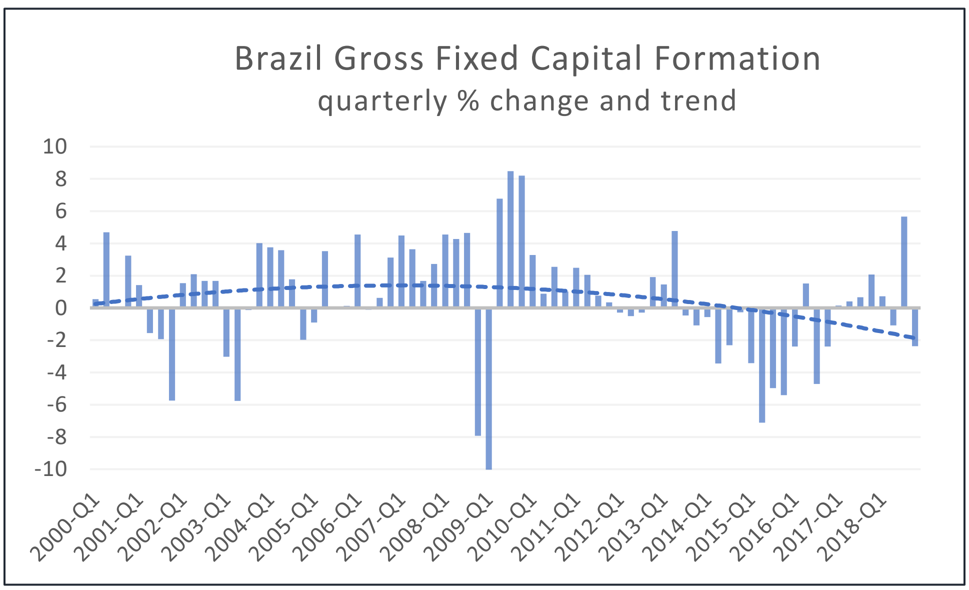
Source: OECD

The result is little to no growth in GDP Per Capita, a measure of overall productivity across the nation's economy. As we see below, it has been flat since 2010. At the same time, OECD countries as a whole have experienced healthy GDP Per Capita growth, leaving Brazil behind. This stagnation has put downward pressure on the real standard of living for the average Brazilian and presents a broad set of challenges for the economy as it looks to return to economic growth and increased prosperity.



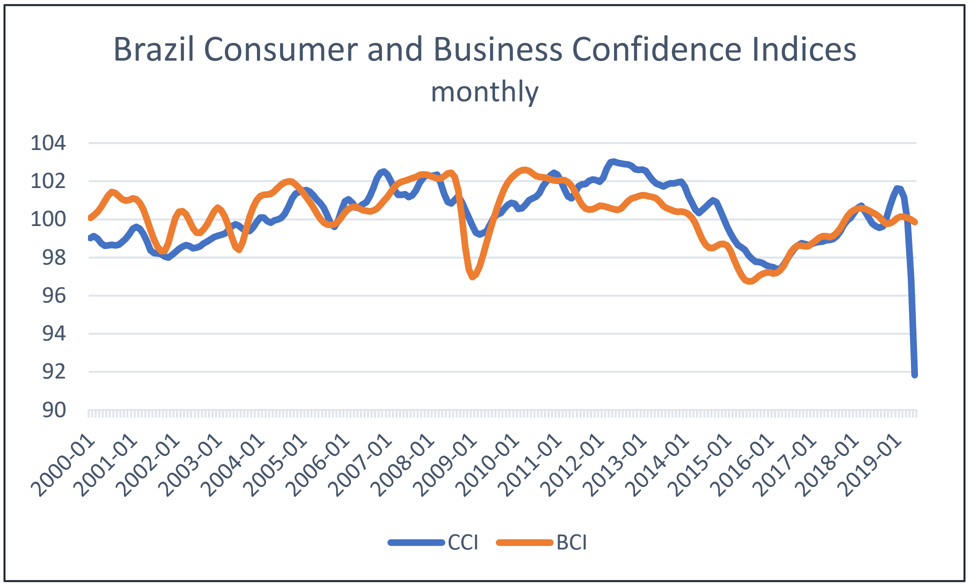
Source: OECD

The poor fundamentals weighing on the economy clearly effect the business outlook and the willingness of firms to make much needed investments. As measured by Gross Fixed Capital Formation, investment in Brazil continues on a downward trend.



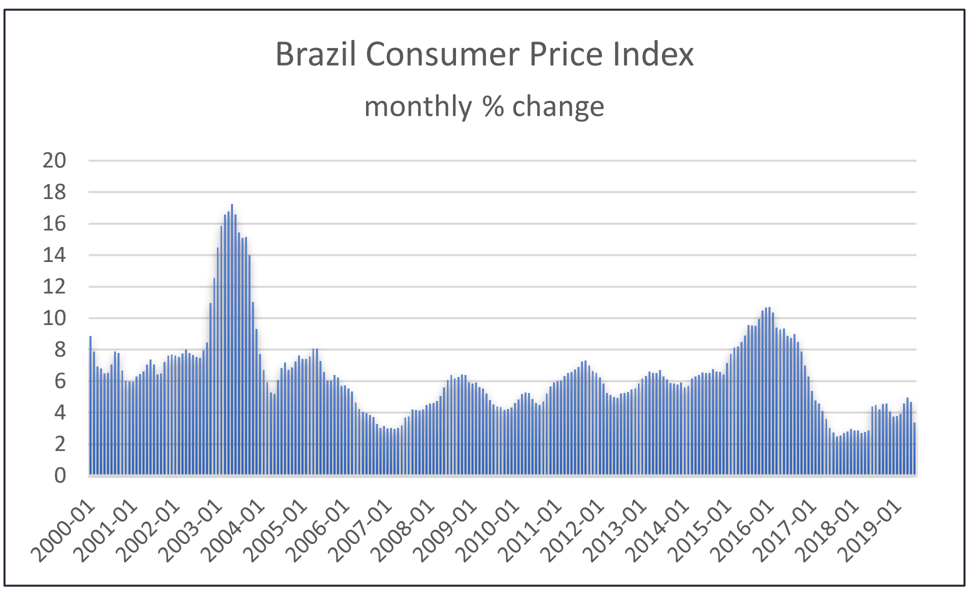
Source: OECD

Consumer and business confidence in the near-term economic outlook play an important role in determining this business investment. Recently, Consumer and Business Confidence Indexes show a return to declining confidence. After declining between 2008 and 2015, confidence rose again between 2015 and 2018. However, 2019 has seen a return of declining expectations from consumers and businesses.



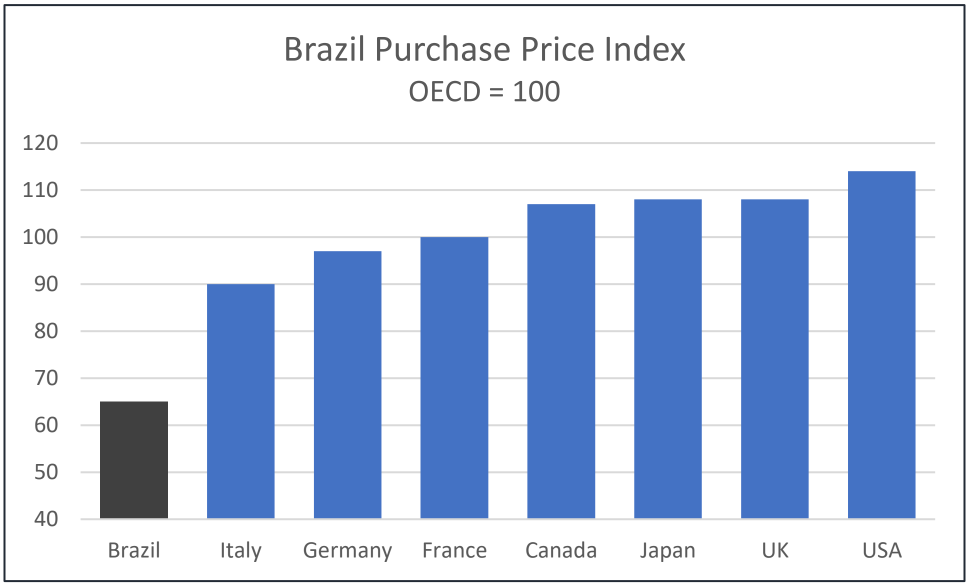
Source: OECD

Fortunately, Brazilian monetary policy has kept inflation reasonably contained. Brazil has a history of high consumer price inflation, so recent increases in the 2-4% range are encouraging. In part, this reflects a lack of confidence and therefore cautious consumer and business behavior that tamp down demand and limit upward pricing pressure. At the same time, the Brazilian Real remains weak against major international currencies, thereby increasing the real cost of imported goods.



Source: OECD

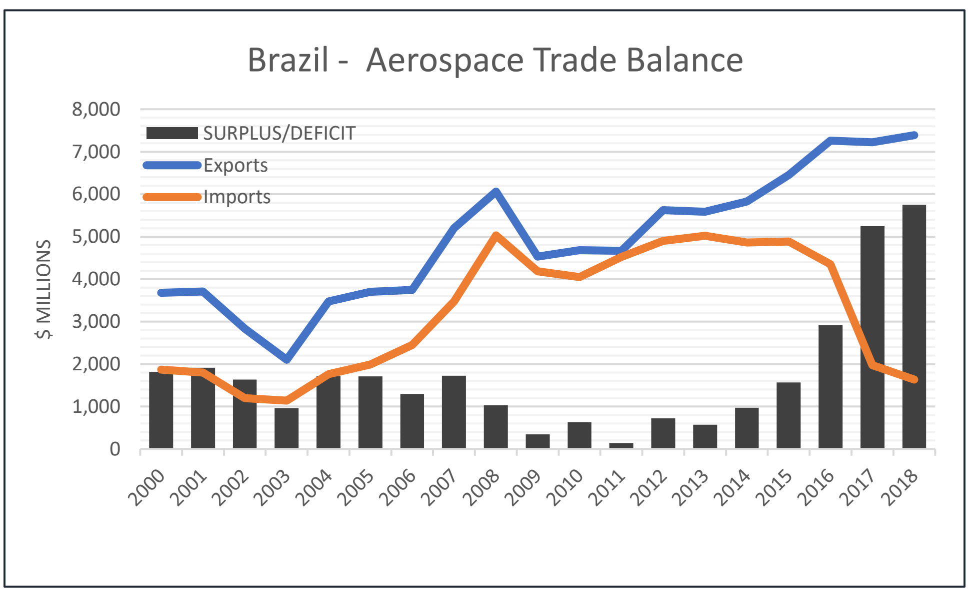
Brazil does offer a more competitive pricing structure compared to more advanced economies. The chart below demonstrates this advantage by looking at a consistent measure of purchase prices faced by businesses. The Purchase Price Index shows that Brazil is substantially less expensive in comparison to the highly developed economies in North America, Europe and Japan.



