AEROSPACE COMPETITIVE ECONOMICS STUDY 2022

Final Report – September 2022

Prepared For:

International Association of Machinists (IAM)
The Society of Professional Engineering Employees in Aerospace (SPEEA)

AeroDynamic ADVISORY

Table of Contents

Executive Summary

For the third time, the 2022 Aerospace Competitive Economics Study ("ACES") finds that the State of Washington is the most competitive business environment for the manufacture of major aerospace structures and for the final assembly of aircraft. Completing the top five states were Texas, Ohio, Arizona, and Alabama. Georgia, North Carolina, Utah, Virginia, and Indiana were also in the top ten.

Washington remains strong across most categories and many individual metrics. It is a top ten finisher in six of the eight categories, ranking within the top three in three categories. The State of Washington ranks in the top ten in twenty of the forty-one individual metrics. This is a very strong showing.

Texas is the biggest mover in the top ten (compared with the 2019 ACES study), jumping from 8th place to 2nd this year. Texas has experienced high growth in recent years and is now the second largest US state exporter of aerospace products behind Washington. While its sharp rise was impressive, it is still well behind Washington in its overall competitiveness and suffers from crowding out from the very heavy defense presence in the state.

Ohio fell one spot down to #3 but is still strong in many categories and metrics. The state's strength comes from its above-average performance in most metrics even though it is only in the top five in one category, Aerospace Industry.

Arizona continues to move up in the rankings, going from #9 in 2018 to #5 in 2019 to #4 this year. It has steadily added key aerospace companies to its industry profile, helping it to also attract a growing number of supply chain partners.

In addition to this year's state-level rankings, ACES 2022 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).

This report updates the global market outlook for air travel demand and aircraft production in the COVID-recovery world. Air travel demand has come a long way since the worst of the COVID-19 pandemic lockdowns, but the recovery has been uneven. While intra-region revenue passenger kilometers (RPKs) have bounced back to almost 80% of pre-COVID levels, inter-region RPKs are still down 44%. China's zero-COVID policy and the war in Ukraine have put a damper on

States	2022 Rank	2019 Rank
Washington	1	1
Texas	2	8
Ohio	3	2
Arizona	4	5
Alabama	5	10
Georgia	6	7
North Carolina	7	4
Utah	8	3
Virginia	9	17
Indiana	10	11
Florida	11	15
New Hampshire	12	28
Oklahoma	13	19
North Dakota	14	24
South Carolina	15	27
District of Columbia	16	45
Wyoming	17	31
South Dakota	18	32
Kansas	19	9
Colorado	20	6
Pennsylvania	21	21
Vermont	22	29
Connecticut	22	14
Tennessee	24	42
Delaware	25	33
Nebraska	26	43
Arkansas	27	26
Wisconsin	28	25
Kentucky	29	18
Oregon	30	34
Illinois	31	39
Michigan	32	16
Minnesota	33	30
Idaho	34	40
Maryland	35	22
California	36	13
New Mexico	37	37
West Virginia	38	35
Alaska	39	41
New York	40	36
Massachusetts	41	20
Mississippi	42	48
Missouri	43	12
Montana	44	50
Maine	45	44
Iowa	46	23
Nevada	47	38
New Jersey	48	47
Rhode Island	49	51
Louisiana	50	49
Hawaii	51	46

recovery and will be critical watch items in the next year. China is not likely to relax their hard-lined approach until the National People's Congress in March of 2023, but economic and social pressures may force some easement after the full government transition occurs. The longer Russia's war in Ukraine keeps staple crop and fuel prices high, the greater the negative impact on the growth of the global middle class, which is critical to air travel growth.

Similarly, the jetliner manufacturing sector's recovery has been uneven. Single aisle jets are quickly headed towards record output numbers; the twin aisle jetliner segment remains depressed. For many reasons, single aisles will continue to outperform twins over the next ten years, at least.

Boeing continues to lose market share to Airbus in the broader jetliner market, the single aisle segment, and the crucial mid-market jetliner segment. Airbus's A321neo continues to attract the overwhelming share of orders, while doubts remain about when Boeing's competing 737MAX10 will be certified. Boeing continues to deny that it needs a new jet in this class, but order trends clearly show that this is not the case. In any event, it has been 18 years since Boeing has launched an all-new clean-sheet jetliner, so the company will need to create something new in the next few years.

ACES 2022 also discusses three important factors impacting aerospace manufacturing site selection decisions: the presence of a dominant incumbent, crowding out related to military aircraft production, and access to technical skills required for Industry 4.0, including Model-Based Systems Engineering. "Fortress clusters", where one manufacturer already dominated 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.

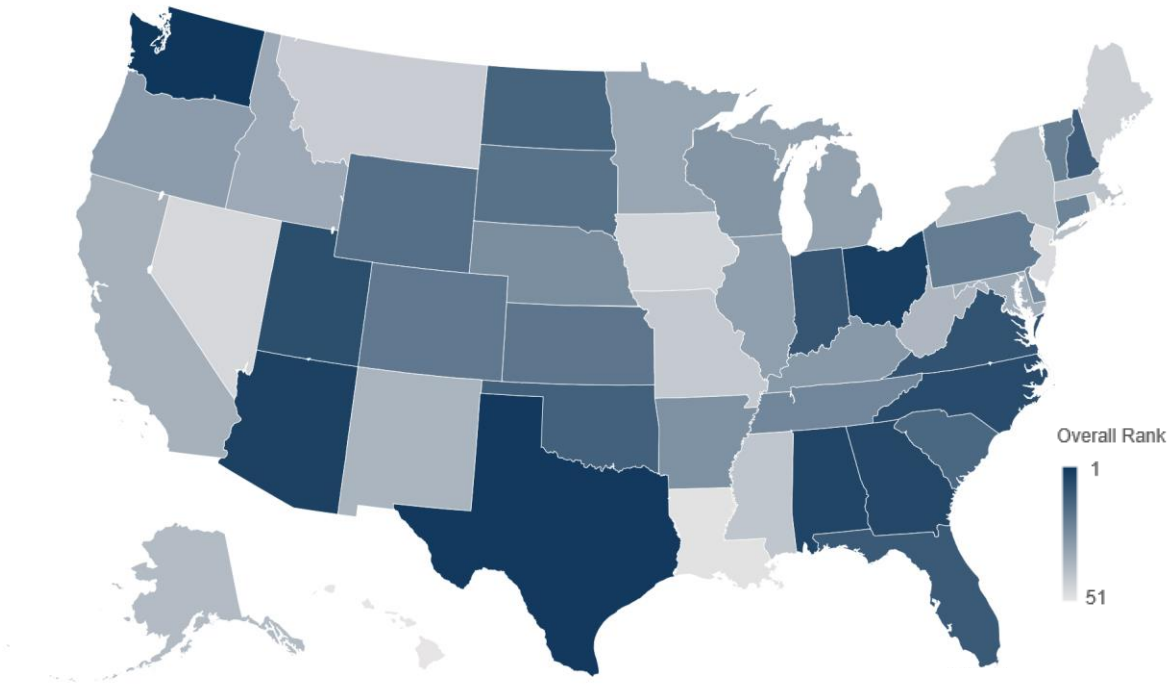
Meanwhile, "military clusters" with a large defense presence may experience the crowding out of commercial aircraft production. Military aircraft cost structures conform to government procurement policies, which often include cost-plus provisions that allow for wage increases that outpace productivity 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.

In addition, Industry 4.0, including Model-Based Systems Engineering (MBSE), requires a different set of skills than is typical for aircraft development and manufacturing, including systems engineering, data scientists, and computer engineers. Aerospace companies will place more emphasis on locating in areas with large sources of talent in these fields. The interconnectedness of design and production models, production data analytics, and automation that Industry 4.0 demands increase the need for engineering support directly on-site. This means engineering labor costs of a region will have a greater impact on site selection than they have in the past.

Top 10 Most Competitive States

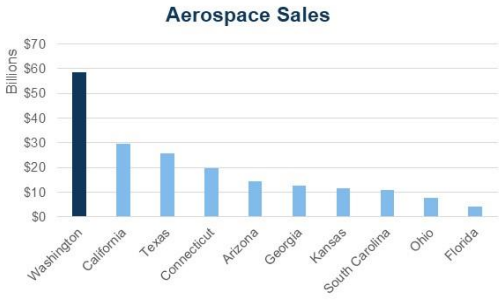
The top performing states are presented in the chart and table below. Based on the various measures included in ACES, these states represent the most competitive business environments for the manufacture or final assembly of large aerospace structures. Each of these ten states incorporates multiple factors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

ACES Ranking



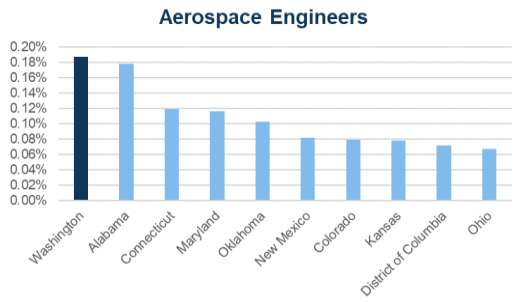
State	Overall Rank	Cost	Labor & Education	Aerospace Industry	Infra-structure	Risk to Operations	Economy	Research & Innovation	Taxes
Washington	1	13	1	3	31	6	6	3	7
Texas	2	19	21	5	10	37	20	23	1
Ohio	3	34	11	2	17	9	16	19	9
Arizona	4	14	9	4	50	1	14	14	13
Alabama	5	4	15	16	24	35	17	33	15
Georgia	6	18	12	8	16	28	27	29	16
North Carolina	7	25	39	9	8	11	17	15	5
Utah	8	41	7	12	42	3	3	7	2
Virginia	9	26	13	29	4	20	31	10	25
Indiana	10	28	30	14	25	22	1	30	10

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 three categories: Labor & Education (#1), Aerospace Industry (#3), and Research and Innovation (#3). It also scores in the top ten in Risk to Operations (#6), Economy (#6), and Taxes & Incentives (#7).

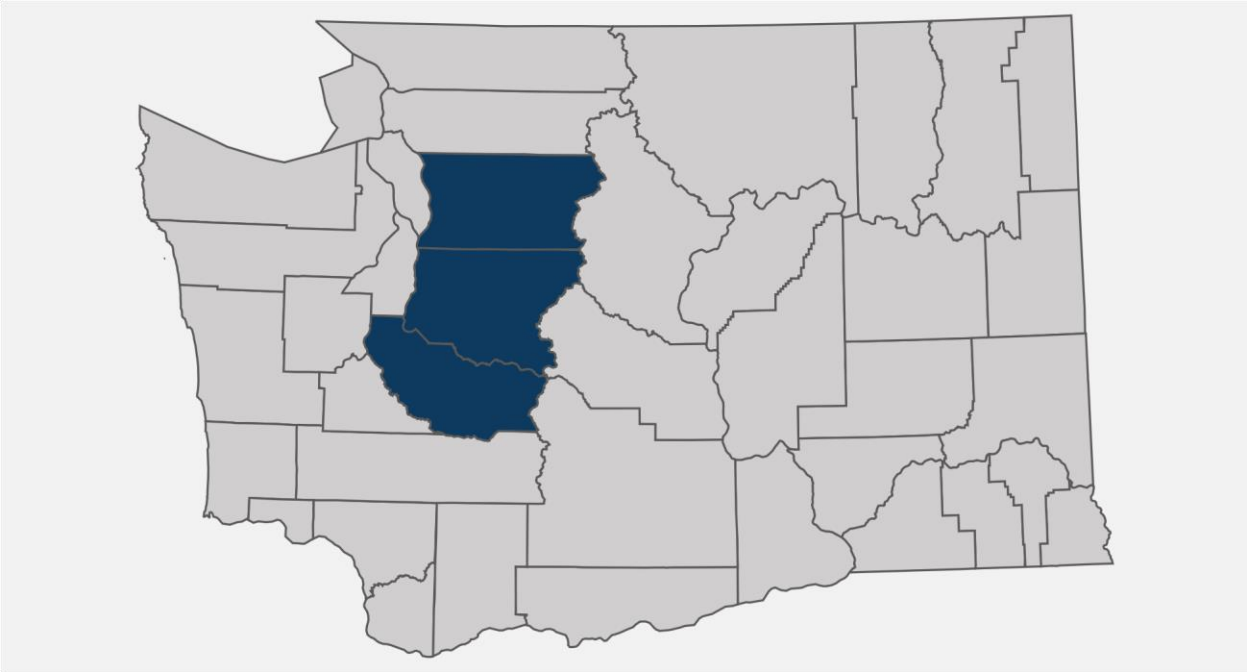
While other states rank well in some of categories and individual metrics, Washington outperforms the competition by ranking extremely high in many measures. Washington is ranked in the top 10 in 20 individual metrics. This is almost half of all metrics in the ACES model. Given its strong presence in aircraft manufacturing, Washington scores high in many industry metrics, but it also scores well in broader industrial measures, such as labor productivity (#1), insurance losses (#1), energy costs (#3), port volume (#4), and multiple tax metrics.