Source: OECD

Aerospace Exports, Imports and Trade Balance

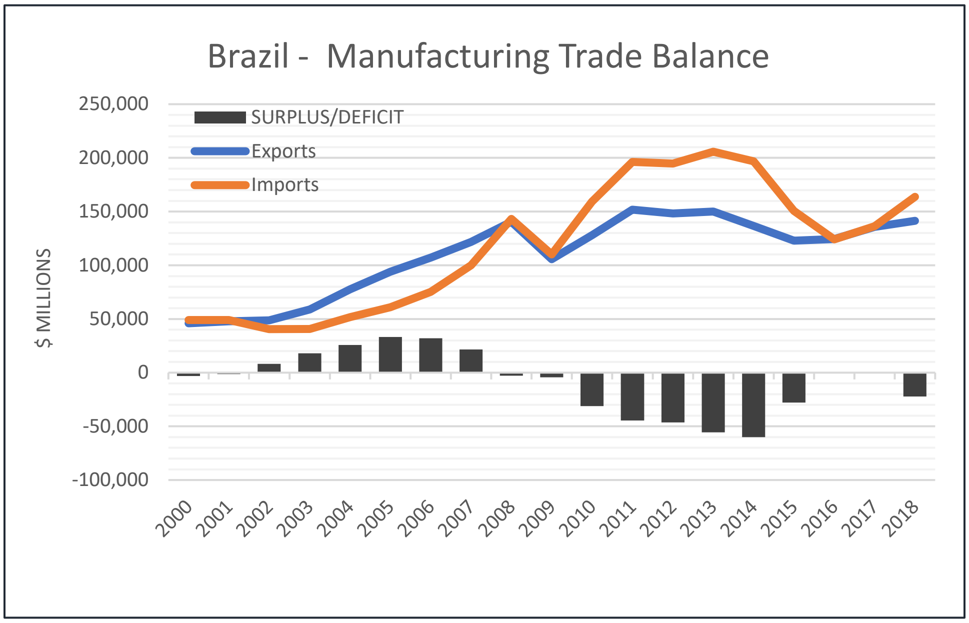
Brazil's aerospace exports have grown steadily over the past 15-20 years. These exports have risen from just under $4 billion in 2000 to over $7 billion in 2018. With the exceptions of the two slowdowns immediately following the September 11th attack in the U.S. and the 2008-09 recession, Brazil aerospace exports have continued on a strong upward trend. Most of this sector is dominated by Embraer and the trade numbers reflect strong sales associated with its aircraft business.



Source: Exports for the Air and spacecraft and related machinery industry, OECD

Increases in aerospace imports mirrored the export trend for most of the last two decades, with a deviation beginning in 2016, when imports began a sharp decline. Over the eighteen-year period, Brazil experienced

trade surpluses related to aerospace, passing $5 billion in 2017 and approaching $6 billion in 2018. The surpluses are a clear sign of sector strength.



Source: Exports for the Air and spacecraft and related machinery industry, OECD

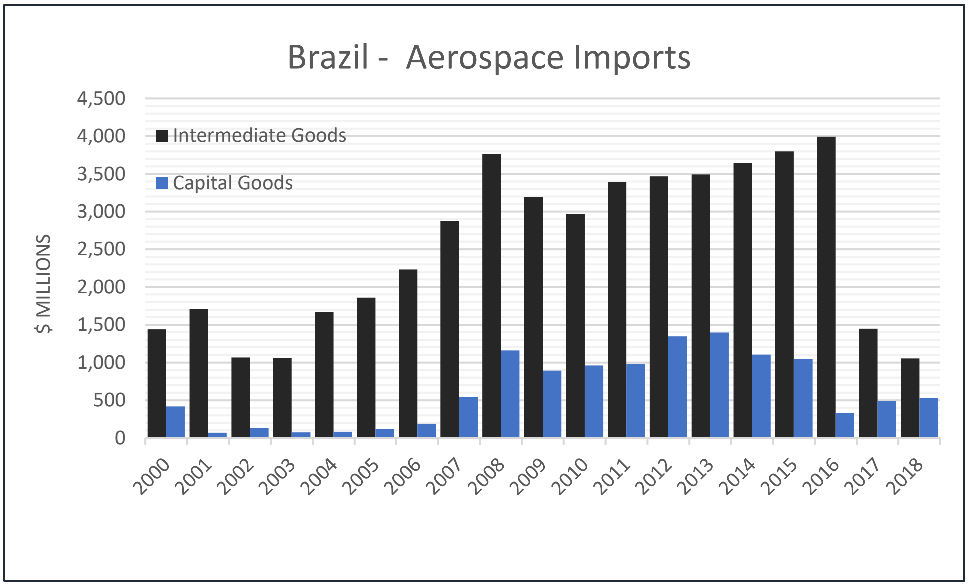
The aerospace sector surplus is important to the nation's trade position with respect to all manufacturing. Brazil has run manufacturing trade deficits over the past ten years, with the overall manufacturing deficit exceeding $22 billion in 2018. The strength of Brazil's aerospace sector and aerospace exports helped mitigate these deficits.

Source: Exports for the Air and spacecraft and related machinery industry, OECD

A deeper look at aerospace exports reveals an important underlying trend. While Capital Goods exports, comprising finished products that are immediately available for final use (i.e. a delivered airplane) and spare

parts inventory, have remained stable, Intermediate Goods aerospace exports, made up of products used in a further manufacturing or finishing process that ultimately contributes to a Capital Good, have increased rapidly. This provides evidence that Brazil's aerospace industry may be developing a capability to manufacture parts and components that are exported to other countries where they are incorporated into other aircraft and spacecraft, which is included in the data.

As we see in the two charts below, Aerospace Imports are also broken out between Capital Goods and Intermediate Goods. Intermediate Goods imports include materials, components and subsystems that ultimately are incorporated into finished aircraft. Most intermediate goods imports are likely driven by Embraer, although the data is not reported by company.



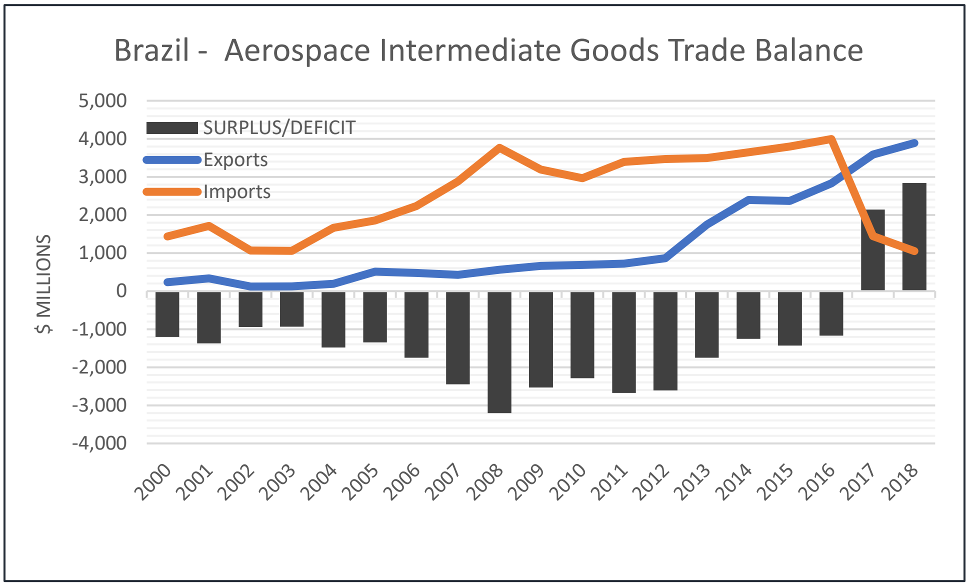
Source: Exports for the Air and spacecraft and related machinery industry, OECD

From 2000 to 2016, there is a strong upward trend in the import of Intermediate Goods, before a decline starting in 2017. This pattern is consistent with a slight decline in Brazil's exports of Capital Goods in 2017 and 2018, which would be expected given that various parts, components and subsystems are being imported in order to support final manufacturing and assembly.

While Brazil experienced a trade deficit for aerospace Intermediate Goods before 2017, over the last two years, the sharp drop in Intermediate Goods Imports coupled with an increase in Intermediate Goods exports have left Brazil with a trade surplus for this trade sub-group.

One area of note is the high degree of Intermediate Goods imports relative to Capital Goods exports. This supports the concern that Brazil (and Embraer) relies heavily on foreign companies to deliver a high share of the manufactured content in the finished aircraft. This implies that Brazil has good integration and final assembly skills but needs further development of its ability to manufacture components or sub-systems.

However, Brazil's Intermediate Goods imports have declined sharply the last two years. This decline coincides with Embraer's opening of its business jet manufacturing facility in Florida. Given the recent change it is difficult to draw conclusions, but there appears to be a potential relationship that could reshape Brazil's aerospace trade balance as both Intermediate Goods imported and Finished Goods exported shift downward.

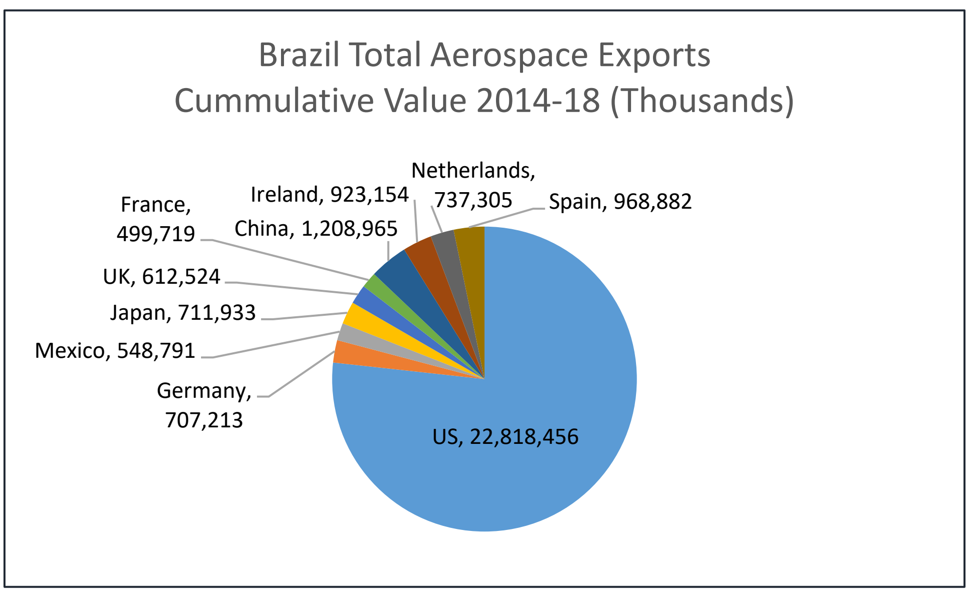


Source: Exports for the Air and spacecraft and related machinery industry, OECD

With respect to trading partners, the U.S. is by far the largest aerospace trading partner with Brazil, purchasing roughly 75% of Brazil's aerospace exports. This reflects both U.S. imports of finished Embraer aircraft, as well as parts, components and subsystems imported into the U.S. for inclusion in aircraft manufactured and assembled in the U.S.

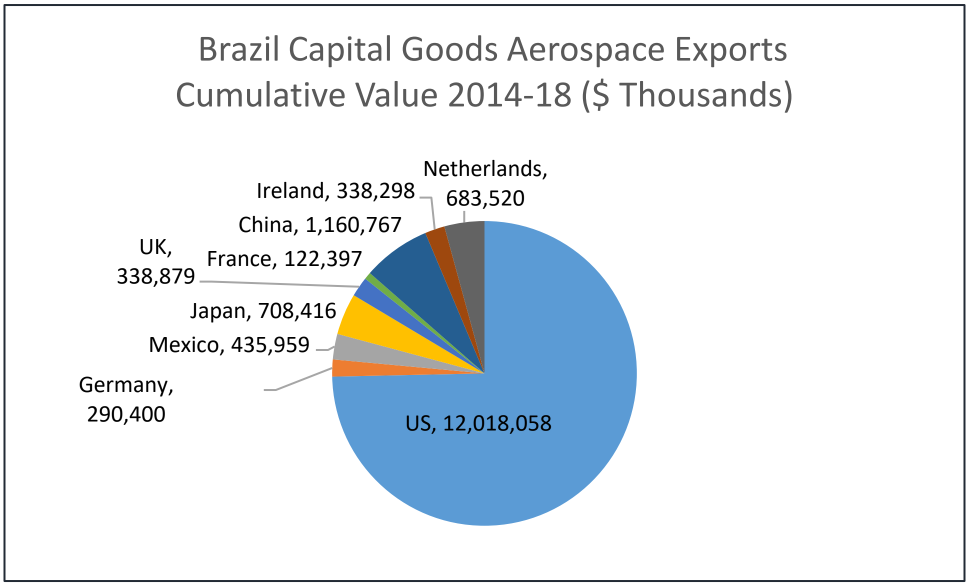
Brazilian Aerospace Exports to the U.S. ($Thousands)				
2014	2015	2016	2017	2018
3,789,876	4,732,011	5,174,392	4,768,523	4,353,653

Over the past five years, the U.S. has dominated aerospace exports from Brazil, with second place China comprising barely 1/20th of the value of Brazilian exports to the U.S.



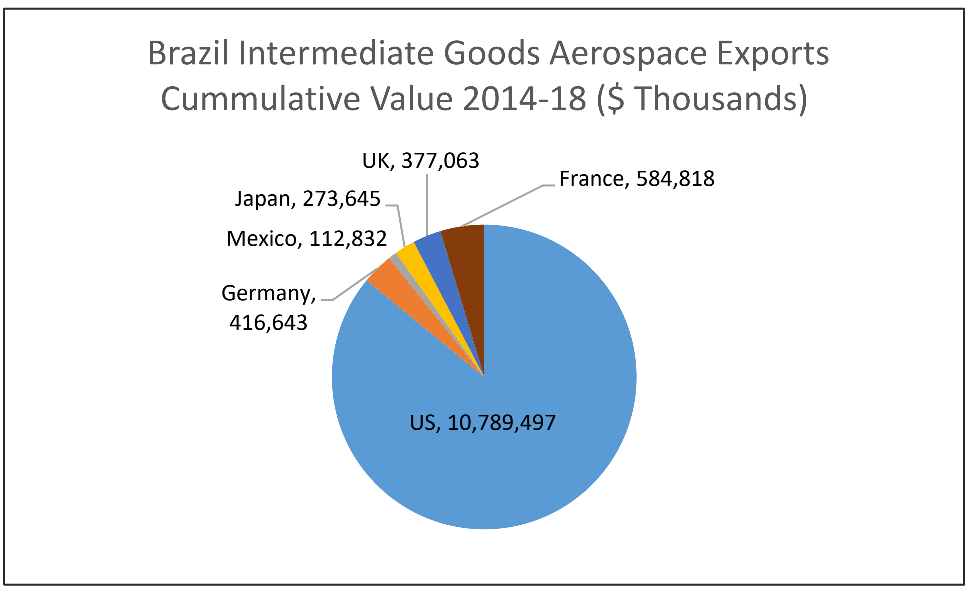
Source: Exports for the Air and spacecraft and related machinery industry, OECD Bilateral Trade database

With respect to finished aerospace products (Capital Goods) like delivered airplanes, the U.S. again is dominant as Brazil's primary export partner. China remains in second place, but with a higher share at about 1/10th the U.S. value.



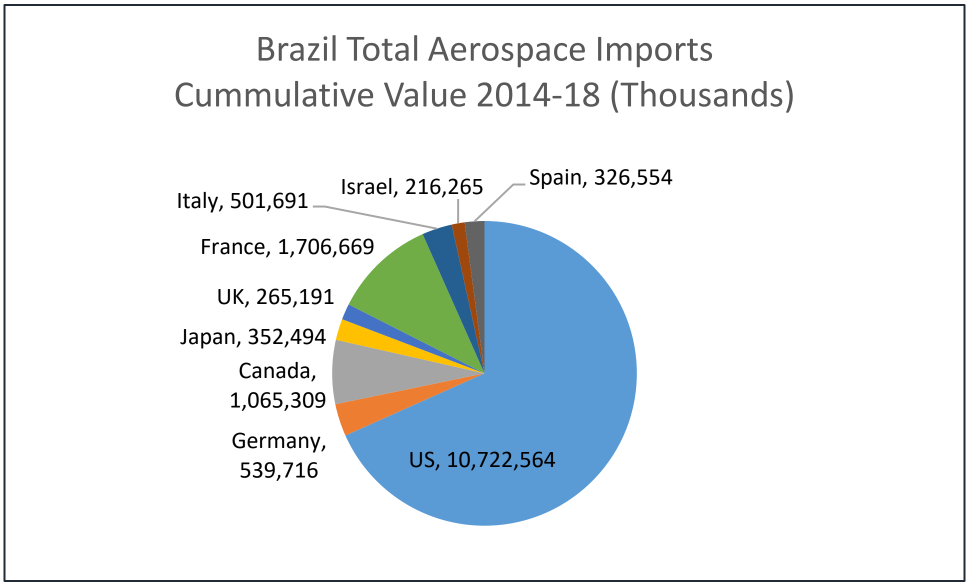
Source: Exports for the Air and spacecraft and related machinery industry, OECD Bilateral Trade database

The U.S. is even more dominant with respect to Intermediate Goods exports from Brazil. As shown below, the U.S. accounts for more than 85% of all Brazilian aerospace exports to its major trading partners.



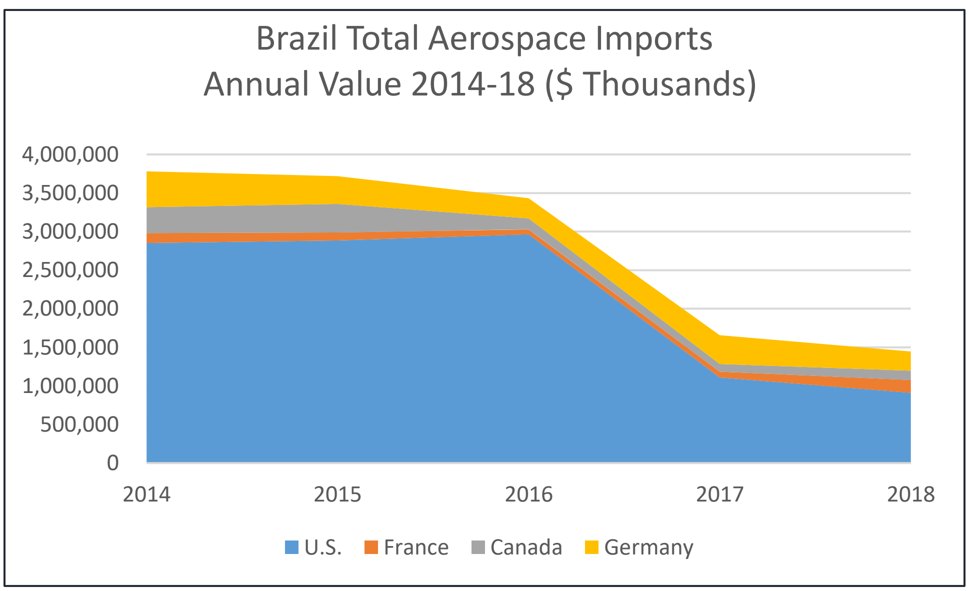
Source: Exports for the Air and spacecraft and related machinery industry, OECD Bilateral Trade database

In terms of imports, Brazil is heavily dependent on U.S. suppliers for aerospace imports. The U.S.'s share among Brazil's largest trading partners for aerospace imports is slightly below 70% for the period analyzed. As shown in the chart below the overall market for importing of aerospace goods is tied heavily to major global aerospace producing countries like the U.S., France and Canada.