- The FAA lifted the ban on 737MAX aircraft in November 2020 but EASA did not unground it until January 2021 and it has yet to re-enter revenue service in China as of June 2022.
- 737MAX supply chain issues have also impacted production, delaying Boeing's plans to increase rate to 31 per month. Fewer than 15 MAX aircraft were produced in May 2022.
- Boeing announced in October 2020 that all 787 production would be consolidated in South Carolina. The last Everett-built 787 rolled off the line in February 2021.
- SPEEA, Boeing's engineering union, gave $21M in raises in 2021, which was $15M more than union contracts required, in an effort to retain talent.
- Eviation opened its engineering, production, and delivery center at the Arlington Municipal Airport in Snohomish County. Eviation's 9-seat electric aircraft, Alice, is expected to have its first flight within 2022.

Cost	**13**
Labor Cost	41
Labor Productivity	1
Energy Cost	3
Construction Cost	30
Labor & Education	**1**
Aerospace Engineers	1
Aerospace Production Workers	2
Engineering BAs	2
Graduate Degrees	12
High School +	16
Education Spending	17
Aerospace Industry	**3**
Aerospace Sales	1
Aerospace Value Added	1
Aerospace Exports	1
Workforce Growth	32
Supplier Density	3
Crowding Out	26
Infrastructure	**31**
Airports	26
Freight Railroad	34
Port Volume	4
Road Condition	43
Transportation Funding	22
Risk to Operation	**6**
Insurance Losses	1
Insurance Premiums	9
Earthquake Premiums	49
Extreme Weather	5
Economy	**6**
GDP Per Capita	4
GDP Per Capita Growth	2
Manufacturing Industry	20
Global Mfg Connectivity	17
Unemployment Rate	33
Research & Innovation	**3**
Patents Per Capita	3
Public R&D	20
Private R&D	1
High Tech Establishments	17
Taxes & Incentives	**7**
Total Taxes / GDP	15
Workers Compensation	30
Corporate Income Tax	1
Individual Income Tax	1
Manufacturing Tax	4
Property Tax	11
Sales Tax	41

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, 777X Composite Wing Center, and Interiors Responsibility 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.

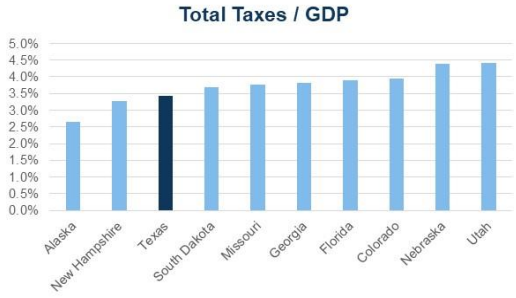
Emerging Aerospace technology companies are also represented in this cluster, with Eviation in Arlington and MagniX in Everett. Boeing also has fabrication facilities in Frederickson and Auburn and engineering in Seattle. Additionally, Boeing and other aerospace firms partner with Washington high schools 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
78,913	84	16.81%
Aerospace Engineers	Manufacturing GDP	Federal Aircraft Contracts
5,660	$45.6 B	$5,387 M

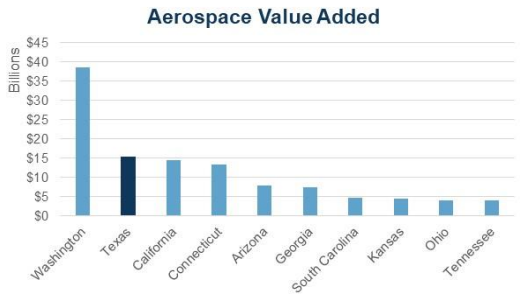
Sources: (Clockwise from Upper Left): QWI (2019), BLS (2020/2021), Census Bureau (2019), BLS OES (2020), BEA (2019), USASpendingGov (2019)

Texas #2

Texas had the biggest move of the top 10, jumping from 8th in 2019 to 2nd . Major contributors include Taxes (#1), Aerospace Industry (#5), and Infrastructure (#10). Texas improved 23 spots in Infrastructure and 11 spots in Costs but slid 5 spots in Risk to Operations.



Taxes in Texas are attractive with top 10 ranks in Corporate Income Tax (#1), Individual Income Tax (#1), Total Taxes / GDP (#3), Workers Compensation (#6), Manufacturing Tax (#6), and Property Tax (#6). Other top 10 finishers include Aerospace Value Added (#2), Aerospace Exports (#2), Aerospace Sales (#3), Port Volume (#6), Transportation Funding (#6), and Labor Productivity (#9).

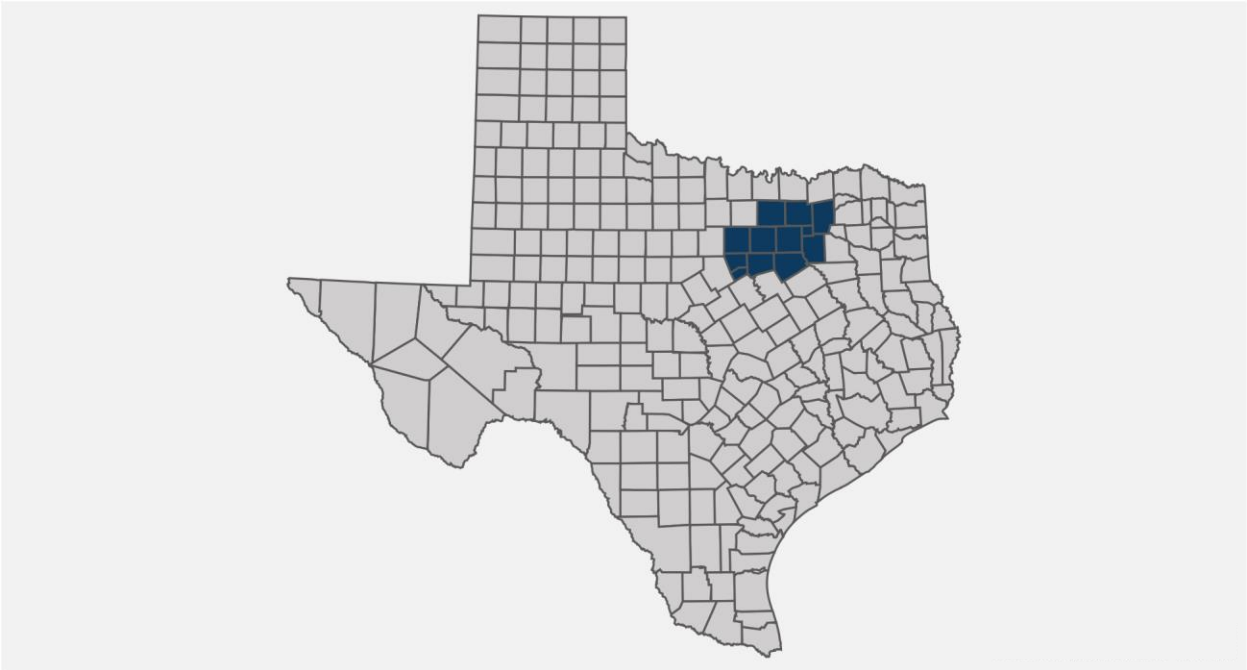


Texas has seen a flurry of aerospace investments recently and is now the second largest aerospace exporter. However, most aerospace production in Texas is military, so crowding out is a challenge.

- Collins Aerospace is expanding their operations in Texas with a 120,000 square foot campus supporting the space industry. A portion of the facility will be used as a collaboration area for start-ups and universities.
- Gulfstream expects to open a 160,000 square foot Customer Support service center at Fort Worth Alliance Airport. It plans to transfer customer-support employees from its Dallas Love Field facility to Fort Worth in addition to creating 50 new jobs.
- In an attempt to growth SpaceX's engineering talent base in Texas, Elon Musk pledged to donate $30 million to schools and city revitalization efforts in Brownsville.
- SpaceX hopes to launch its Starship rocket from its facility in Boca Chica, but the FAA's environmental impact assessment identified 75 changes the company must make prior to receiving its license.
- Boeing's Air Force One program was further delayed in 2022 due to mechanic labor shortages and challenges hiring engineers with security clearances. Work is being done in San Antonio.

Cost	**19**
Labor Cost	32
Labor Productivity	9
Energy Cost	14
Construction Cost	42
Labor & Education	**21**
Aerospace Engineers	14
Aerospace Production Workers	20
Engineering BAs	11
Graduate Degrees	34
High School +	50
Education Spending	40
Aerospace Industry	**5**
Aerospace Sales	3
Aerospace Value Added	2
Aerospace Exports	2
Workforce Growth	23
Supplier Density	20
Crowding Out	45
Infrastructure	**10**
Airports	20
Freight Railroad	36
Port Volume	6
Road Condition	33
Transportation Funding	6
Risk to Operation	**37**
Insurance Losses	43
Insurance Premiums	48
Earthquake Premiums	13
Extreme Weather	15
Economy	**20**
GDP Per Capita	13
GDP Per Capita Growth	14
Manufacturing Industry	28
Global Mfg Connectivity	23
Unemployment Rate	40
Research & Innovation	**23**
Patents Per Capita	17
Public R&D	34
Private R&D	26
High Tech Establishments	11
Taxes & Incentives	**1**
Total Taxes / GDP	3
Workers Compensation	6
Corporate Income Tax	1
Individual Income Tax	1
Manufacturing Tax	6
Property Tax	6
Sales Tax	37

Dallas-Fort Worth Aerospace Cluster



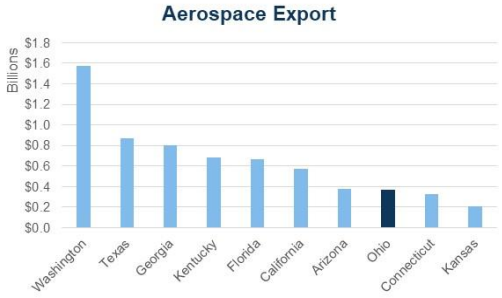
Dallas-Fort Worth ("DFW") is Texas' primary aerospace cluster and is dominated by the defense industry. Lockheed Martin Aeronautics, headquartered in Fort Worth, operates a 16,400-employee factory in the city constructing 130 F-35 fighter jets per year as part of the largest military program of all time. Raytheon employs over 5,000 people in the DFW region, just opened a 178,000 square foot facility in McKinney, and already has plans to invest $216 million to expand the McKinney campus. Bell Helicopter Textron is headquartered in DFW, while Qarbon Aerospace's (formerly Triumph Group) 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 Degreed
38,017	77	12.60%
Aerospace Engineers	Manufacturing GDP	Federal Aircraft Contracts
3,190	$61.3 B	$25,674 M

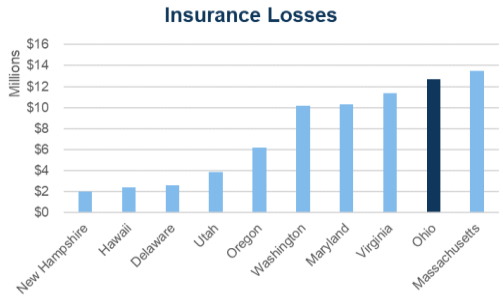
Sources: (Clockwise from Upper Left): QWI (2019), BLS (2020/2021), Census Bureau (2019), BLS OES (2020), BEA (2019), USASpendingGov (2019)

Ohio #3

Ohio fell one spot to third this year. Measures contributing to its position include Aerospace Industry (#2), risk to Operations (#9), and Taxes (#9). Ohio stayed relatively consistent in all categories except Costs, which fell 21 places to #34.



The state outperforms the other states because it performs moderately well in many individual metrics, even though it only ranks in the top 5 in three – Corporate Income Tax (#1), Insurance Losses (#3), and Freight Railroad (#3). In total, though, the state ranks in the top ten in 13 individual metrics including Airports (#6), Insurance Premiums (#7), and many Aerospace Industry metrics.



Ohio has a mature aerospace industry, with major entities like GE Aviation in Cincinnati, the NASA Glenn Research Center in Cleveland, and the Air Force Research Laboratory in Dayton.

- General Electric announced it would split into three publicly traded companies – aviation, healthcare, and energy – by early 2024. It is not yet clear what impact this may have on GE's Aviation HQ in Cincinnati.
- FlyOhio, an Ohio industry and academic collaboration, was selected to participate in NASA's Advanced Air Mobility National Campaign. Development work includes systems development and use case testing.
- Crane Aerospace is investing $4M to expand their repair and overhaul facility in Elyria.
- In 2021 the Air Force Research Laboratory opened an altitude chamber facility, which is used to test how air crew and flight equipment respond under pressure.
- A business alliance of 6 counties in the state launched a project to connect manufacturers to the aerospace supply chain to bring more aerospace work to the region. Training will focus on how to do business with the federal government to prepare suppliers to work with NASA and Wright Patterson Air Force Base.