Source: Exports for the Air and spacecraft and related machinery industry, OECD Bilateral Trade database

As noted above, aerospace imports by Brazil have dropped significantly over the last two years. Given the overall importance of the U.S. to Brazil's trade in aerospace, it is no surprise that much of this decline in imports is driven by the trading relationship with the U.S. While exports remained high, the decline in imports yielded a sharp increase in trade surplus for the aerospace sector.



Source: Exports for the Air and spacecraft and related machinery industry, OECD

In conclusion, Brazil is heavily dependent on the U.S. market for both exports and imports of aerospace goods. This is true for both the Capital Goods and Intermediate Goods subgroups. In this regard, it makes sense for

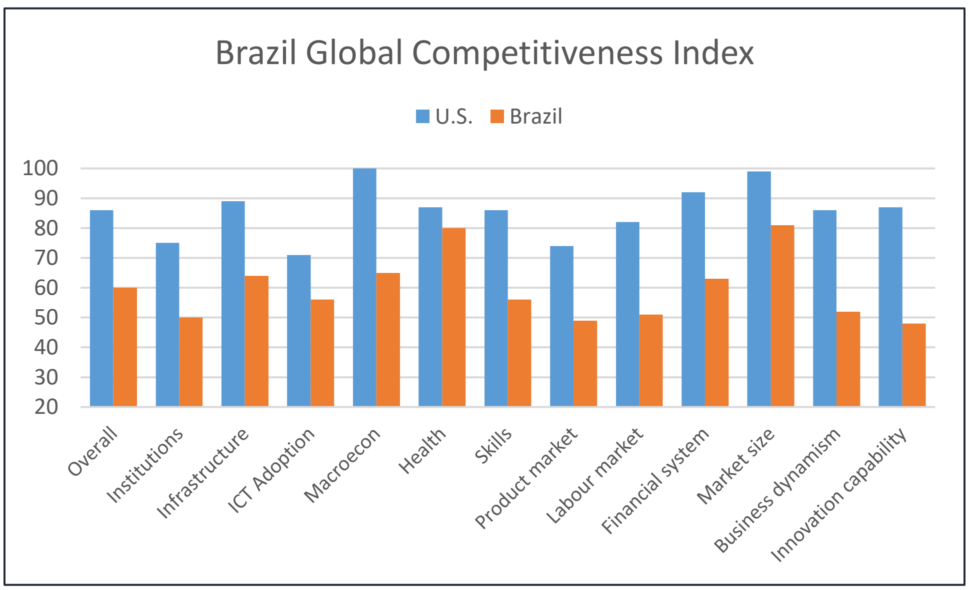
Brazil (Embraer) to align itself more closely with Boeing and work to leverage this relationship into further growth for its domestic aerospace industry. The aerospace sector trade data confirms that Embraer and the other smaller aerospace sector companies in Brazil have not achieved major gains with the Airbus-aligned nations, and that growing these trade relationships to U.S. levels would be extremely difficult.

Global Competitiveness Measurement

The World Economic Forum's 2018 Global Competitiveness Index (GCI) includes various measures of international competitiveness. While the GCI's analysis and conclusions apply to national economies as a whole, a nation's overall competitiveness directly effects many sectors including the aerospace industry. The GCI is data rich and incorporates twelve categories, referred to as "Pillars," comprised of nearly 100 separate variables measuring economic, infrastructure, institutional, financial system, business dynamics and other metrics.

The Global Competitiveness Report 2018 finds that the U.S. ranks as the most competitive country in the world. Also, in the top five were Singapore, Germany, Switzerland and Japan. Of the 140 countries included in the WEF's analysis, Brazil ranked as the 72nd most competitive country.

Source: World Economic Forum



Brazil ranks below the U.S. across all of the GCI's 12 Pillars. This further reinforces the challenges that any highly developed manufacturing company will face when looking to expand operations in Brazil.

Assessment of Brazil as a Good Location for Boeing Commercial Aircraft Manufacturing: Industry Context

In addition to Brazil's macroeconomic climate, it's important to look at the history of Embraer, and factors specific to Brazil's aerospace industry, to assess whether Boeing will use its Brazil unit as a new aircraft design and manufacturing center.

First, Embraer has become the only truly successful aircraft manufacturer created since the second World War in part because it knows its strengths, and outsources accordingly. It is a remarkable company, capable of creating new, successful products with very reasonable development and recurring costs, in large part because of its extensive outsourcing.

Embraer outsources the majority of its aerostructure needs, in addition to avionics, engines and systems. Major structure vendors and Risk-Sharing Partners (RSPs) on the E-Jet series include Triumph Group, Aernnova, Latécoère, Kawasaki, FACC, and AeroSpace Technologies of Korea (ASTK).

As a result of this outsourcing strategy, Embraer is not just one of Brazil's biggest exporters; it's also one of its biggest importers.

Second, Embraer's smart outsourcing strategy, coupled with a successful focus on meeting market needs with innovative and efficient new aircraft, means the company has played a minimal role in the world market for building outsourced structures and components.

Japan's Mitsubishi and Kawasaki, and Italy's Leonardo, for example, build aircraft, but are also three of the largest structures suppliers for Boeing, Airbus, and other prime customers. Embraer supplies no large structures of any note, and has not won new aerostructures business since it secured small roles on the MD-11 in the 1980s (composite outboard flap sections) and on the original 777-200 in the early 1990s (wing tips and dorsal fins).

This lack of aerostructures business does not represent a failure, since the company's strategic direction has successfully taken it elsewhere. But it does mean the company has no experience serving as an RSP of the kind Boeing seeks in the Japanese or Italian companies listed above, or in Spirit AeroSystems, or GKN. Since the structures business is based on decades of experience, this represents a serious disadvantage in bidding for new work packages.

Third, Brazil barely registers as an aerospace components supplier to US industry. According to US International Trade Commission numbers, Brazil is not on the list of 15 top aircraft parts and structures suppliers that account for 90% of total US component imports. In other words, it isn't just that Embraer has little or no interest in structures work, it's that no other Brazilian company has succeeded with this, either.

That failure may be due to broader competitiveness factors inherent in the Brazilian economy (as described above), or it may be due to Embraer's outsized role in Brazilian aerospace resource allocation (i.e., government contracts, or foreign offset agreements). Typically, structures companies around the world rely to a certain extent on government or offset work. If Embraer secures the bulk of Brazil's share, that means minimal resources for other companies that want to grow an aerospace business and perhaps even grow in to global RSPs.

Fourth, it's important to note that Embraer has often reached the conclusion that there are advantages in building aircraft outside of Brazil. The company has had considerable success keeping its costs down and productivity high, in part because it is a global player.

This was originally true with defense systems, where offsets play a role, such as transplanting some Tucano trainer production to Northern Ireland in the 1980s. But more recently the company has sought to move business jet production to Florida. The first US-built Phenom 100 was delivered in December 2011, while the first US-built Phenom 300 was delivered in December 2012.

In October 2018 Embraer announced that it would move the rest of its business jet product lines, the Legacy/Praetor series, to Florida as well. The company has also established a strong engineering and design facility in the state.

The US has no trade barriers that would favor the manufacture of business aircraft on American soil, so moving this work wasn't driven by tariffs or incentives. Rather, Embraer decided that higher US productivity and other economic factors provided good reasons to move work to the US.

Embraer's history and factors unique to Brazil's aerospace industry do not mean that Boeing's new Brazil unit, or Brazil in general, would be an unthinkable choice for NMA work. However, when combined with concerns about overall economic competitiveness, along with geopolitical country risk, Embraer's lack of experience supplying structures and preference for outsourcing reinforce the conclusion that Brazil will likely not be a major site for NMA production.

ACES FULL RESULTS

CATEGORY RANKINGS

State	Overall Rank	Costs	Labor & Education	Industry	Infrastructure	Risk to Operations	Economy	Research & Innovation	Taxes & Incentives
Washington	1	1	2	1	14	5	1	6	5
Ohio	2	13	9	4	16	7	16	23	17
Utah	3	12	11	16	51	3	8	3	4
North Carolina	4	2	40	7	28	13	27	19	12
Arizona	5	14	8	6	50	1	40	10	16
Colorado	6	24	5	12	45	30	22	5	13
Georgia	7	21	10	14	24	21	14	26	18
Texas	8	30	22	10	33	32	18	22	3
Kansas	9	26	4	3	18	49	15	32	31
Alabama	10	25	12	9	40	24	23	33	8
Indiana	11	10	37	21	25	23	9	31	2
Missouri	12	3	17	15	34	46	36	30	21
California	13	36	7	2	31	20	12	2	45
Connecticut	14	48	1	5	8	37	21	4	47
Florida	15	35	29	8	10	41	27	29	19
Michigan	16	33	20	22	49	2	10	13	15
Virginia	17	37	15	28	13	17	40	12	22
Kentucky	18	8	46	17	15	38	26	45	11
Oklahoma	19	17	21	24	41	51	27	41	9
Massachusetts	20	46	14	32	1	35	3	1	33
Pennsylvania	21	41	19	20	6	18	25	21	30
Maryland	22	42	6	41	7	22	33	8	38
Iowa	23	4	28	31	19	34	6	34	39
North Dakota	24	23	30	39	9	31	30	49	6
Wisconsin	25	15	44	26	17	10	4	26	36
Arkansas	26	6	33	13	47	47	44	42	23
South Carolina	27	20	26	11	44	48	11	40	34
New Hampshire	28	47	13	25	22	12	2	7	36
Vermont	29	43	3	34	3	19	20	26	50
Minnesota	30	31	34	19	20	25	7	14	43
Wyoming	31	9	32	46	23	15	45	38	24
South Dakota	32	5	47	48	32	28	35	51	1
Delaware	33	27	16	50	11	26	37	17	29
Oregon	34	44	24	23	43	4	5	15	35
West Virginia	35	7	36	33	35	11	48	50	26
New York	36	16	39	27	5	42	17	25	49
New Mexico	37	29	30	44	42	8	46	24	19
Nevada	38	19	48	43	46	9	38	35	7
Illinois	39	38	38	36	2	33	19	11	44
Idaho	40	28	35	29	48	14	31	16	32
Alaska	41	32	43	40	39	16	49	39	14
Tennessee	42	39	49	35	36	39	13	36	10
Nebraska	43	22	41	37	29	40	24	47	40
Maine	44	45	25	18	30	6	39	43	48
District of Columbia	45	50	23	49	4	27	47	17	25
Hawaii	46	34	45	38	26	29	32	44	41
New Jersey	47	49	18	30	12	45	34	9	51
Mississippi	48	11	51	42	37	50	43	46	27
Louisiana	49	17	50	45	38	43	51	48	28
Montana	50	39	42	47	27	36	50	37	42
Rhode Island	51	51	27	51	21	44	42	19	46

INDIVIDUAL METRIC RANKINGS

State	Costs Category	Unit Labor Cost	Unit Material Cost	Energy Cost	Construction Cost
Washington	**1**	7	6	1	32
North Carolina	**2**	1	18	18	12
Missouri	**3**	2	11	28	18
Iowa	**4**	10	10	21	18
South Dakota	**5**	9	13	37	5
Arkansas	**6**	6	42	5	4
West Virginia	**7**	15	25	19	7
Kentucky	**8**	5	41	6	12
Wyoming	**9**	3	21	25	26
Indiana	**10**	25	2	29	18
Mississippi	**11**	4	43	15	5
Utah	**12**	42	1	11	18
Ohio	**13**	14	16	24	26
Arizona	**14**	24	17	22	12
Wisconsin	**15**	13	9	34	32
New York	**16**	27	5	12	44
Oklahoma	**17**	29	35	2	7
Louisiana	**17**	16	30	4	32
Nevada	**19**	18	21	14	35
South Carolina	**20**	41	3	16	26
Georgia	**21**	19	39	10	12
Nebraska	**22**	37	13	33	2
North Dakota	**23**	10	11	41	40
Colorado	**24**	17	21	30	35
Alabama	**25**	22	43	13	12
Kansas	**26**	26	19	32	24
Delaware	**27**	8	26	35	38
Idaho	**28**	31	38	20	1
New Mexico	**29**	32	46	8	2
Texas	**30**	23	29	7	42
Minnesota	**31**	12	36	37	26
Alaska	**32**	20	6	50	51
Michigan	**33**	30	20	31	35
Hawaii	**34**	21	6	51	50
Florida	**35**	40	28	36	7
California	**36**	35	4	46	45
Virginia	**37**	43	34	27	12
Illinois	**38**	39	24	23	40
Tennessee	**39**	38	48	9	24
Montana	**39**	45	49	3	18
Pennsylvania	**41**	28	47	26	26
Maryland	**42**	33	26	39	38
Vermont	**43**	47	31	44	7
Oregon	**44**	44	45	17	18
Maine	**45**	48	33	42	7
Massachusetts	**46**	46	15	48	48
New Hampshire	**47**	49	31	45	26
Connecticut	**48**	34	37	47	46
New Jersey	**49**	36	40	43	47
District of Columbia	**50**	50	50	40	48
Rhode Island	**51**	50	50	49	42

CATEGORY 1: COSTS

Metrics include:

- Unit Labor Cost -- The amount of labor, measured by payroll, necessary to produce $1 in aerospace revenue
- Unit Material Cost -- The amount of materials necessary to produce $1 in aerospace revenue
- Energy Cost -- The cost (cents/kilowatt hour) for the Industrial End-Use Sector
- Construction Cost -- The National Association of Builders modifiers for construction costs for buildings by state

Category 2: Labor & Education

State	Labor & Education Category	Aerospace Engineers	Aerospace Production Workers	Engineering BAs	Graduate Degrees	High School Degree or More	Education Spending
Connecticut	**1**	4	3	9	4	24	3
Washington	**2**	2	1	3	13	16	22
Vermont	**3**	16	4	17	7	6	5
Kansas	**4**	3	2	28	17	17	33
Colorado	**5**	6	15	2	9	14	39
Maryland	**6**	5	22	7	3	28	13
California	**7**	11	11	5	16	51	23
Arizona	**8**	8	5	14	28	39	49
Ohio	**9**	7	17	29	32	25	20
Georgia	**10**	14	6	22	21	41	37
Utah	**11**	10	16	21	23	10	51
Alabama	**12**	1	12	32	41	45	40
New Hampshire	**13**	38	18	10	10	2	11
Massachusetts	**14**	31	26	1	2	21	8
Virginia	**15**	15	37	6	5	29	25
Delaware	**16**	23	33	13	11	23	12
Missouri	**17**	24	8	43	27	30	31
New Jersey	**18**	20	42	4	8	27	4
Pennsylvania	**19**	32	21	23	19	22	10
Michigan	**20**	30	24	8	24	19	21
Oklahoma	**21**	12	9	47	45	35	48
Texas	**22**	13	20	11	37	50	42
District of Columbia	**23**	19	49	12	1	26	2
Oregon	**24**	40	19	20	15	18	30
Maine	**25**	46	14	36	20	8	17
South Carolina	**26**	35	7	34	35	38	32
Rhode Island	**27**	18	49	15	14	34	9
Iowa	**28**	25	27	42	42	11	28
Florida	**29**	26	28	19	31	33	44
North Dakota	**30**	21	40	41	44	5	16
New Mexico	**30**	9	43	26	22	47	38
Wyoming	**32**	22	46	39	36	4	7
Arkansas	**33**	29	10	48	47	43	36
Minnesota	**34**	39	41	18	18	1	18
Idaho	**35**	17	38	37	46	20	50
West Virginia	**36**	37	13	50	51	40	27
Indiana	**37**	33	25	38	40	32	35
Illinois	**38**	48	34	16	12	31	14
New York	**39**	49	31	30	6	44	1
North Carolina	**40**	34	29	27	25	37	46
Nebraska	**41**	36	36	49	30	15	19
Montana	**42**	42	39	35	34	3	26
Alaska	**43**	43	47	24	29	13	6
Wisconsin	**44**	51	35	31	33	7	24
Hawaii	**45**	45	49	25	26	9	15
Kentucky	**46**	44	23	46	39	46	34
South Dakota	**47**	28	48	45	43	12	41
Nevada	**48**	27	44	33	48	42	43
Tennessee	**49**	47	32	40	38	36	45
Louisiana	**50**	50	30	44	49	48	29
Mississippi	**51**	40	45	51	50	49	47

Metrics Include:
- Aerospace Engineers -- Aerospace Engineers per 1000 jobs
- Aerospace Production Workers -- Aerospace Production Worker Hours/(Total Employees x Average Hours)
- Engineering BAs -- The percentage of population 25+ with an engineering B.A.
- Graduate Degrees -- The percentage of population 25+ with an advanced degree
- High School + -- The percentage of population 25+ with at least a high school education
- Education Spending -- Primary and Secondary Education Spending Per Pupil

CATEGORY 3: AEROSPACE INDUSTRY

State	Industry Category	Aerospace Sales	Aerospace Value Added	Aerospace Exports	Workforce Growth	Supplier Density	Crowding Out
Washington	**1**	1	1	1	27	3	22
California	**2**	2	2	4	23	7	40
Kansas	**3**	6	5	12	33	1	20
Ohio	**4**	8	8	9	11	12	42
Connecticut	**5**	4	6	7	35	2	36
Arizona	**6**	5	4	10	32	4	35
North Carolina	**7**	9	9	11	5	36	13
Florida	**8**	11	10	8	14	13	46
Alabama	**9**	14	12	13	19	10	39
Texas	**10**	3	3	3	37	18	45
South Carolina	**11**	18	13	6	15	26	27
Colorado	**12**	16	15	34	2	29	7
Arkansas	**13**	15	16	18	39	6	4
Georgia	**14**	7	7	5	36	25	30
Missouri	**15**	10	21	24	8	22	38
Utah	**16**	26	17	32	10	9	25
Kentucky	**17**	22	27	2	13	30	28
Maine	**18**	23	20	35	12	27	3
Minnesota	**19**	32	32	31	3	21	10
Pennsylvania	**20**	12	18	22	16	35	43
Indiana	**21**	13	11	14	38	28	41
Michigan	**22**	21	22	21	34	17	29
Oregon	**23**	31	31	28	26	11	14
Oklahoma	**24**	20	25	27	31	5	49
New Hampshire	**25**	38	36	25	9	20	16
Wisconsin	**26**	34	33	29	1	34	12
New York	**27**	17	14	15	29	40	33
Virginia	**28**	27	26	23	4	45	34
Idaho	**29**	42	39	46	6	14	26
New Jersey	**30**	37	35	19	7	44	32
Iowa	**31**	25	28	33	22	42	23
Massachusetts	**32**	24	24	26	30	33	50
West Virginia	**33**	28	29	36	28	39	17
Vermont	**34**	39	38	43	20	24	21
Tennessee	**35**	33	37	17	45	32	8
Illinois	**36**	19	19	20	40	48	37
Nebraska	**37**	41	41	44	17	38	5
Hawaii	**38**	36	34	45	24	46	1
North Dakota	**39**	40	42	48	25	31	6
Alaska	**40**	49	49	42	18	8	51
Maryland	**41**	29	23	16	46	43	44
Mississippi	**42**	35	40	40	21	41	31
Nevada	**43**	43	43	38	44	16	19
New Mexico	**44**	44	44	39	42	15	24
Louisiana	**45**	30	30	37	47	47	11
Wyoming	**46**	47	47	51	43	23	1
Montana	**47**	46	45	47	48	19	15
South Dakota	**48**	45	46	50	49	37	9
District of Columbia	**49**	50	50	0	50	49	47
Delaware	**50**	48	48	41	41	50	18
Rhode Island	**51**	50	50	49	50	51	47

Metrics include:

- Aerospace Sales -- Aerospace Parts and Manufacturing Total value of shipments and receipts for services
- Aerospace Value Added -- Aerospace Parts and Manufacturing Value Added
- Aerospace Exports -- Aircraft, Spacecraft and Parts Exports
- Employee Growth -- Percent Increase in Aerospace Employees
- Supplier Density -- Aerospace Parts and Manufacturing establishments/Total establishments
- Crowding Out -- Federal Aerospace Manufacturing Contracts/Total value of shipments and receipts for services