Cost	**34**
Labor Cost	45
Labor Productivity	19
Energy Cost	21
Construction Cost	31
Labor & Education	**11**
Aerospace Engineers	10
Aerospace Production Workers	18
Engineering BAs	27
Graduate Degrees	32
High School +	25
Education Spending	20
Aerospace Industry	**2**
Aerospace Sales	9
Aerospace Value Added	9
Aerospace Exports	8
Workforce Growth	9
Supplier Density	8
Crowding Out	23
Infrastructure	**17**
Airports	6
Freight Railroad	3
Port Volume	22
Road Condition	23
Transportation Funding	40
Risk to Operation	**9**
Insurance Losses	3
Insurance Premiums	7
Earthquake Premiums	30
Extreme Weather	38
Economy	**16**
GDP Per Capita	27
GDP Per Capita Growth	29
Manufacturing Industry	9
Global Mfg Connectivity	10
Unemployment Rate	32
Research & Innovation	**19**
Patents Per Capita	20
Public R&D	12
Private R&D	23
High Tech Establishments	26
Taxes & Incentives	**9**
Total Taxes / GDP	11
Workers Compensation	12
Corporate Income Tax	1
Individual Income Tax	20
Manufacturing Tax	30
Property Tax	15
Sales Tax	25

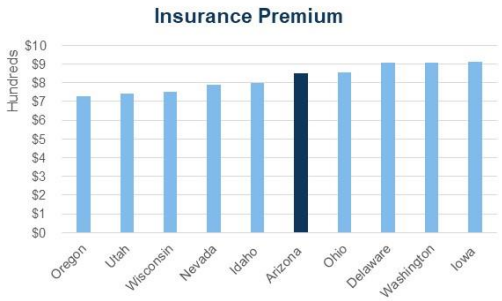
Cincinnati Aerospace Cluster

Ohio's largest aerospace cluster is in Cincinnati and anchored by GE Aviation, the world's leading manufacturer of jet engines with more than 9,000 employees in Southwest Ohio. This cluster spills over into neighboring Indiana and Kentucky. GE Aviation engines power the Boeing 747-8, 777, 777X, and 787. GE Aviation's CFM International joint venture ("JV") with Safran Aircraft Engines produces LEAP engines for the Airbus A320neo, A321neo, and Boeing 737MAX aircraft, 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 the aircraft is finally certified and enters service, which is not expected until late 2023 at the earliest. Wright-Patterson Air Force base is 50 miles north of Cincinnati and aerospace engineers are educated at the University of Cincinnati.

Aerospace Employees 8,490	Aerospace Establishments 38	Advanced Degree 13.79%
Aerospace Engineers 1,430	Manufacturing GDP $24.7 B	Federal Aircraft Contracts $860 M

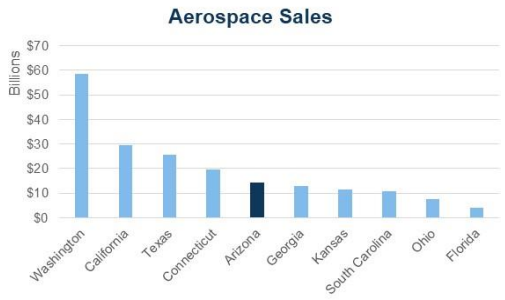
Sources: (Clockwise from Upper Left): QWI (2019), BLS (2020/2021), Census Bureau (2019), BLS OES (2020), BEA (2019), USASpendingGov (2019)

Arizona #4



Arizona has steadily climbed in the rankings, moving from #9 in 2018 to #5 in 2019 up to #4 this year. Strong category rankings including Risk to Operations (#1), Aerospace Industry (#4), and Labor & Education (#9). Contributing to Arizona's rise is its improvement in Economy, led by growth in GDP per Capita. The state ranks 50th in Infrastructure, though, which helps prevent it from overtaking Ohio.

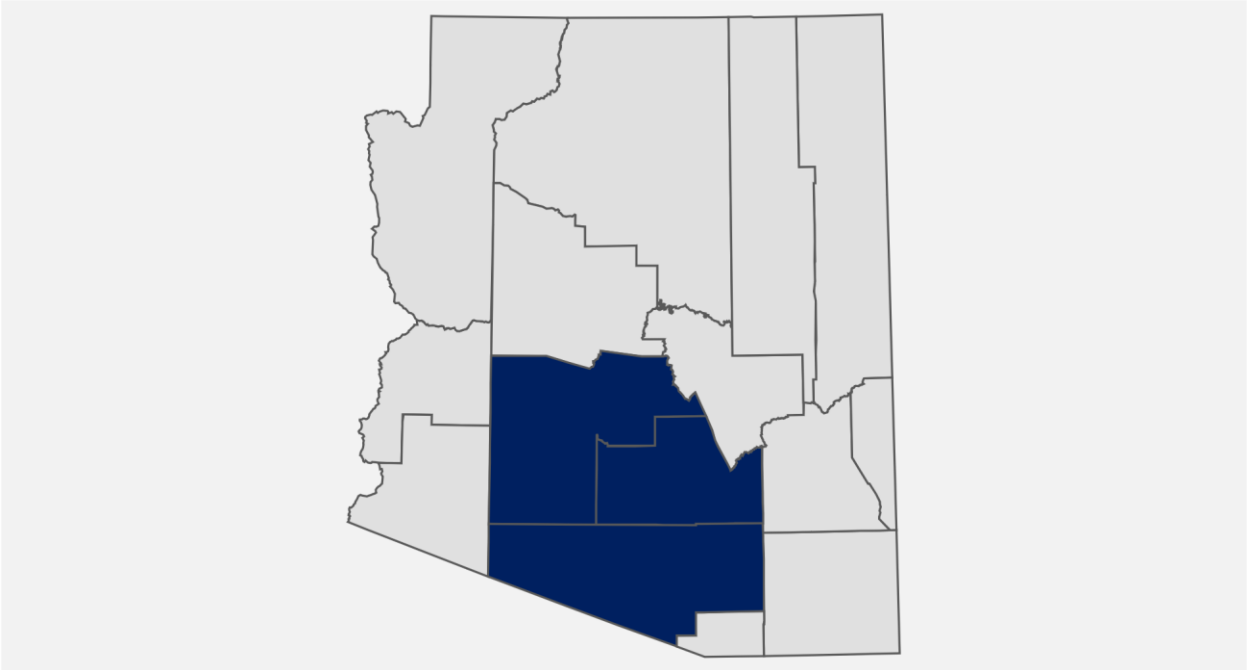
Arizona ranked highly in the individual metrics of Aerospace Production Workers (#4), GDP per Capita Growth (#4), Aerospace Sales (#5), Aerospace Value Added (#5), Supplier Density (#5), Insurance Premiums (#6), and Aerospace Exports (#7). Arizona's aerospace industry is more heavily weighted towards the defense industry, but it does contain some commercial work including composites fabrication at Boeing's facility in Mesa and aeroengines machining.



- Gulfstream plans to build a new 225,000 sq ft aircraft service center at the Pheonix airport. The facility will open in 2023. The investment is expected to total over $70 million and will employ more than 200 people.
- KP Aviation, an aerospace maintenance, repair, and overhaul provider, opened their new global headquarters in June 2022 in Mesa. The headquarters was previously located in Reno and the company cited pro-business regulations as a contributing factor for the move.
- The first deliveries of Boeing's remanufactured AH-64D helicopters will occur from their facility in Mesa by the end of 2022.
- Raytheon Missile & Defense facility in Tucson is growing and is having such a difficulty finding engineers with security clearances that they are offering sign-on bonuses up to $50k for individuals with active security clearances.
- TAE Aerospace completed its acquisition of Southwest Airmotive, a maintenance, repair, and overhaul company located in Elory.

Cost	**14**
Labor Cost	29
Labor Productivity	12
Energy Cost	25
Construction Cost	13
Labor & Education	**9**
Aerospace Engineers	11
Aerospace Production Workers	4
Engineering BAs	15
Graduate Degrees	29
High School +	40
Education Spending	49
Aerospace Industry	**4**
Aerospace Sales	5
Aerospace Value Added	5
Aerospace Exports	7
Workforce Growth	19
Supplier Density	5
Crowding Out	36
Infrastructure	**50**
Airports	46
Freight Railroad	47
Port Volume	22
Road Condition	34
Transportation Funding	50
Risk to Operation	**1**
Insurance Losses	12
Insurance Premiums	6
Earthquake Premiums	17
Extreme Weather	11
Economy	**14**
GDP Per Capita	39
GDP Per Capita Growth	4
Manufacturing Industry	16
Global Mfg Connectivity	19
Unemployment Rate	19
Research & Innovation	**14**
Patents Per Capita	19
Public R&D	21
Private R&D	16
High Tech Establishments	15
Taxes & Incentives	**13**
Total Taxes / GDP	13
Workers Compensation	9
Corporate Income Tax	14
Individual Income Tax	22
Manufacturing Tax	24
Property Tax	16
Sales Tax	24

Phoenix and Tucson Aerospace Clusters

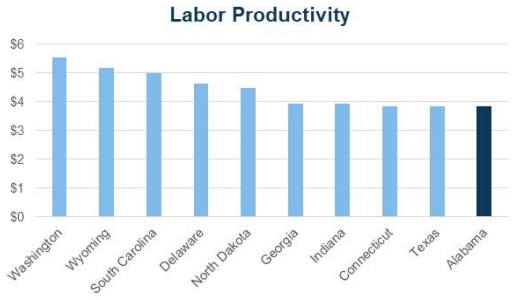


Arizona has two primary aerospace clusters centered in Phoenix and Tucson. In Phoenix, Honeywell Aerospace produces aircraft engines, cockpit and cabin electronics, wireless connectivity services, and auxiliary power units at four facilities, including its global headquarters, while Boeing produces AH-64 Apache attack helicopters in nearby Mesa. Tucson's aerospace sector is anchored by Raytheon Missile Systems, with over 10,000 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 17,190$_{(PHX)}$ / 15,080$_{(TUS)}$	Aerospace Establishments 56 / 8	Advanced Degree 11.84% / 14.28%
Aerospace Engineers 1,730 / 190	Manufacturing GDP $24.0 B / $6.5 B	Federal Aircraft Contracts $2,365 M / $4,104 M

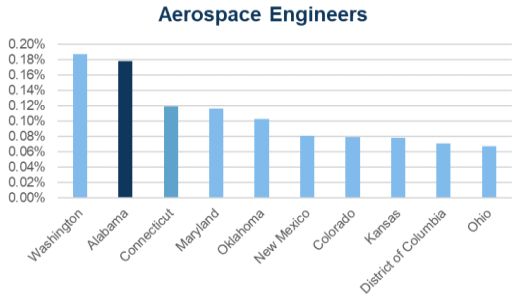
Sources: (Clockwise from Upper Left): QWI (2019), BLS (2020/2021), Census Bureau (2019), BLS OES (2020), BEA (2019), USASpendingGov (2019)

Alabama #5



Alabama moved up five spots to number five this year. Key contributors to its move were improvements in Costs and Infrastructure. Alabama only ranks in the top 10 in Costs (#4) but ranks in the top third in Taxes (#15), Labor & Education (#15), and Aerospace Industry (#16). Improvements in Costs and Infrastructure were slightly offset by a drop of 11 places in Risk to Operations.

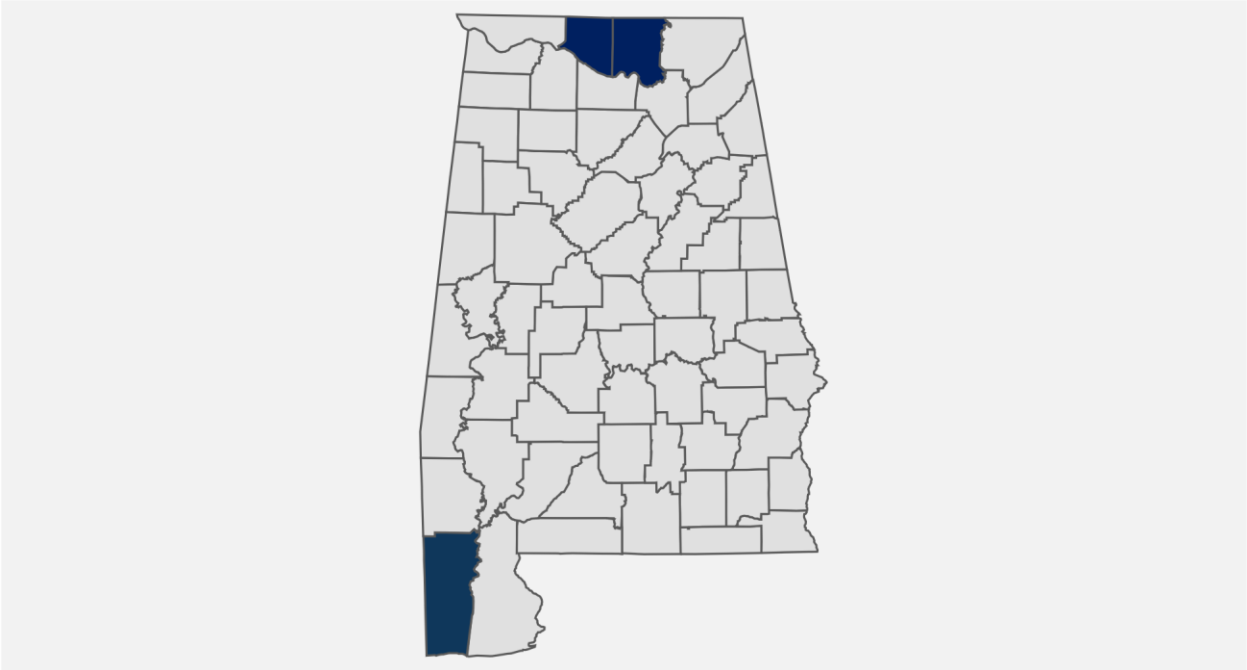
With major industry companies like Lockheed Martin, Boeing, Airbus, and Raytheon, Alabama has a highly technical aerospace presence. It ranks well on many Industry, Labor & Education, and Economy metrics including Aerospace Engineers (#2), Manufacturing Industry (#4), Global Manufacturing Connectivity (#5), and Supplier Density (#7). It also ranks in the top ten in Manufacturing Tax (#3), Sales Tax (#9), and Labor Productivity (#10).



- Blue Origin is expanding their new facility in Huntsville, hiring 300 new engineers, machinists, and technicians to expand rocket engine production. This will double Blue Origin's employee count at the facility.
- Teledyne Brown Engineering opened its new 40,000 square foot high bay manufacturing facility in Huntsville, which will support hypersonics development. It will add 50-75 jobs.
- Airbus' latest expansion project calls for the addition of a third 350,000 square-foot Final Assembly Line, or FAL, at its Mobile factory to support increased production of its A320neo Family of single-aisle passenger aircraft, adding 1,000 more jobs.
- Investment continues to grow in the state to support Airbus production. In total, companies within the Mobile, Alabama cluster have announced future investments totaling $220 million.
- Auburn's National Center for Additive Manufacturing Excellence has received multiple grants from the US Army to improve additive material consistency.

Cost	**4**
Labor Cost	15
Labor Productivity	10
Energy Cost	17
Construction Cost	13
Labor & Education	**15**
Aerospace Engineers	2
Aerospace Production Workers	15
Engineering BAs	32
Graduate Degrees	41
High School +	46
Education Spending	42
Aerospace Industry	**16**
Aerospace Sales	18
Aerospace Value Added	16
Aerospace Exports	16
Workforce Growth	47
Supplier Density	7
Crowding Out	42
Infrastructure	**24**
Airports	36
Freight Railroad	21
Port Volume	15
Road Condition	11
Transportation Funding	31
Risk to Operation	**35**
Insurance Losses	26
Insurance Premiums	40
Earthquake Premiums	20
Extreme Weather	40
Economy	**17**
GDP Per Capita	48
GDP Per Capita Growth	39
Manufacturing Industry	4
Global Mfg Connectivity	5
Unemployment Rate	12
Research & Innovation	**33**
Patents Per Capita	46
Public R&D	7
Private R&D	29
High Tech Establishments	40
Taxes & Incentives	**15**
Total Taxes / GDP	22
Workers Compensation	22
Corporate Income Tax	28
Individual Income Tax	24
Manufacturing Tax	3
Property Tax	13
Sales Tax	9

Huntsville and Mobile Aerospace Clusters



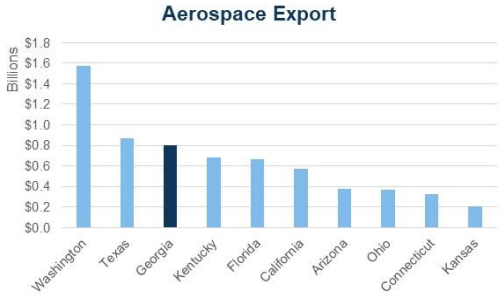
Huntsville, once known as “Rocket City,” is the center of Alabama’s aerospace industry. Home to NASA’s Marshall Space Flight Center with almost 6,000 employees conducting rocketry and spacecraft propulsion research, Huntsville also hosts more than 3,000 Boeing employees working on NASA’s Space Launch System, as well as air and missile defense. Aerojet Rocketdyne opened its rocket propulsion Advanced Manufacturing Facility in 2019, and Jeff Bezos’ Blue Origin’s BE-4 rocket engine plant opened in 2020. Northrop 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. Mobile is an emerging aerospace cluster thanks to Airbus’s selection of the area for is U.S. A320 production and A220 production. Suppliers have flocked to the area to support Airbus, including Collins Aerospace with their 440,000 square foot facility in Foley which makes A320neo nacelles.

Aerospace Employees 5,921$_{(Hunts)}$ / 709$_{(Mobile)}$	Aerospace Establishments 11 / 6	Advanced Degree 14.95% / 8.20%
Aerospace Engineers 3,010 / 70	Manufacturing GDP $4.2 B / $5.0 B	Federal Aircraft Contracts $1,867 M / $4 M

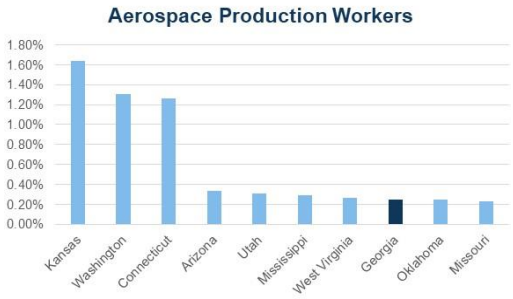
Sources: (Clockwise from Upper Left): QWI (2019), BLS (2020/2021), Census Bureau (2019), BLS OES (2020), BEA (2019), USASpendingGov (2019)

Georgia #6

Georgia moved up one spot to sixth this year. Georgia only finished in the top ten in Aerospace Industry at #8 but finished just outside the top ten in Labor & Education (#12), the second highest weighted category. It also ranked in the top third in Infrastructure (#16) and Taxes (#16). Georgia movement was a result of a 6-spot jump in Aerospace Industry and 8-spot jump in Infrastructure.



Contributing to Georgia's strength in Aerospace Industry was its 3rd place finish in Aerospace Exports and 6th place finish in both Aerospace Sales and Aerospace Value Added.

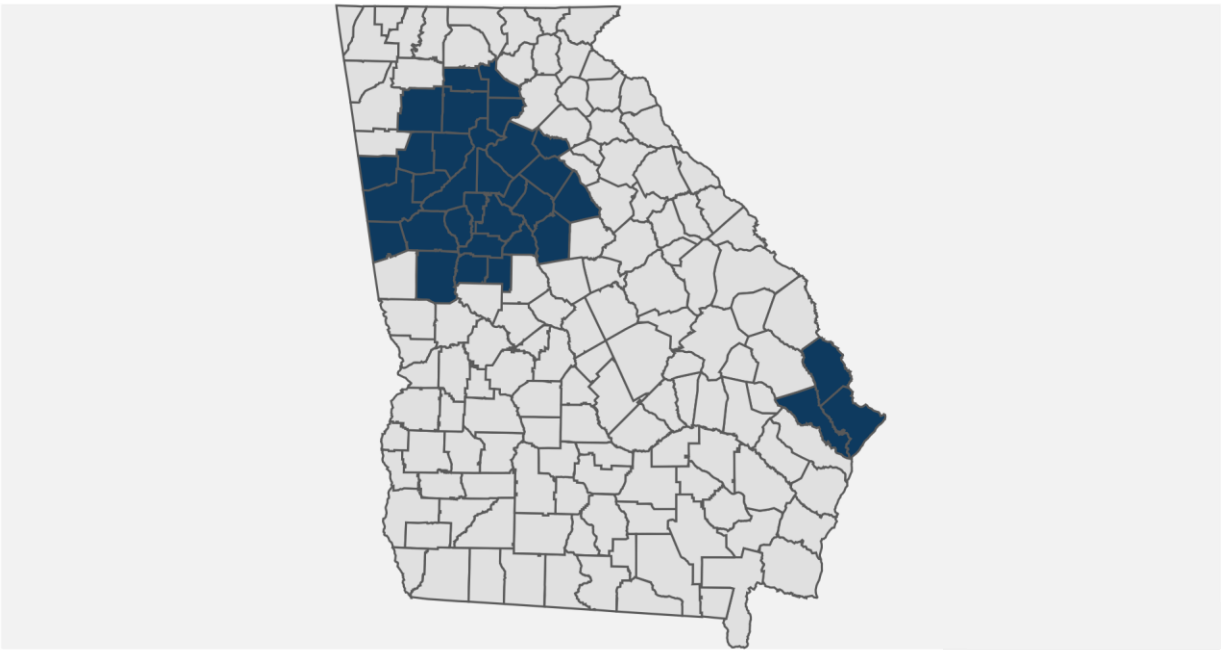


Georgia also finished in the top ten in Port Volume (#3), Property Tax (#4), Total Taxes / GDP (#6), Road Condition (#6), Labor Productivity (#6), Aerospace Production Workers (#8), and Sales Tax (#9).

- Gulfstream Aerospace Corp. recently opened a hub dedicated to worldwide aircraft parts distribution in Atlanta. Positioned within two miles of Atlanta Airport (ATL), the warehouse's location will allow parts to be delivered around the world more quickly and efficiently.
- Qarbon Aerospace Inc. has partnered with Georgia Tech to participate in NASA's $5.37 million University Leadership Initiative (ULI), to address the technical barriers associated with developing advanced structures for civil vertical lift vehicles.
- Kipper Tool Co. in Gainesville, Georgia, has been awarded a $187 million contract for airfield damage repair materials by the DoD. This contract provides updated capabilities to rapidly recover damaged airfield pavements. Work will be performed in Gainesville, Georgia, and is expected to be completed by July 2027.
- Anduril Industries, a defense technology company that specializes in building advanced technology for US and allied militaries, will invest $60 million in a new manufacturing and research facility in Atlanta, creating more than 180 new jobs over the next three years.

Cost	**18**
Labor Cost	43
Labor Productivity	6
Energy Cost	24
Construction Cost	16
Labor & Education	**12**
Aerospace Engineers	17
Aerospace Production Workers	8
Engineering BAs	22
Graduate Degrees	20
High School +	39
Education Spending	32
Aerospace Industry	**8**
Aerospace Sales	6
Aerospace Value Added	6
Aerospace Exports	3
Workforce Growth	30
Supplier Density	22
Crowding Out	29
Infrastructure	**16**
Airports	21
Freight Railroad	13
Port Volume	3
Road Condition	6
Transportation Funding	46
Risk to Operation	**28**
Insurance Losses	25
Insurance Premiums	37
Earthquake Premiums	18
Extreme Weather	27
Economy	**27**
GDP Per Capita	26
GDP Per Capita Growth	13
Manufacturing Industry	34
Global Mfg Connectivity	35
Unemployment Rate	18
Research & Innovation	**29**
Patents Per Capita	30
Public R&D	37
Private R&D	31
High Tech Establishments	12
Taxes & Incentives	**16**
Total Taxes / GDP	6
Workers Compensation	37
Corporate Income Tax	25
Individual Income Tax	29
Manufacturing Tax	18
Property Tax	4
Sales Tax	9

Atlanta and Savannah Aerospace Clusters

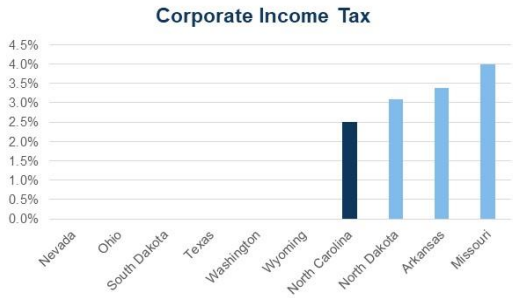


Georgia's aerospace industry is concentrated in two distinct clusters in Atlanta and Savannah. Lockheed Martin Aeronautics assembles the C-130 Hercules military transport plane in Marietta, GA near Atlanta, the longest continuous military aircraft program in history. Delta Airlines also employs about 30,000 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. The Savannah cluster has a density of aerospace engineers six times the national average. 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, G600, G650, and soon-to-be certified G700 and G800.

Aerospace Employees	Aerospace Establishments	Advanced Degree
6,103$_{(ATL)}$ / 9,205$_{(SAV)}$	18 / 8	15.02% / 12.41%
Aerospace Engineers	**Manufacturing GDP**	**Federal Aircraft Contracts**
1,040 / N/A	$30.2 B / $4.1 B	$3,070 M / $127 M

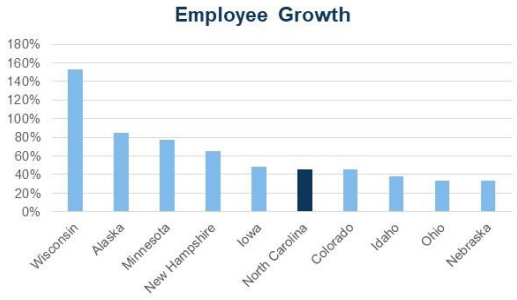
Sources: (Clockwise from Upper Left): QWI (2019), BLS (2020/2021), Census Bureau (2019), BLS OES (2020), BEA (2019), USASpendingGov (2019)

North Carolina #7



North Carolina dropped three positions from #4 in 2019. It ranks in the top ten in Taxes (#5), Infrastructure (#8), and Aerospace Industry (#9) but poorly in the important Cost (#25) and Labor & Education (#39) categories. North Carolina did make significant progress in Infrastructure, moving up twenty places, but this gain was offset by a 23-spot drop in Costs.