CATEGORY 4: INFRASTRUCTURE

State	Infrastructure Category	Airports	Freight Railroad	Port Volume	Road Condition	Transportation Funding
Massachusetts	**1**	9	2	15	13	9
Illinois	**2**	12	3	22	21	8
Vermont	**3**	17	21	22	2	7
District of Columbia	**4**	1	1	22	51	1
New York	**5**	13	15	2	44	4
Pennsylvania	**6**	10	7	12	38	14
Maryland	**7**	3	13	11	36	18
Connecticut	**8**	7	8	22	22	23
North Dakota	**9**	33	31	22	9	3
Florida	**10**	8	28	5	5	32
Delaware	**11**	2	6	16	49	19
New Jersey	**12**	4	4	19	43	21
Virginia	**13**	16	12	6	33	28
Washington	**14**	24	33	4	40	11
Kentucky	**15**	34	18	22	7	25
Ohio	**16**	5	5	22	29	39
Wisconsin	**17**	14	23	22	41	20
Kansas	**18**	30	24	22	10	30
Iowa	**19**	37	16	22	34	17
Minnesota	**20**	31	27	22	37	13
Rhode Island	**21**	11	26	22	20	36
New Hampshire	**22**	18	37	22	1	37
Wyoming	**23**	50	45	22	15	6
Georgia	**24**	20	11	3	28	47
Indiana	**25**	6	9	22	25	49
Hawaii	**26**	28	51	9	50	5
Montana	**27**	45	41	22	19	12
North Carolina	**28**	15	19	17	24	44
Nebraska	**29**	42	35	22	14	22
Maine	**30**	35	38	21	16	24
California	**31**	39	39	1	46	16
South Dakota	**32**	44	40	22	30	10
Texas	**33**	21	36	7	32	34
Missouri	**34**	23	25	22	8	45
West Virginia	**35**	40	10	22	27	33
Tennessee	**36**	25	22	22	3	50
Mississippi	**37**	32	29	18	11	40
Louisiana	**38**	22	17	13	47	35
Alaska	**39**	49	50	10	48	2
Alabama	**40**	36	20	14	17	43
Oklahoma	**41**	27	32	22	31	29
New Mexico	**42**	48	48	22	6	27
Oregon	**43**	38	42	20	26	26
South Carolina	**44**	26	14	8	39	51
Colorado	**45**	43	43	22	45	15
Nevada	**46**	51	49	22	4	31
Arkansas	**47**	29	30	22	35	38
Idaho	**48**	41	44	22	18	42
Michigan	**49**	19	34	22	42	48
Arizona	**50**	46	47	22	12	46
Utah	**51**	47	46	22	23	41

Metrics include:

- Airports -- Airports per Square Mile
- Freight Railroad -- Total Freight Railroad miles per Square Mile
- Port Volume -- Total Container Traffic at U.S. Ports
- Road Condition -- Index of Road Quality
- Transportation Funding -- Total Airport, Highway, Seaport and Transit spending/Population

CATEGORY 5: RISK TO OPERATIONS

State	Risk to Operations Category	Insurance Losses	Insurance Premiums	Earthquake Premiums	Extreme Weather
Arizona	**1**	14	6	9	6
Michigan	**2**	15	15	2	15
Utah	**3**	6	2	47	4
Oregon	**4**	10	1	48	3
Washington	**5**	3	8	49	7
Maine	**6**	25	10	18	12
Ohio	**7**	1	9	31	37
New Mexico	**8**	22	19	13	9
Nevada	**9**	23	4	41	2
Wisconsin	**10**	33	5	4	23
West Virginia	**11**	17	12	3	40
New Hampshire	**12**	9	16	26	28
North Carolina	**13**	7	26	10	34
Idaho	**14**	39	3	27	5
Wyoming	**15**	4	27	36	14
Alaska	**16**	13	18	50	1
Virginia	**17**	5	17	24	44
Pennsylvania	**18**	27	13	12	35
Vermont	**19**	35	11	19	29
California	**20**	18	20	51	10
Georgia	**21**	19	32	15	27
Maryland	**22**	12	22	21	48
Indiana	**23**	16	21	38	33
Alabama	**24**	21	40	17	19
Minnesota	**25**	32	38	6	18
Delaware	**26**	37	7	20	45
District of Columbia	**27**	2	33	33	51
South Dakota	**28**	50	28	1	21
Hawaii	**29**	11	23	40	50
Colorado	**30**	29	42	22	13
North Dakota	**31**	51	34	5	11
Texas	**32**	31	50	7	16
Illinois	**33**	28	24	35	32
Iowa	**34**	48	14	14	41
Massachusetts	**35**	8	43	32	46
Montana	**36**	49	29	34	8
Connecticut	**37**	20	44	23	42
Kentucky	**38**	26	25	43	43
Tennessee	**39**	24	31	45	36
Nebraska	**40**	47	41	11	24
Florida	**41**	44	49	8	20
New York	**42**	34	37	30	39
Louisiana	**43**	46	51	16	17
Rhode Island	**44**	30	45	25	47
New Jersey	**45**	42	30	28	49
Missouri	**46**	38	35	46	31
Arkansas	**47**	40	39	44	25
South Carolina	**48**	36	36	42	38
Kansas	**49**	43	47	29	30
Mississippi	**50**	45	46	37	22
Oklahoma	**51**	41	48	39	26

Metrics include:
- Insurance Premiums – Average Homeowners Insurance Premiums
- Insurance Losses -- Incurred Insurance Losses, Commercial Insurance, by State/State GDP
- Earthquake Premiums -- Total Earthquake Premiums/Population
- Extreme Weather -- Total number of storm events per Square Mile

CATEGORY 6: ECONOMY

State	Economy Category	GDP Per Capita	GDP Per Capita Growth	Manufacturing	Global Manufacturing Connectivity	Unemployment Rate
Washington	**1**	9	3	15	3	12
New Hampshire	**2**	19	12	10	15	2
Massachusetts	**3**	3	6	22	24	12
Wisconsin	**4**	25	21	4	19	8
Oregon	**5**	28	2	3	9	37
Iowa	**6**	22	22	11	25	1
Minnesota	**7**	16	30	9	21	5
Utah	**8**	31	10	20	12	10
Indiana	**9**	32	23	1	6	22
Michigan	**10**	38	5	2	4	37
South Carolina	**11**	47	20	7	2	12
California	**12**	8	1	21	23	40
Tennessee	**13**	37	14	13	10	22
Georgia	**14**	29	4	31	20	12
Kansas	**15**	24	24	14	27	12
Ohio	**16**	26	11	8	13	48
New York	**17**	2	9	44	26	29
Texas	**18**	17	33	27	7	26
Illinois	**19**	13	25	26	18	29
Vermont	**20**	35	34	29	5	12
Connecticut	**21**	7	49	18	14	35
Colorado	**22**	15	8	36	44	21
Alabama	**23**	46	37	5	8	29
Nebraska	**24**	14	35	34	40	5
Pennsylvania	**25**	20	7	30	34	40
Kentucky	**26**	45	38	6	1	42
North Carolina	**27**	36	28	17	30	22
Florida	**27**	42	17	40	22	12
Oklahoma	**27**	33	18	33	39	10
North Dakota	**30**	6	51	38	37	4
Idaho	**31**	49	15	16	28	29
Hawaii	**32**	18	19	48	51	2
Maryland	**33**	12	13	43	43	29
New Jersey	**34**	11	27	41	33	35
South Dakota	**35**	23	48	25	45	7
Missouri	**36**	39	45	24	35	9
Delaware	**37**	10	39	47	31	26
Nevada	**38**	34	29	37	11	42
Maine	**39**	44	16	32	42	20
Arizona	**40**	41	31	19	17	46
Virginia	**40**	21	41	39	41	12
Rhode Island	**42**	27	36	28	38	29
Mississippi	**43**	51	43	12	16	44
Arkansas	**44**	50	42	23	32	22
Wyoming	**45**	5	40	50	49	37
New Mexico	**46**	40	26	46	29	44
District of Columbia	**47**	1	44	50	46	50
West Virginia	**48**	48	32	35	36	48
Alaska	**49**	4	50	49	50	51
Montana	**50**	43	46	45	48	26
Louisiana	**51**	30	47	42	47	47

Metrics include:
- GDP Per Capita -- GDP Per Capita
- Growth in GDP Per Capita -- GDP Per Capita 5-Year Growth
- Manufacturing Industry -- Durable Goods Output/State GDP
- Global Manufacturing Connectivity -- Durable Goods Exports/State GDP
- Unemployment Rate

CATEGORY 7: RESEARCH & INNOVATION

State	Research & Innovation Category	Patents per Capita	Public R&D	Private R&D	High Tech Establishments
Massachusetts	**1**	2	8	1	9
California	**2**	1	12	2	7
Utah	**3**	11	13	11	6
Connecticut	**4**	5	10	6	23
Colorado	**5**	10	6	24	5
Washington	**6**	3	21	5	17
New Hampshire	**7**	7	17	8	19
Maryland	**8**	25	1	23	4
New Jersey	**9**	12	30	9	10
Arizona	**10**	17	15	15	15
Illinois	**11**	15	16	17	16
Virginia	**12**	30	5	28	2
Michigan	**13**	8	23	4	32
Minnesota	**14**	6	35	12	18
Oregon	**15**	4	33	7	27
Idaho	**16**	16	9	10	41
Delaware	**17**	29	42	3	3
District of Columbia	**17**	26	3	47	1
North Carolina	**19**	21	25	16	20
Rhode Island	**19**	19	7	25	31
Pennsylvania	**21**	24	14	20	25
Texas	**22**	20	27	26	11
Ohio	**23**	18	22	19	26
New Mexico	**24**	32	2	35	29
New York	**25**	13	28	27	33
Wisconsin	**26**	14	37	18	36
Georgia	**26**	28	36	29	12
Vermont	**26**	9	32	30	34
Florida	**29**	33	29	33	13
Missouri	**30**	35	20	13	46
Indiana	**31**	23	40	14	37
Kansas	**32**	27	50	22	21
Alabama	**33**	47	4	31	40
Iowa	**34**	22	31	21	50
Nevada	**35**	31	44	45	8
Tennessee	**36**	37	11	39	42
Montana	**37**	39	24	38	35
Wyoming	**38**	36	51	40	14
Alaska	**39**	51	18	51	24
South Carolina	**40**	34	39	34	39
Oklahoma	**41**	42	43	42	22
Arkansas	**42**	45	34	46	30
Maine	**43**	38	38	36	47
Hawaii	**44**	48	26	48	38
Kentucky	**45**	40	48	32	43
Mississippi	**46**	50	19	49	49
Nebraska	**47**	43	45	37	44
Louisiana	**48**	46	49	50	28
North Dakota	**49**	41	46	41	48
West Virginia	**50**	49	41	44	45
South Dakota	**51**	44	47	43	51