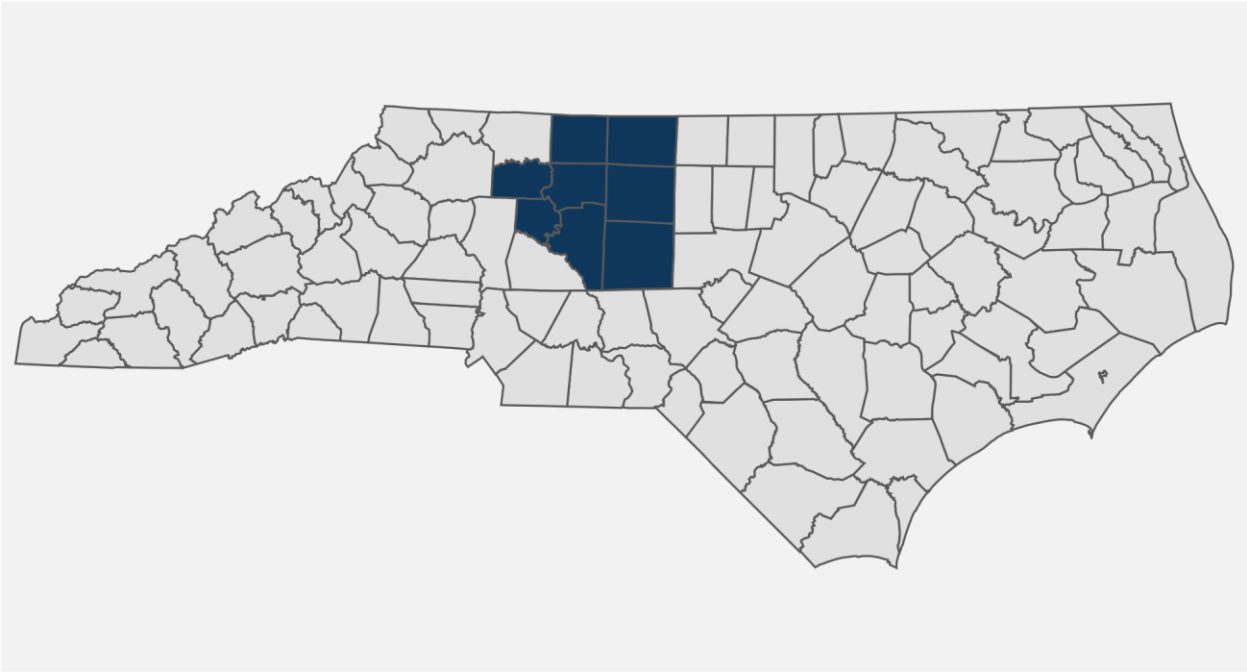
The state has seen strong growth in the aerospace sector and ranks sixth in employee growth. Paired with no individual income tax and favorable corporate taxes (#7) and property taxes (#8), North Carolina is an attractive location for industry growth. Individual metrics also ranking in the top ten are Earthquake Premiums (#9) and Energy Cost (#10).



- Collins Aerospace is investing $30 million to expand their current MRO facility by 25%. The facility focuses on repairs of actuation, cargo systems, landing gear, air management, water lines, and lighting for both commercial and military aircraft.
- Collins Aerospace also opened a new $30 million additive manufacturing center on their campus in Monroe in June 2022.
- Boom Supersonic selected Greensboro, North Carolina for its first supersonic aircraft manufacturing facility. The company expects to break ground on the factory in 2022 and begin production in 2024, adding more than 2,400 local jobs by 2032. Aircraft design and certification delays are typical for new aircraft OEMs, though.
- In June 2022, three leading U.S. healthcare organizations began long-range drone deliveries in North Carolina. This on-demand delivery system is conducted by Zipline, a logistics specialist and drone delivery system based in Kannapolis, NC.

Cost	**25**
Labor Cost	38
Labor Productivity	31
Energy Cost	10
Construction Cost	15
Labor & Education	**39**
Aerospace Engineers	37
Aerospace Production Workers	25
Engineering BAs	26
Graduate Degrees	25
High School +	36
Education Spending	43
Aerospace Industry	**9**
Aerospace Sales	17
Aerospace Value Added	21
Aerospace Exports	15
Workforce Growth	6
Supplier Density	34
Crowding Out	13
Infrastructure	**8**
Airports	15
Freight Railroad	25
Port Volume	16
Road Condition	14
Transportation Funding	20
Risk to Operation	**11**
Insurance Losses	15
Insurance Premiums	26
Earthquake Premiums	9
Extreme Weather	31
Economy	**17**
GDP Per Capita	31
GDP Per Capita Growth	18
Manufacturing Industry	17
Global Mfg Connectivity	16
Unemployment Rate	26
Research & Innovation	**15**
Patents Per Capita	24
Public R&D	18
Private R&D	12
High Tech Establishments	20
Taxes & Incentives	**5**
Total Taxes / GDP	14
Workers Compensation	21
Corporate Income Tax	7
Individual Income Tax	1
Manufacturing Tax	11
Property Tax	8
Sales Tax	18

Piedmont Triad Aerospace Cluster

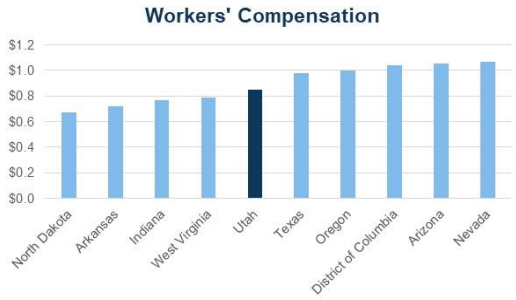


Greensboro, Winston-Salem, and High Point form the Piedmont Triad, the densest aerospace cluster in North Carolina. Honda Aircraft Company's global headquarters and 133-acre campus lie adjacent to Piedmont Triangle International Airport ("PTI") near Greensboro, where the company designs and manufactures its HA-420 HondaJet Elite. Collins Aerospace manufactures aircraft interiors out of the former B/E Aerospace headquarters in Winston-Salem. Boom Supersonic sees the appeal of North Carolina and has selected the state for its supersonic aircraft manufacturing facility, if it ever gets built. 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
2,661	3	10.05%
Aerospace Engineers	Manufacturing GDP	Federal Aircraft Contracts
110	$18.4 B	$9 M

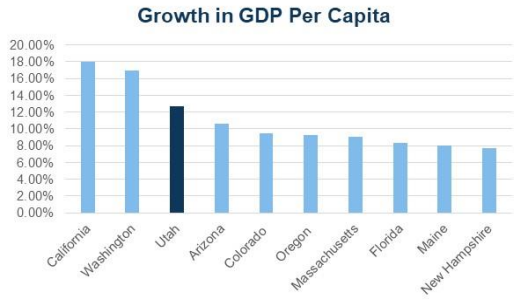
Sources: (Clockwise from Upper Left): QWI (2019), BLS (2020/2021), Census Bureau (2019), BLS OES (2020), BEA (2019), USASpendingGov (2019)

Utah #8



Utah had moved up from 7th in 2018 to 3rd in 2019, but it reversed course this year and fell to 8th. Although Utah ranks in the top 10 in Taxes (#2), Risk to Operations (#3), Economy (#3), and Research and Innovation (#7), it ranks 41st in the important Cost category. The weight of Risk to Operations, Economy, and Research and Innovation together are less than Costs, so strong performance in these categories cannot offset Utah's poor Cost performance.

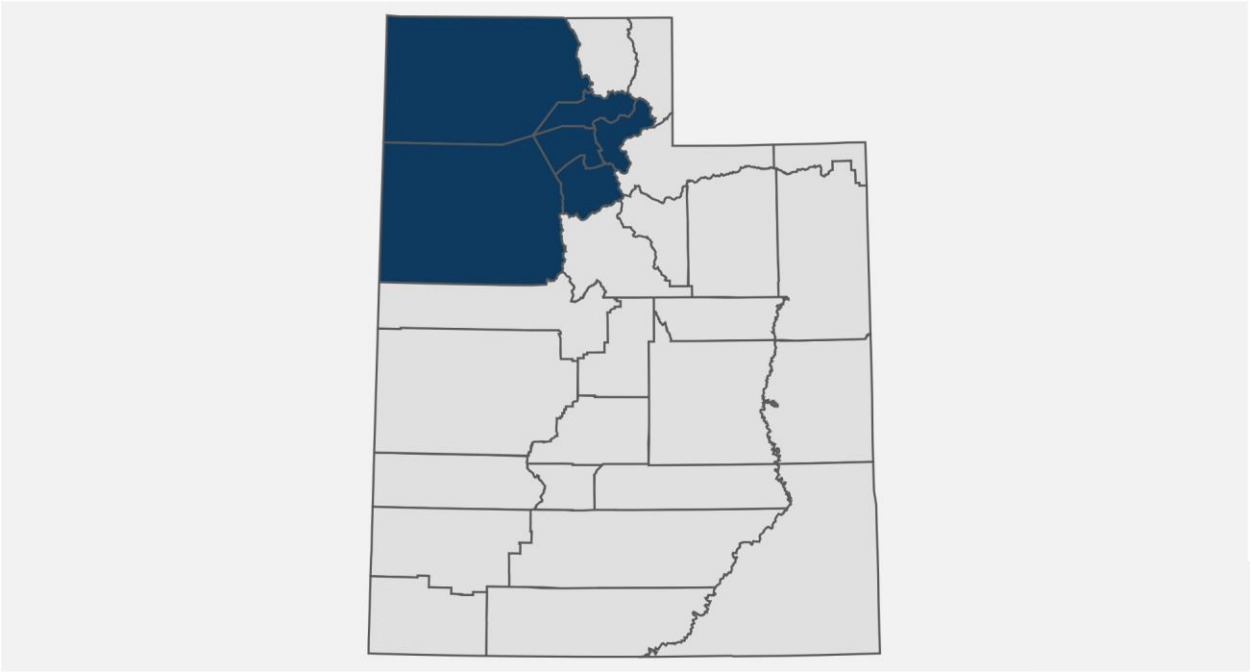
With respect to individual metrics, Utah ranks #1 in unemployment rate, individual income tax, and sales tax. It also ranks in the top ten in Insurance Premiums (#2), GDP per Capital Growth (#3), Insurance Losses (#5), Workers Compensation (#5), Aerospace Production Workers (#5), High-Tech Establishments (#6), Extreme Weather (#9), High School Degree or More (#9), and Manufacturing Tax (#10).



- Northrop Grumman is adding 200 new jobs in Utah to increase solid rocket motor manufacturing capacity after it was awarded a contract valued at more than $2 billion from United Launch Alliance.
- Northrop Grumman's Ground Based Strategic Deterrent Program (GBSD) in Utah is the most ambitious overhaul of American ICBM infrastructure in history. This program will lead to as many as 100 new high paying jobs added in Utah every month for the foreseeable future.
- Raytheon Technologies has been selected for a $46.2 million project-level agreement to modernize the US Air Force's A-10 Thunderbolt II aircraft in Layton, Utah.
- BAE Systems has been awarded a $12 billion contract for Integration Support Contract (ISC) 2.0 to be performed at Hill Air Force Base, Utah. The main function of ISC 2.0 is to support the government as the lead systems integrator for Intercontinental Ballistic Missile (ICBM) systems engineering and integration.

Cost	**41**
Labor Cost	33
Labor Productivity	49
Energy Cost	13
Construction Cost	19
Labor & Education	**7**
Aerospace Engineers	20
Aerospace Production Workers	5
Engineering BAs	18
Graduate Degrees	23
High School +	9
Education Spending	50
Aerospace Industry	**12**
Aerospace Sales	19
Aerospace Value Added	29
Aerospace Exports	33
Workforce Growth	13
Supplier Density	15
Crowding Out	28
Infrastructure	**42**
Airports	47
Freight Railroad	46
Port Volume	22
Road Condition	29
Transportation Funding	18
Risk to Operation	**3**
Insurance Losses	5
Insurance Premiums	2
Earthquake Premiums	47
Extreme Weather	9
Economy	**3**
GDP Per Capita	23
GDP Per Capita Growth	3
Manufacturing Industry	18
Global Mfg Connectivity	21
Unemployment Rate	1
Research & Innovation	**7**
Patents Per Capita	12
Public R&D	16
Private R&D	18
High Tech Establishments	6
Taxes & Incentives	**2**
Total Taxes / GDP	10
Workers Compensation	5
Corporate Income Tax	16
Individual Income Tax	1
Manufacturing Tax	10
Property Tax	14
Sales Tax	1

Salt Lake City Aerospace Cluster

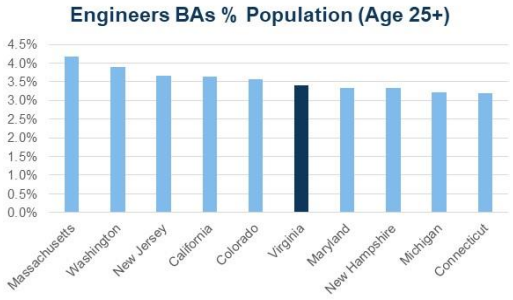


Utah's growing aerospace industry is concentrated in Salt Lake City and centered around advanced composite fabrication and the defense industry. Albany Engineered Composites' Salt Lake City facility manufactures light-weight composites for large OEMs like Boeing and Airbus, while Hexcel's West Valley 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
9,827	7	12.86%
Aerospace Engineers	Manufacturing GDP	Federal Aircraft Contracts
160	$9.9 B	$130 M

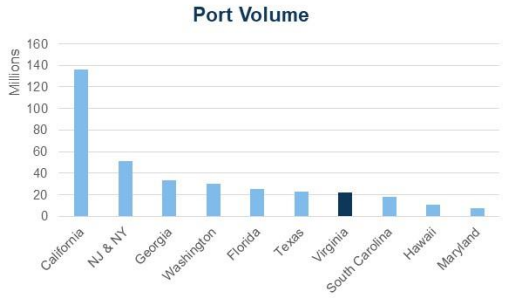
Sources: (Clockwise from Upper Left): QWI (2019), BLS (2020/2021), Census Bureau (2019), BLS OES (2020), BEA (2019), USASpendingGov (2019)

Virginia #9



Virginia has seen tremendous gains in aerospace activity in the last year, contributing to its rise into the top ten at 9th. The state's rise can be attributed to gains in multiple categories including an 11-spot improvement in Costs and 9-spot improvements in both Infrastructure and Economy. The movement of Boeing and Raytheon headquarters to Virginia is evidence of its increase in attractiveness for aerospace investments.