Metrics include:
- Patents per Capita -- Patents Issued to Residents/Total Population
- Public Research and Development -- Federal R&D Spending for Selected Agencies/State GDP
- Private Research and Development -- Private R&D from All Sources/State GDP
- High Tech Establishments – Percent of Businesses in Industries with High Science, Engineering, and Technology (SET) Employment

CATEGORY 8: TAXES AND INCENTIVES

State	Taxes & Incentives Category	Total Taxes/GDP	Workers' Compensation	Corporate Income Tax	Individual Income Tax	Manufacturing Tax	Property Tax	Sales Tax
South Dakota	**1**	5	29	1	1	8	26	21
Indiana	**2**	13	2	16	11	6	10	28
Texas	**3**	7	9	4	1	9	39	40
Utah	**4**	8	5	11	16	16	14	26
Washington	**5**	9	36	6	1	4	17	48
North Dakota	**6**	51	1	8	9	1	9	24
Nevada	**7**	21	8	3	1	32	16	39
Alabama	**8**	12	23	24	19	3	2	47
Oklahoma	**9**	15	28	19	19	2	3	46
Tennessee	**10**	4	20	24	8	23	4	51
Kentucky	**11**	31	19	12	19	18	6	11
North Carolina	**12**	11	33	7	25	21	11	27
Colorado	**13**	18	17	9	14	17	25	36
Alaska	**14**	1	48	45	1	7	38	5
Michigan	**15**	25	15	19	12	14	35	11
Arizona	**16**	19	12	10	13	29	23	41
Ohio	**17**	26	16	5	18	30	22	32
Georgia	**18**	6	46	16	28	20	18	33
New Mexico	**19**	16	31	15	1	38	34	30
Florida	**19**	37	18	18	15	19	5	37
Missouri	**21**	10	25	22	26	27	15	38
Virginia	**22**	14	11	19	28	40	30	10
Arkansas	**23**	39	3	24	36	5	7	49
Wyoming	**24**	40	36	1	1	41	44	7
District of Columbia	**25**	2	10	40	46	45	12	0
West Virginia	**26**	47	4	24	33	12	19	20
Mississippi	**27**	44	21	12	19	28	32	31
Louisiana	**28**	17	42	38	32	13	8	50
Delaware	**29**	3	47	47	34	48	1	1
Pennsylvania	**30**	33	35	49	10	15	29	18
Kansas	**31**	27	6	31	27	25	36	44
Idaho	**32**	29	31	30	38	26	20	15
Massachusetts	**33**	28	14	38	24	31	41	17
South Carolina	**34**	22	38	12	40	33	33	35
Oregon	**35**	30	6	34	48	37	28	1
New Hampshire	**36**	32	41	37	42	11	37	8
Wisconsin	**36**	20	26	35	19	51	51	1
Maryland	**38**	38	13	40	28	36	24	11
Iowa	**39**	24	22	51	43	22	31	23
Nebraska	**40**	23	26	36	35	39	40	24
Hawaii	**41**	46	39	23	50	35	13	6
Montana	**42**	35	39	29	36	42	42	1
Minnesota	**43**	41	24	48	47	10	27	34
Illinois	**44**	36	30	46	16	34	43	45
California	**45**	34	50	43	51	24	21	43
Rhode Island	**46**	42	44	31	31	44	47	28
Connecticut	**47**	43	45	33	39	43	46	19
Maine	**48**	49	33	44	41	47	48	9
New York	**49**	48	51	24	45	49	45	42
Vermont	**50**	50	43	42	44	50	50	16
New Jersey	**51**	45	49	50	49	46	49	22

Metrics include:
- Total Taxes/GDP -- Total Taxes as a percent of State GDP
- Workers' compensation premium rate
- Corporate Income Tax -- Top Corporate Income Tax Rate, or Implied Corporate Income Tax Rate using B&O and Aerospace Margin
- Personal Income Tax -- Top Individual Income Tax Rate
- Manufacturing Tax -- Taxes on Production and Imports Minus Subsidies for Durable Goods Manufacturing/GDP for Durable Goods Manufacturing
- Property Tax -- State & Local Property Tax Collection Per Capita / GDP Per Capita
- Sales Tax – State and Local Sales Tax Rate

METHODOLOGY

ACES 2019 utilizes a quantitative ranking methodology that includes a broad array of statistical measures that characterize individual state economies, and associated factors contributing to the ability of commercial enterprises to profitably produce aerospace-related products.

The methodology addresses the competitive environment that aerospace manufacturing companies face when considering alternative locations in the U.S. The results offer a comparative tool to help public and private interests evaluate the strengths and weaknesses of individual states.

ACES 2019 relies on forty-one metrics. Each is assigned to one of eight categories. Individual metrics were chosen based on relevance, availability, consistency across states and potential impact to production and profitability. Wherever possible, metrics were selected based on their ability to characterize the aerospace sector.

Category	Weight
Costs	20.0%
Labor & Education	17.5%
Taxes & Incentives	17.5%
Industry	15.0%
Infrastructure	15.0%
Economy	5.0%
Research & Innovation	5.0%
Risk to Operations	5.0%

The eight categories appear in the table to the right. The assigned weights are based on an assessment of how impactful the category might be to the overall productivity and profitability of an aerospace facility. The higher the likely impact to profitability, the higher the weight assigned. The metrics and categories chosen include elements that are directly or indirectly impactful. Direct impacts carry higher weights than indirect impacts.

Some states are highly competitive across a number of categories and metrics, while other states are strong in a category or two, or not competitive at all. The ACES analysis and findings focus on the aerospace sector, but some of the results for non-aerospace specific categories could apply to other sectors.

State category rankings change from year-to-year. Tax metrics, for instance, are influenced by government policy which can change quickly within a legislative session, with rates adjusted and incentives increased, reduced or repealed. This year's ACES Rankings represent a quantitative snapshot of the current competitive landscape rather than an analysis of long-term trends.

Aerospace manufacturing encompasses a broad array of processes and products, and these various inputs depend on many different attributes in a production site. For example, manufacturing avionics or satellites involves a greater emphasis on a skilled engineering workforce, and relatively little emphasis on infrastructure. On the other hand, heavy manufacturing of large metal aerostructures involves greater emphasis on a skilled manufacturing workforce and physical infrastructure; composite structures would involve a greater emphasis on energy costs.

Given these requirements, ACES 2019 criteria weightings reflect a balanced approach. In general, we have tried to look at the qualities most desirable for the manufacture or final assembly of large aerospace structures. But a manufacturer seeking to build, for example, missile engines or flight simulators, might apply alternative weighting to the various metrics and categories.

ACES 2019 draws on many data sources and incorporates various measures. Each of the 41 metrics was chosen for inclusion because it meets all or most of the following criteria:

1. Important to manufacturing costs and profitability
2. Readily available for all 50 states and the District of Columbia
3. Uniformity of calculation and reporting, so that the variable can be fairly compared across all states
4. Publicly available data
5. Available for a recent year
6. Aerospace industry specific

Each metric is ranked by state based on the absolute variable value. The result is a matrix of rankings by metric by state: 41 metrics by 50 states + D.C. The weights are based on a review of potential impact to a typical aerospace company's income statement and profitability. The more directly impactful a category (or individual metric) is believed to be, the higher the weight assigned. For example, Costs are more directly linked and impactful to an individual corporation's overall cost structure and ability to generate profit than are indirect impacts from the state's Economy. Therefore, Costs receive a weight of 20%, while Economy receives a weight of only 5%.

Likewise, the specific metrics within a category received a higher weight depending on their perceived income statement impact within that category. Where individual metrics were perceived to be somewhat equal in importance, or their impact was understood to be less direct to the income statement, similar weights were assigned, or the weighting was clustered in a narrow range.

A state's ranking for each category (i.e. Infrastructure or Risk to Operations) is calculated by multiplying each metric rank in the category by its metric weight, summing all of the resulting weighted metrics, and then ranking each state from smallest to largest weighted metric sum for that category. Each state's overall ranking is calculated by multiplying all 41 metrics by their metric and category weights, summing the resulting weighted metrics (into each state's index value), and then ranking states by the final sum of these 41 weighted metrics.

The ACES rankings include data that are as aerospace specific as possible while also remaining publicly available for all 50 states and the District of Columbia; and for the large majority of metrics, data were available for every state. However, for a handful of metrics, data were missing for one or more states. In these cases, econometric and analytical techniques were used to come to a reasonable estimation of the state's missing data for that metric. These techniques used data from previous years, related available aerospace data, and data from a broader NAICS category to develop an accurate estimate.

Finally, several of the metrics included in the 2019 ACES model required estimation methods in order to update the full set of variables that originated with the 2018 methodology. U.S. Census Bureau data release schedules and the resulting unavailability of Census produced timeseries data necessitated this requirement. Fortunately, alternative or supporting data series were acquired from various state sources. An econometric model was constructed that included the non-Census sourced data and estimates were prepared for inclusion in the 2019 ACES model.