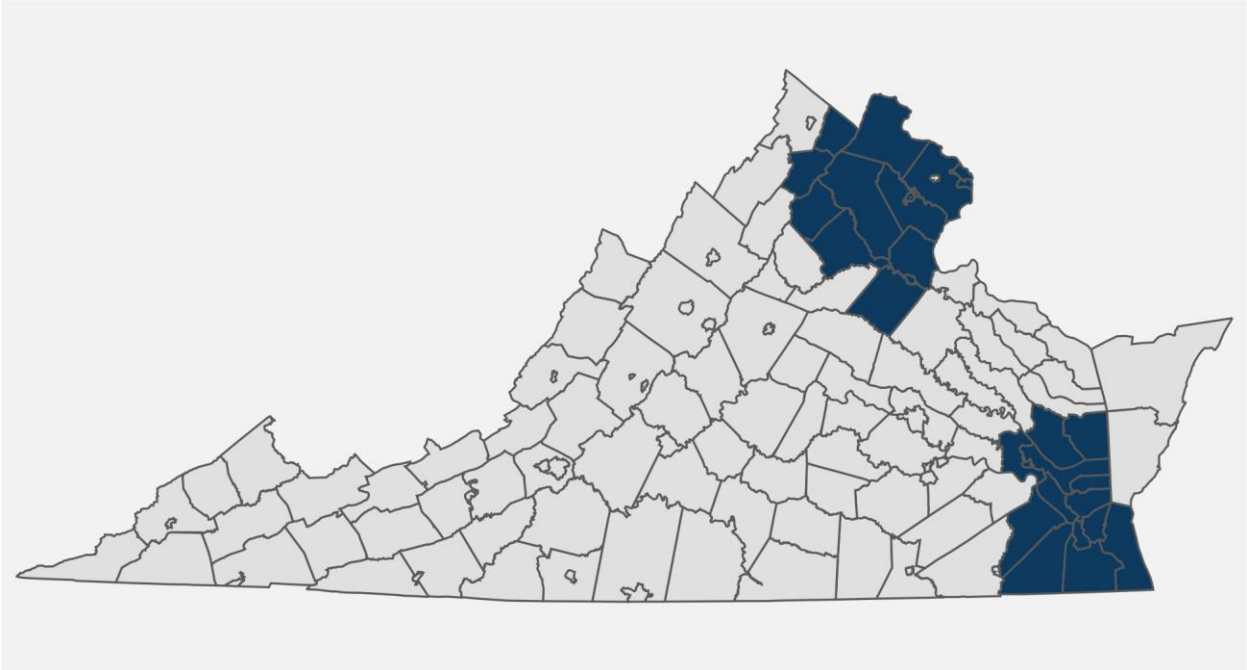
Virginia now ranks in the top ten in Infrastructure (#4) and Research and Innovation (#10). With respect to individual metrics, Virginia ranked highly in Graduate Degrees (#5), Engineering BAs (#6), Port Volume (#7), Public R&D (#4), High Tech Establishments (#2), and Sales Tax (#1).



- Raytheon and Boeing recently joined ranks of most other major US A&D companies in relocating to Northern Virginia and the greater Washington DC area. In addition, Boeing announced plans to develop a research & technology hub in Northern Virginia to attract aerospace engineering and technical capabilities.
- In April, launch and space systems company Rocket Lab USA Inc. broke ground on a rocket production complex where the company's Neutron launch vehicle will be manufactured, adjacent to NASA's Wallops Flight Facility and Mid-Atlantic Regional Spaceport.
- In July, BAE Systems ordnance unit won a $1.3 billion contract modification to continue to run the US Government's Radford Army Ammunition Plant (RFAAP).
- NASA's Langley Research Center continues its research on new aircraft manufacturing under its Hi-Rate Composite Aircraft Manufacturing (HiCAM) initiative. Toray joined the shortlist of composite suppliers on the program in 2022.

Cost	**26**
Labor Cost	36
Labor Productivity	29
Energy Cost	22
Construction Cost	12
Labor & Education	**13**
Aerospace Engineers	13
Aerospace Production Workers	30
Engineering BAs	6
Graduate Degrees	5
High School +	30
Education Spending	24
Aerospace Industry	**29**
Aerospace Sales	21
Aerospace Value Added	14
Aerospace Exports	28
Workforce Growth	22
Supplier Density	45
Crowding Out	31
Infrastructure	**4**
Airports	16
Freight Railroad	15
Port Volume	7
Road Condition	19
Transportation Funding	21
Risk to Operation	**20**
Insurance Losses	4
Insurance Premiums	20
Earthquake Premiums	29
Extreme Weather	46
Economy	**31**
GDP Per Capita	19
GDP Per Capita Growth	28
Manufacturing Industry	40
Global Mfg Connectivity	39
Unemployment Rate	15
Research & Innovation	**10**
Patents Per Capita	26
Public R&D	4
Private R&D	27
High Tech Establishments	2
Taxes & Incentives	**25**
Total Taxes / GDP	18
Workers Compensation	20
Corporate Income Tax	26
Individual Income Tax	29
Manufacturing Tax	41
Property Tax	25
Sales Tax	1

Arlington and Norfolk Aerospace Clusters

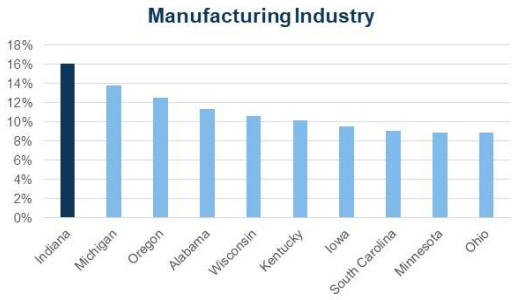


Virginia's aerospace industry is best known for the growing Arlington-area concentration of company headquarters, which do not involve manufacturing. Northrop Grumman, Raytheon, Boeing, and Airbus Americas are now all headquartered in this cluster. However, research and development facilities in this region are growing, too, led by Boeing's Aurora Flight Sciences unit in Manassas and others. The southern part of the state has a stronger aerospace manufacturing, research, and services sector, with Lockheed Martin, Howmet, Northrop Grumman, and L3Harris all having a notable presence. NASA's Langley Research Center and Wallops Flight Facility and Navy and Air Force sustainment facilities round out this cluster's capabilities too.

Aerospace Employees 150 (Newport) / 581 (DC)	Aerospace Establishments N/A / 11	Advanced Degree 13.09% / 26.23%
Aerospace Engineers 810 / 2,310	Manufacturing GDP $9.9 B / $12.7 B	Federal Aircraft Contracts $30 M / $503 M

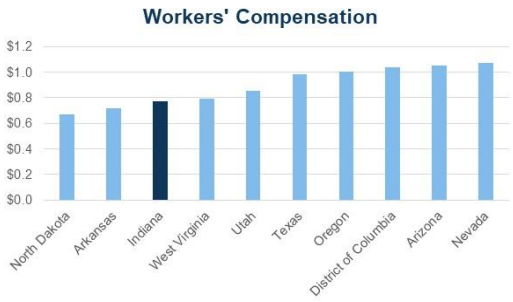
Sources: (Clockwise from Upper Left): QWI (2019), BLS (2020/2021), Census Bureau (2019), BLS OES (2020), BEA (2019), USASpendingGov (2019)

Indiana #10



Indiana continued its upward movement this year, just making it into the top 10. Indiana ranks highest in Economy (#1), Taxes (#10), and Aerospace Industry (#14). Indiana's rise can be attributed to its 7-spot improvement in Aerospace Industry. Saab's selection of West Lafayette for T-7 aft fuselage production (for Boeing) is partially responsible for this gain.

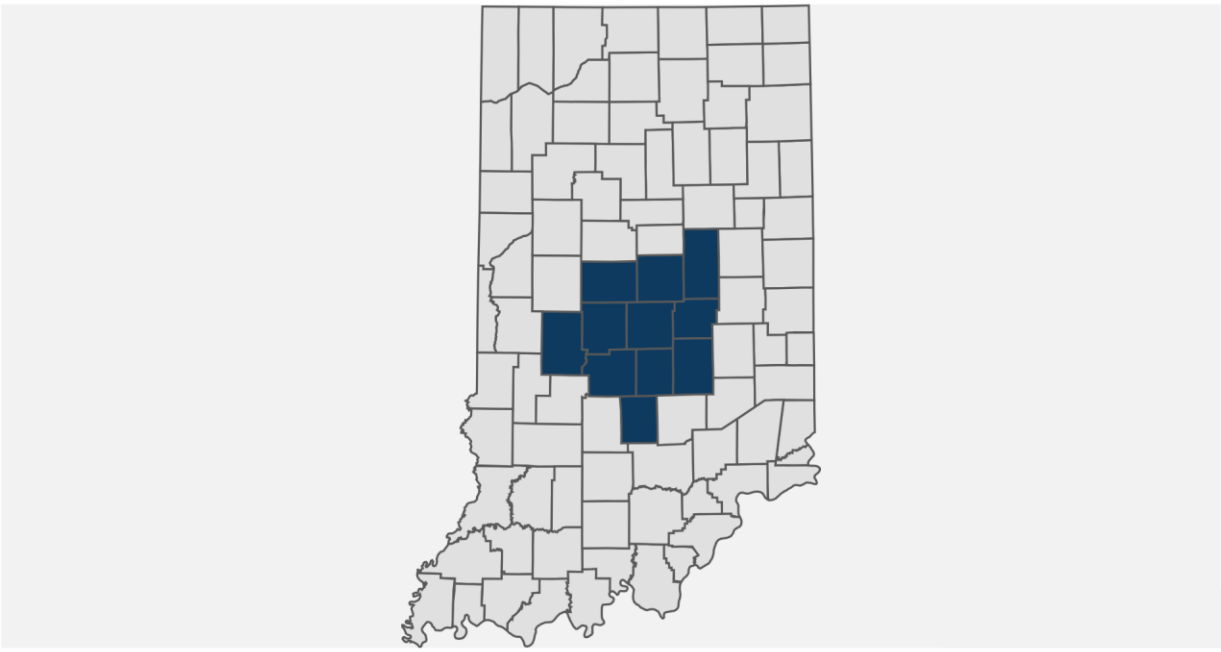
Indiana ranks in the top ten in many individual metrics including Manufacturing Industry (#1), Global Manufacturing Connectivity (#1), Individual Income Tax (#1), Unemployment Rate (#3), Workers Compensation (#3), Airports (#5), Labor Productivity (#7), Manufacturing Tax (#7), and Freight Railroad (#9).



- Rolls Royce will invest $400 million to modernize their engine test facilities in West Lafayette, adding to their $600 million investment in manufacturing in Indianapolis which was completed in 2021.
- Rolls Royce also signed a $75 million partnership with Purdue on gas turbine technology research and testing. In addition, Purdue plans to build a $73 million hypersonic propulsion laboratory.
- Saab selected West Lafayette for the U.S. manufacturing facility of the T-7 Trainer aft fuselage, which is supplied to Boeing St. Louis, in 2019. The total investment was estimated to be $37 million. Production shifted from Sweden to West Lafayette in mid-2022.
- BAE Systems announced intent to acquire Raytheon's Airborne Tactical Radios division in Fort Wayne in 2020. BAE already has similar work in the area, and Raytheon will still maintain other facilities in the region.
- AAR expanded their national maintenance training program in 2019 via a partnership with Indiana's Vincennes University to address the impending shortage of maintenance technicians.

Cost	**28**
Labor Cost	46
Labor Productivity	7
Energy Cost	31
Construction Cost	23
Labor & Education	**30**
Aerospace Engineers	24
Aerospace Production Workers	23
Engineering BAs	37
Graduate Degrees	40
High School +	32
Education Spending	38
Aerospace Industry	**14**
Aerospace Sales	12
Aerospace Value Added	13
Aerospace Exports	14
Workforce Growth	41
Supplier Density	25
Crowding Out	32
Infrastructure	**25**
Airports	5
Freight Railroad	9
Port Volume	22
Road Condition	25
Transportation Funding	44
Risk to Operation	**22**
Insurance Losses	13
Insurance Premiums	16
Earthquake Premiums	37
Extreme Weather	34
Economy	**1**
GDP Per Capita	28
GDP Per Capita Growth	12
Manufacturing	1
Global Mfg Connectivity	1
Unemployment Rate	3
Research & Innovation	**30**
Patents Per Capita	26
Public R&D	38
Private R&D	14
High Tech Establishments	37
Taxes & Incentives	**10**
Total Taxes / GDP	36
Workers Compensation	3
Corporate Income Tax	14
Individual Income Tax	1
Manufacturing Tax	7
Property Tax	12
Sales Tax	47

Indianapolis Aerospace Cluster



Indiana's aerospace core is in the Indianapolis metropolitan area, anchored by Rolls Royce. Rolls Royce employs almost 4,000 people in the region in their engineering, manufacturing, and testing facilities. More Rolls Royce products are built in Indianapolis than anywhere else in the world. Numerous machine shops in the region supply Rolls Royce and other OEMs. MRO activity is also present in the region with AAR, a major aircraft maintenance provider, and Safran's nacelle services facility. Although Indianapolis's aerospace legacy spans over 100 years, recent aerospace investments have flourished in the Fort Wayne and West Lafayette regions. Purdue University's placement in West Lafayette makes it an attractive location for engineering, and Saab selected the region for their new T-7 trainer aft fuselage fabrication facility. BAE and Raytheon both have Electronic Systems and Avionics facilities in Fort Wayne, employing 950 and 600 people respectively.

Aerospace Employees 4,800	Aerospace Establishments 10	Advanced Degree 12.86%
Aerospace Engineers 150	Manufacturing GDP $27.0 B	Federal Aircraft Contracts $788 M

Sources: (Clockwise from Upper Left): QWI (2019), BLS (2020/2021), Census Bureau (2019), BLS OES (2020), BEA (2019), USASpendingGov (2019)

Other Results

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. California, for example, appears four times in the category top ten, which is more than many of the other states that made the overall top ten, but it was in nearly last place in key categories such as Costs and Taxes & Incentives. This does well to illustrate both the importance of balance, as well as the importance of the category weightings to the study.

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

Note: Overall top ten states are **bold**

The Industry and Taxes & Incentives categories each had six of the top ten performing states. Interestingly, the Costs category only contained one of the top ten states: Alabama. Most low-cost states rank poorly in Labor & Education and do not have a strong Aerospace Industry, but Alabama ranks 15th and 16th in these categories respectively. Airbus's astute assessment of the state's combination of low cost and above average workforce led them to Alabama and has contributed significantly to its rise in the rankings.

Comparison Between 2019 and 2022 Report

A number of states moved up or down by a significant amount in this year's rankings. Kansas and Colorado both fell out of the 10. Kansas fell to #39 in Costs and #37 in Infrastructure, contributing to its demise. Costs are also responsible for Colorado's drop in rankings, which fell from 24th down to 50th. Colorado is still in the top 10 in Labor & Education (#4), Research & Innovation (#4), and Taxes (#6) which demonstrates the importance of the Cost category.

Winners			
States	Overall Rank		Gains
	2022	2019	
District of Columbia	16	45	+29
Tennessee	24	42	+18
Nebraska	26	43	+17
New Hampshire	12	28	+16
Wyoming	17	31	+14
South Dakota	18	32	+14
South Carolina	15	27	+12
North Dakota	14	24	+10
Virginia	9	17	+8
Delaware	25	33	+8
Illinois	31	39	+8

Losers			
States	Overall Rank		Loss
	2022	2019	
Missouri	43	12	-31
California	36	13	-23
Iowa	46	23	-23
Massachusetts	41	20	-21
Michigan	32	16	-16
Colorado	20	6	-14
Maryland	35	22	-13
Kentucky	29	18	-11
Kansas	19	9	-10
Nevada	47	38	-9
Connecticut	22	14	-8

As was the case with previous reports, there were some substantial changes between the last report (2019) and this report (2022).

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 2019 and 2022 is noted with an arrow.

State	2022		Rank Change	2019	
	Index Value	Rank		Index Value	Rank
Washington	9.85	1	⇄	11.79	1
Texas	13.90	2	↑	21.67	8
Ohio	15.35	3	↓	18.85	2
Arizona	16.20	4	↑	20.55	5
Alabama	16.30	5	↑	22.06	10
Georgia	16.30	6	↑	21.23	7
North Carolina	17.40	7	↓	20.54	4
Utah	18.53	8	↓	19.54	3
Virginia	19.85	9	↑	24.25	17
Indiana	21.10	10	↑	22.11	11
Florida	22.03	11	↑	23.97	15
New Hampshire	22.03	12	↑	25.82	28
Oklahoma	22.53	13	↑	24.39	19
North Dakota	22.65	14	↑	25.07	24
South Carolina	22.88	15	↑	25.78	27
Dist. of Columbia	23.50	16	↑	30.62	45
Wyoming	23.90	17	↑	26.67	31
South Dakota	24.20	18	↑	26.69	32
Kansas	24.40	19	↓	21.68	9
Colorado	24.50	20	↓	20.79	6
Pennsylvania	24.78	21	⇄	24.71	21
Vermont	24.88	22	↑	26.22	29
Connecticut	24.88	22	↓	23.87	14
Tennessee	25.33	24	↑	29.49	42
Delaware	25.48	25	↑	26.71	33
Nebraska	26.00	26	↑	29.64	43
Arkansas	26.75	27	↓	25.45	26
Wisconsin	26.85	28	↓	25.43	25
Kentucky	26.85	29	↓	24.27	18
Oregon	27.50	30	↑	26.79	34
Illinois	27.53	31	↑	27.96	39
Michigan	27.60	32	↓	24.11	16
Minnesota	28.25	33	↓	26.39	30
Idaho	28.48	34	↑	28.03	40
Maryland	28.85	35	↓	24.97	22
California	28.85	36	↓	23.45	13
New Mexico	28.98	37	⇄	27.65	37
West Virginia	29.78	38	↓	27.12	35
Alaska	30.50	39	↑	28.92	41
New York	31.15	40	↓	27.26	36
Massachusetts	31.45	41	↓	24.41	20
Mississippi	31.48	42	↑	31.30	48
Missouri	31.63	43	↓	22.16	12
Montana	31.80	44	↑	33.16	50
Maine	31.95	45	↓	30.00	44
Iowa	32.20	46	↓	25.03	23
Nevada	34.35	47	↓	27.73	38
New Jersey	35.70	48	↓	31.27	47
Rhode Island	36.95	49	↑	36.69	51
Louisiana	38.40	50	↓	31.77	49
Hawaii	41.73	51	↓	31.23	46

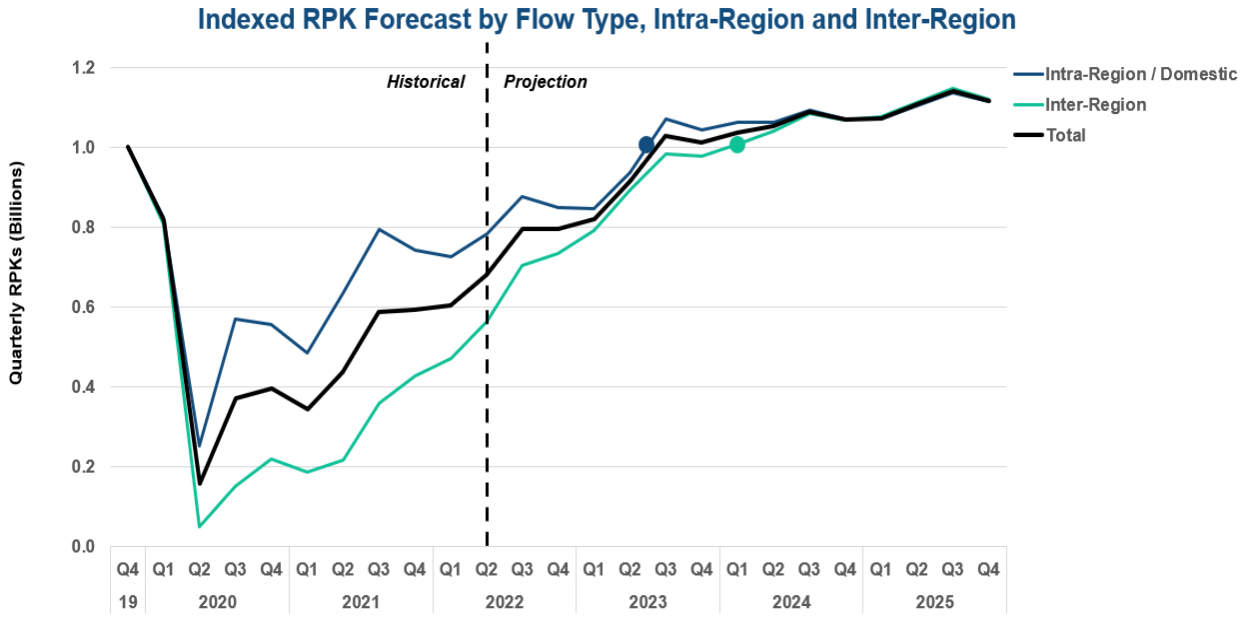
Global Aircraft Market Forecast & Analysis

Both air travel and aircraft production levels were set back by record-breaking levels because of COVID-19, but there are positive signs of growth on both the supply and demand side of the aircraft production equation.

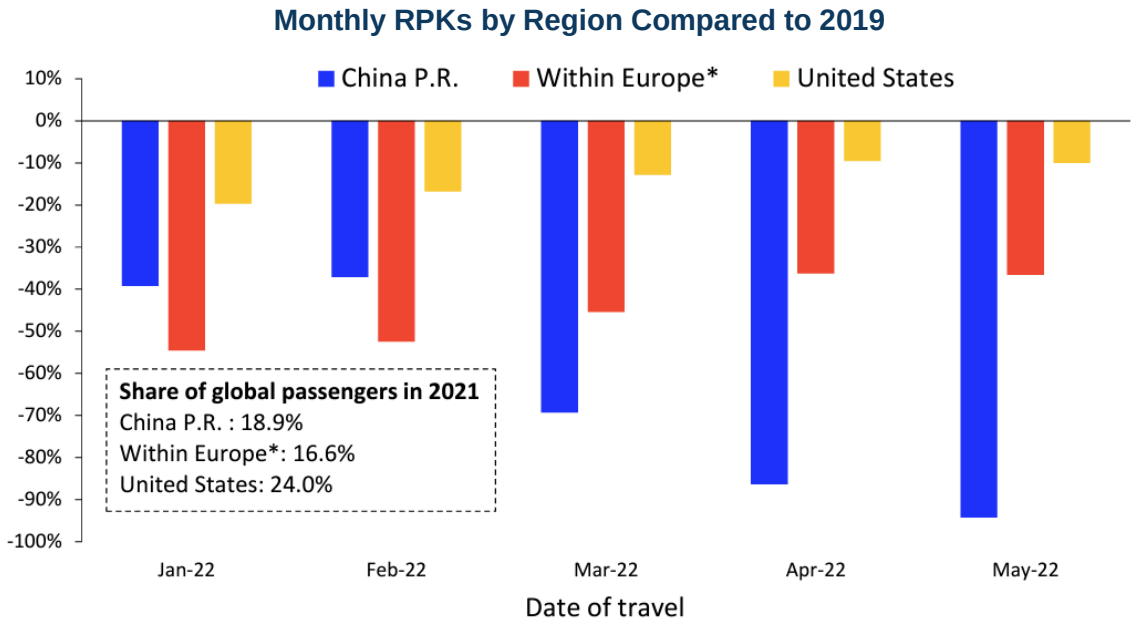
Air Travel Demand: Kicked When Down

Air travel demand has come a long way since the height of the COVID-19 pandemic lockdowns, but the recovery has been uneven. This bifurcation of recovery can be best seen by comparing short-haul, intra-region travel with long-haul inter-region travel, as seen below. Intra-region includes domestic traffic and traffic within a global sub-region, such as Southeast Asia or Central America.

While intra-region revenue passenger kilometers (RPKs) have bounced back to almost 80% of pre-COVID levels, inter-region RPKs are still down 44%. There have been recent signs of growth in inter-region traffic though, including the lifting of testing requirements in the U.S. and opening of non-essential travel from Japan to 34 countries. Intra-region traffic is dominated by narrowbody jets and inter-region by widebody jets, so narrowbodies have fared far better. Intra-region traffic is expected to fully recover by Q3 of 2023 and inter-region is expected to lag by six months, recovering in Q1 of 2024.



Recovery took multiple hits in late 2021 and early 2022. First, demand started to slip in domestic China in August of 2021 as China's zero-COVID policy struggled to contain the more-contagious Delta variant. Next, Russia's invasion of Ukraine caused global travel hesitancy and closed off the Russian airspace to western operators, making some long-haul flights uneconomical. Then the Omicron wave reached China, decimating domestic traffic during the seven-plus week lockdown in Shanghai. By May, airline ticket sales fell about 90% compared to 2019, as can be seen in the following IATA graphic.



With the ultra-high transmissibility of the Omicron variant, China will likely face rolling lockdowns as the government plays whack-a-mole when outbreaks crop up in different cities. China is not expected to relax their strict zero-COVID policy until the 20th Party Congress in Q4 of 2022 at the earliest, but changes are most likely after the National People's Congress elections in March of 2023. This is when the full transition of government takes place in China, so there is a desire for political stability until the elections occur.

The impacts of the war in Ukraine are less acute but will be long lasting. Typically, GDP growth is a key indicator of air travel demand growth. Growth in the global middle class is particularly important to travel growth since this increases the total number of people who can afford to travel by air. Since Ukraine is a breadbasket for the developing world, providing about half of the World Food Program's wheat, the inability to harvest and export this crop will lead to widespread famine in developing nations. Embargos on oil, staple crops, and other goods have exacerbated inflation around the world too, which reduces real GDP growth. Inflation rates will be a key indicator for if and when global air travel demand growth will return to the 6-7% average seen in the last decade.

Aircraft: A Steep Drop, But A Powerful Recovery

Inevitably, record air travel declines drove a terrible decline on the manufacturing side of the aviation industry. Aircraft deliveries fell 35% in 2020 year-over-year. As with air travel, that represents a jet age record decline.

Yet with aircraft markets and production numbers, there's reason for cautious optimism. Relative to 2020 deliveries, the aircraft industry grew 7.5% in 2021. Even better, 2022 should see a very strong 20-25% expansion, with jetliners leading the way.