CATEGORIES AND METRICS INCLUDED IN ACES 2019

Category	Metric	Description	Source
Costs	Unit Labor Cost	The amount of labor, measured by payroll, necessary to produce $1 in revenue (2017 Estimate)	U.S. Census Bureau, U.S. Bureau of Economic Analysis, Teal Group Model.
	Unit Material Cost	The amount of materials necessary to produce $1 in revenue (2017 Estimate)	U.S. Census Bureau, U.S. Bureau of Economic Analysis, Teal Group Model.
	Energy Cost	The cost (cents/kilowatt hour) for the Industrial End-Use Sector (December 2018)	U.S. Energy Information Administration
	Construction Cost	The National Association of Builders modifiers for construction costs for buildings by state (2018)	National Building Cost Manual
Labor & Education	Aerospace Engineers	Aerospace Engineers per 1000 jobs (2017)	U.S. Bureau of Labor Statistics
	Aerospace Production Workers	Aerospace Production Workers Hours/(Total Employees x Average Hours) (2017)	U.S. Census Bureau, U.S. Bureau of Economic Analysis, Teal Group Model.
	Engineering BAs	The percentage of population 25+ with an engineering B.A. (2017)	U.S. Census Bureau
	Graduate Degrees	The percentage of population 25+ with an advanced degree (2017)	U.S. Census Bureau
	High School +	The percentage of population 25+ with at least a high school education (2017)	U.S. Census Bureau
	Education Spending	Primary and Secondary Education Spending Per Pupil (2016)	U.S. Census Bureau
Industry	Aerospace Sales	Aerospace Parts and Manufacturing Total value of shipments and receipts for services (2017)	U.S. Census Bureau, U.S. Bureau of Economic Analysis, Teal Group Model.
	Aerospace Value Added	Aerospace Parts and Manufacturing Value Added (2016)	U.S. Census Bureau, U.S. Bureau of Economic Analysis, Teal Group Model.
	Aerospace Exports	Exports of Aerospace Products and Parts (2018)	U.S. Census Bureau
	Employee Growth	Pct Increase in Aerospace Employees (2013 - 2017)	U.S. Census Bureau
	Supplier Density	Aerospace Parts and Manufacturing establishments/Total establishments (2016)	U.S. Census Bureau
	Crowding Out	Federal Aerospace Manufacturing Contracts/Total value of shipments and receipts for services (2017)	USASpending.Gov, U.S. Census Bureau, Teal Group Model
Infrastructure	Airports	Airports per Sq Mile (2019)	U.S. Federal Aviation Administration
	Freight Railroad	Freight Railroad Miles per Sq Mile (2017)	Association of American Railroads
	Port Volume	Total Container Traffice at U.S. Ports (2017)	US Army Corps of Engineers
	Road Condition	Index of Road Quality (2017)	U.S. Federal Highway Administration
	Transportation Funding	Total Airport, Highway, Seaport and Transit spending/Population (2015)	U.S. Census Bureau
Risk to Operations	Insurance Premiums	Average Homeowners Insurance Premiums (2016)	Insurance Information Institute
	Insurance Losses	Current 2013 - 2017 Incurred Insurance Losses, Commercial Insurance, by State/Current State GDP (2013 - 2017)	Insurance Information Institute, U.S. Bureau of Economic Analysis
	Earthquake Premiums	Total Earthquake Premiums/Population (2017)	S&P Global Market Intelligence, Insurance Information Institute, U.S. Census Bureau
	Extreme Weather	Total number of storm events per Sq Mile (2013 - 2017)	U.S. National Oceanic and Atmospheric Administration
Economy	GDP Per Capita	Real GDP Per Capita (4Q 2017 - 3Q 2018)	U.S. Bureau of Economic Analysis
	Growth in GDP Per Capita	Real GDP Per Capita 5-Year Growth (4Q 2012 - 3Q 2013, 4Q 2017 - 3Q 2018)	U.S. Bureau of Economic Analysis
	Manufacturing Industry	Real Durable Goods Output/Real State GDP (4Q 2017 - 3Q 2018)	U.S. Bureau of Economic Analysis
	Global Manufacturing Connectivity	Current Durable Goods Exports/Current State GDP (4Q 2017 - 3Q 2018)	US Census Bureau, U.S. Bureau of Economic Analysis
	Unemployment Rate	Unemployment Rate (December 2018)	U.S. Bureau of Labor Statistics
Research & Innovation	Patents per Capita	Patents Issued to Residents/Total Population (2018)	U.S. Patent and Trademark Office
	Public Research and Development	Current Federal R&D Spending for Selected Agencies/Current State GDP (2016)	U.S. Bureau of Economic Analysis
	Private Research and Development	Current Private R&D From All Sources/Current State GDP (2015)	U.S. Bureau of Economic Analysis
	High Tech Establishments	Pct of Businesses in Industries with High Science,Engineering, and Technology (SET) Employment (2014)	National Science Foundation, U.S. Census Bureau
Taxes & Incentives	Total Taxes/GDP	Total Taxes as a pct of State GDP (2015)	US Census Bureau, U.S. Bureau of Economic Analysis
	Workers' Compensation	Workers' compensation premium rate (2018)	Oregon Department of Consumer and Business Services
	Corporate Income Tax	Actual or Estimated Corporate Income Tax Rate (Estimated using B&O and Aerospace Margin) (2019)	Tax Policy Institute, Delaware Division of Revenue, Nevada Department of Taxation, Ohio Department of Taxation, Texas Office of the Comptroller, Washington
	Personal Income Tax	Top Individual Income Tax Rate (2019)	Tax Policy Institute
	Manufacturing Tax	Current Taxes on Production and Imports Minus Subsidies for Durable Goods Manufacturing/Current GDP for Durable Goods Manufacturing (2017)	U.S. Bureau of Economic Analysis
	Property Tax	Current State & Local Property Tax Collection Per Capita (2016) / Current GDP Per Capita (2016)	Tax Policy Institute, U.S. Bureau of Economic Analysis
	Sales Tax	General Local and Sales Tax Rate (2019)	Tax Policy Institute

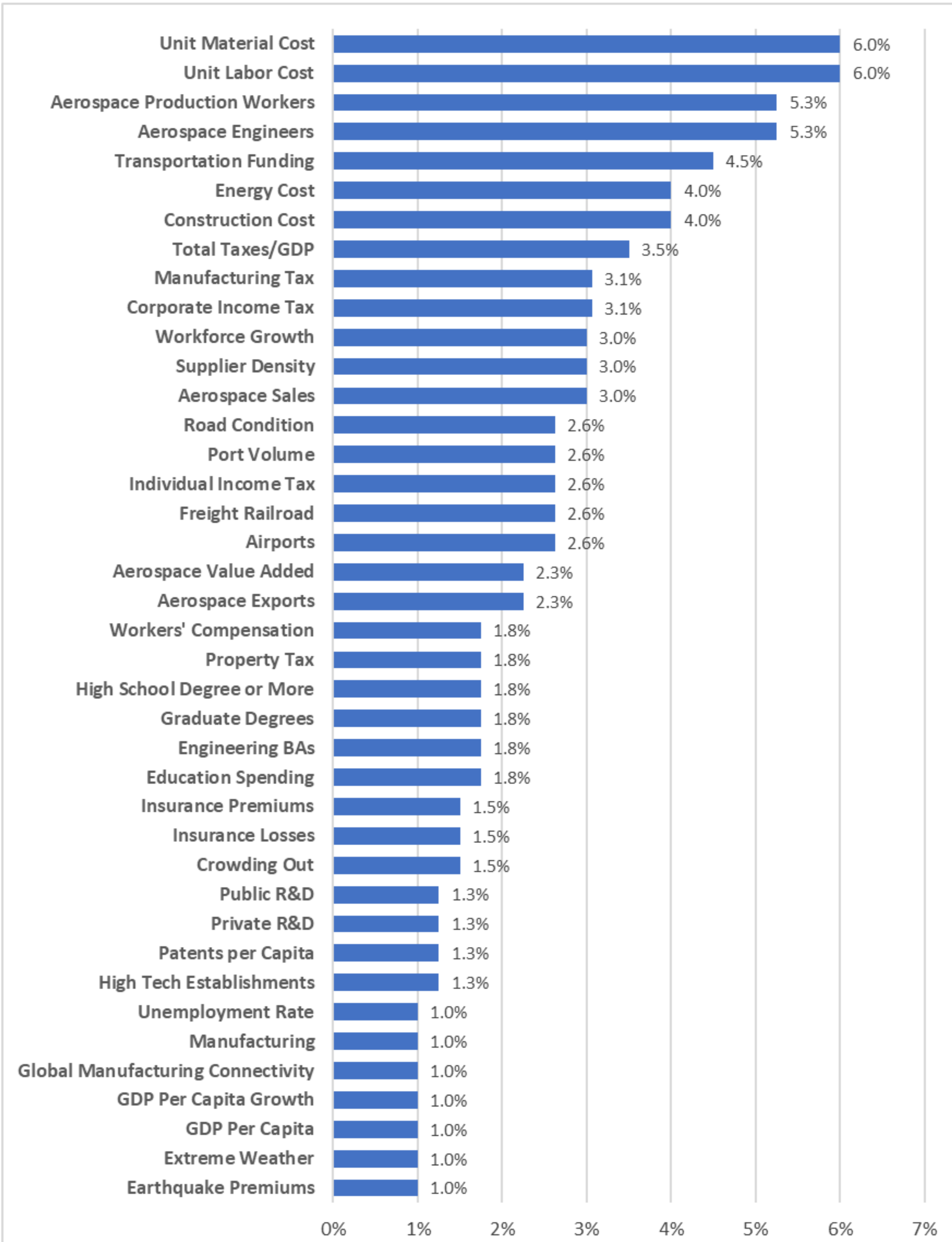
Weights for Categories and Individual Metrics

Below are the 41 metrics used in the ACES model, the category to which each metric is assigned and the associated weights.

Category	Weight	Metric	Weight
Costs	20.0%	Unit Labor Cost	30%
		Unit Material Cost	30%
		Energy Cost	20%
		Construction Cost	20%
Labor & Education	17.5%	Aerospace Engineers	30%
		Aerospace Production Workers	30%
		Engineering BAs	10%
		Graduate Degrees	10%
		High School Degree or More	10%
		Education Spending	10%
Industry	15.0%	Aerospace Sales	20%
		Aerospace Value Added	15%
		Aerospace Exports	15%
		Workforce Growth	20%
		Supplier Density	20%
		Crowding Out	10%
Infrastructure	15.0%	Airports	18%
		Freight Railroad	18%
		Port Volume	18%
		Road Condition	18%
		Transportation Funding	30%
Risk to Operations	5.0%	Insurance Losses	30%
		Insurance Premiums	30%
		Earthquake Premiums	20%
		Extreme Weather	20%
Economy	5.0%	GDP Per Capita	20%
		GDP Per Capita Growth	20%
		Manufacturing	20%
		Global Manufacturing Connectivity	20%
		Unemployment Rate	20%
Research & Innovation	5.0%	Patents per Capita	25%
		Public R&D	25%
		Private R&D	25%
		High Tech Establishments	25%
Taxes & Incentives	17.5%	Total Taxes/GDP	20%
		Workers' Compensation	10%
		Corporate Income Tax	18%
		Individual Income Tax	15%
		Manufacturing Tax	18%
		Property Tax	10%
		Sales Tax	10%

Contribution of Each Individual Metric to the Overall Rankings

Each individual metric weight within its category is multiplied by the category weight. The result is the individual metric's share in the overall ranking calculation.



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