Each industry segment tells a different story, but the simplest one is defense. Military deliveries were hit last year for purely logistical reasons – pandemic related factory closures and supply chain disruptions. The market – actual demand – wasn't hit at all. Countries that initially

announced pandemic-related defense budget cuts, such as South Korea, quickly reversed those plans, and actually increased spending over the previous year.

Domestic and export defense demand has been strong, both for geopolitical reasons, and because defense spending is viewed as a good way for governments to support national aerospace industries, and national economies, in a very difficult time. Military output has already recovered to pre-pandemic levels, with additional strong growth to come.

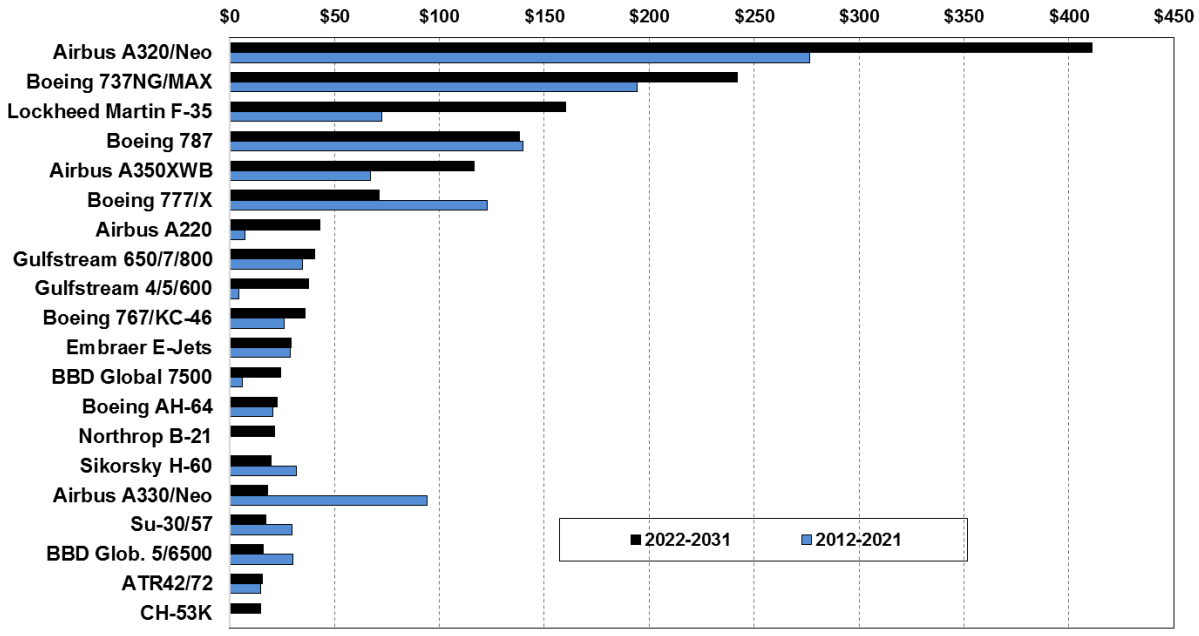
Business aircraft also tell a happy story. Utilization has more than passed 2019 peak levels, with charter and fractional operations exceeding all-time highs. Corporate profits, equities markets, and oil prices, the three key drivers behind market demand, are all at very high levels, coupled with strong interest in avoiding the service cutbacks and high load factors of airline transport. If you remove the output gap between Gulfstream's G650ER and G700 (which won't enter service until the fourth quarter of 2022), then production (for most other products and classes) will be back to 2019 levels in 2022.

The largest industry segment, single aisle jetliners, tells the happiest story, and contributes most to the steep upward angle now being experienced by the industry. Deliveries increased by over 40% in 2021 and will increase another 40+% in 2022. This is largely driven by the very strong domestic market recovery we've seen in North America and Europe. Also, there's the impact of 737MAX production and deliveries resuming, with a goal of 31 new build jets per month, in addition to deliveries of already-built MAXs.

Our chart shows the relative importance of single aisle jetliners to total industry output. It shows historical and forecast output for the top 20 aviation manufacturing programs. The two major single aisle families offer much greater volume for the industry than any other program.

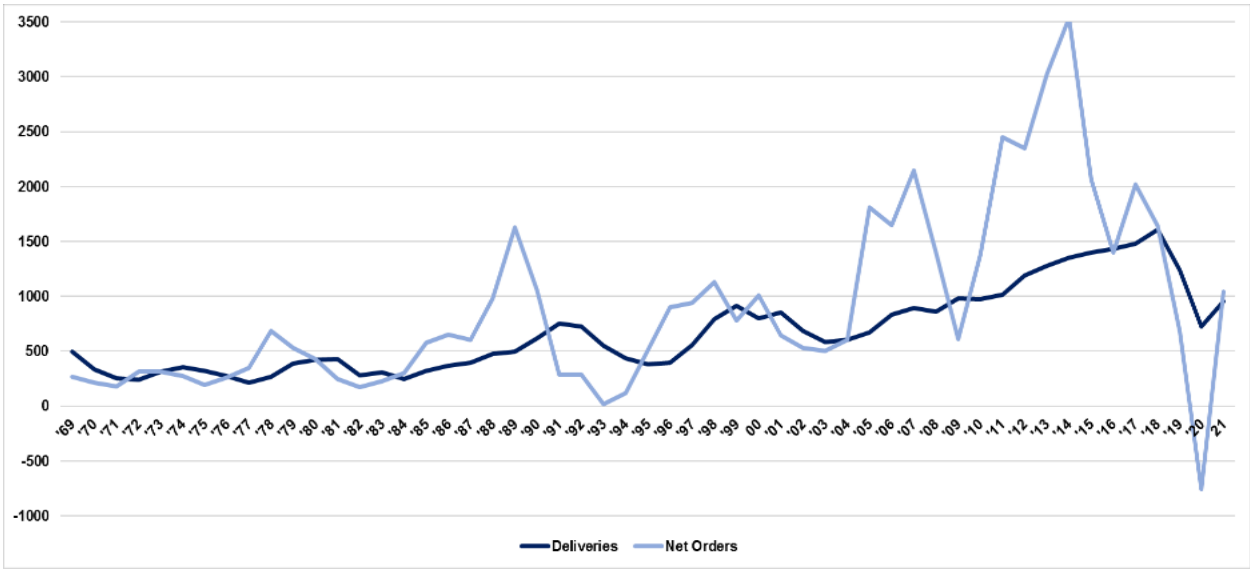
Top 20 Aviation Programs: Volume Matters

Cumulative Deliveries Value in '21 Bns



The ratio of jetliner orders to deliveries – the book-to-bill ratio – tells the story of this recovery. In 2020, for the first time in jetliner history, as indicated in our chart, this ratio turned sharply negative, thanks to cancelations. But in 2021, despite a deliveries recovery, orders slightly exceeded deliveries by a slight margin. This year will also see a positive ratio.

Total Jetliner Orders and Deliveries



Airbus, meanwhile, is aiming for all-time record single-aisle production rates and is more concerned about supply chain issues than faltering market demand. A320 family output was slashed to 40 per month during the pandemic, but the manufacturer is back close to rate 60. As of the July 2022 Farnborough Air Show, it's aiming for rate 65 by early 2024 (a delay of six months relative to earlier in 2022, and 75 in 2025. For comparison, the previous all-time annualized record was rate 53.5, in 2019.

Again, the big problem is on the production side – at the 2022 Farnborough show, Airbus cut 2022 single aisle deliveries to 700 jets from 720. Also at Farnborough, Boeing lowered 737MAX deliveries to the low 400s for 2022, from a plan of about 500 at the beginning of the year. The company cited supply chain disruptions, a slower than expected pace of taking jetliners out of storage, and the timing of MAX deliveries to Chinese customers.

Jetliners – normally accounting for around 60% of total aircraft industry output – are overall in a good position. As discussed above, we're expecting air traffic to return to its 2019 peak in the next two years. Crucially, fuel prices are back from record lows, to a high $100/bbl level, while jetliner financing costs remain reasonably low.

This ratio – the cost of fuel to the cost of capital – is the most important determinant of jetliner market health after airline traffic, and right now the ratio looks good. On the positive side, fuel might decrease, but on the negative side interest rates are rising.

The only exception to this positive aircraft industry outlook is twin aisle commercial jetliners, as discussed below.

Some of the steep upward output line in our aircraft deliveries forecast doesn't reflect manufacturing activity. Next year will see the delivery of scores of 787s and hundreds of 737MAXs that were already built, so the supplier base won't benefit much from these. Inflation could also impact supplier profitability. And the financial damage from this downturn (and the 737MAX shutdown) will impact most manufacturers for years to come.

Meanwhile, there are many ways the recovery could derail. If inflation persists, interest rates will rise further, impacting jetliner financing. If Omicron, or a new Covid variant causes shutdowns, closed borders, and another air traffic slump, some airlines and suppliers could prove unable to withstand another major crisis.

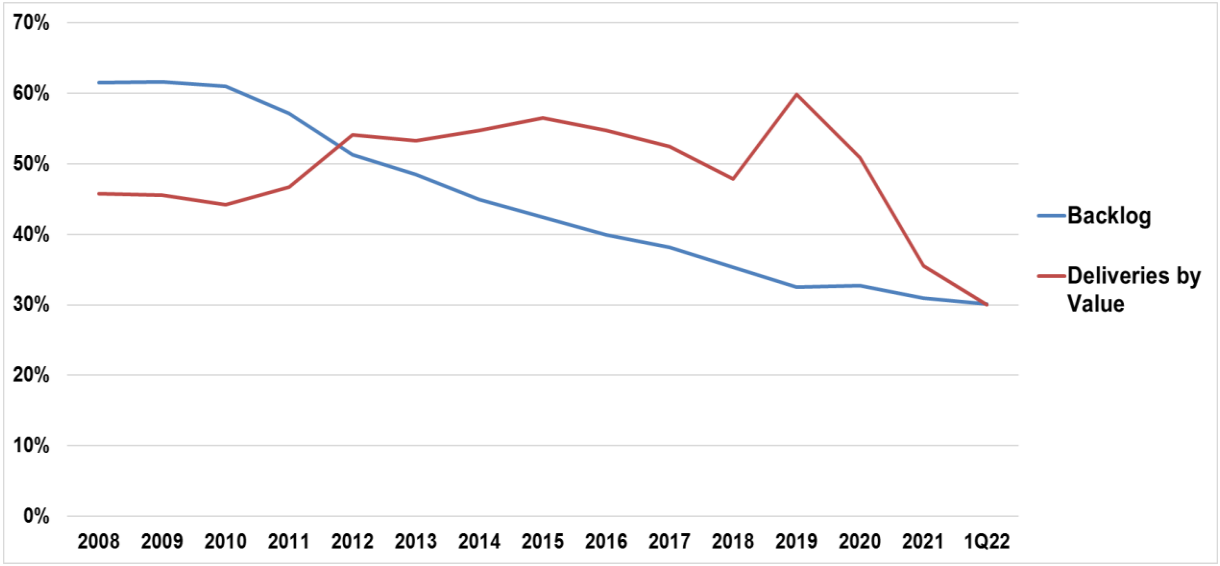
But as of this writing, the terrible Covid-19 aviation downturn looks set to be remembered as shorter-lived and more sector-specific than originally feared. After falling off a cliff, the industry is heading sharply up.

Single Versus Twins

The COVID-19 pandemic and Russia's Ukraine War, in largely different ways, have both impacted commercial aviation markets. But one impact they have in common is they've accelerated a marked split in fortunes between single aisle and twin aisle jetliners. The two crises created a bifurcation: these once-equal market segments are headed in very different directions.

The operative word here is "accelerated." The shift to single aisles has been apparent for years. Backlog and delivery numbers both show this, although the percentage of twin aisle deliveries was boosted in 2019 and 2020 by the 737MAX line shutdown. By the first half of 2022, both twin aisle deliveries and backlogs, by value, had declined to just 30% of the market, as indicated in our chart.

Twin Aisle Share of Total Backlog and Deliveries



This is an all-time low since twin aisles first arrived. For deliveries, the long-term average for the past 30 years is 48%. But backlogs have trended steadily down, from a peak of 62% twin aisles in 2008 to just 31% in 2021.

Twin aisle orders have now completely collapsed. Last year, Airbus and Boeing received 1,416 net new jetliner orders; not a bad year at all, strangely. But only 54 of these were for twin aisle passenger jetliners. The first quarter of this year saw negative 87 twin aisle passenger orders, most of which were Air Asia's A330neo cancellations.

The long-term trend driving single aisles upward and twin aisle downward is route fragmentation, aided and enabled by the latest generation of new, more capable Neo and MAX jets. But then, the pandemic hit international traffic first, most, and longest. This created a terrible twin aisle overcapacity situation. The growing role of third-party finance made the problem worse for twin aisles, for the simple reason that lessors and other financiers simply prefer to finance single aisles, due largely to their much larger client base.

The pandemic-induced downturn also reminded fleet planners that small is beautiful, or, as ex-American Airlines CEO Robert Crandall once remarked, nobody ever went bankrupt flying a plane that was too small. Flexible, point-to-point routes, whenever allowed by the growing range capabilities of new single aisles, are in vogue, whether transatlantic, intra-Asia, or wherever. Widebodies for hub and spoke networks are out. Air Asia has belatedly realized that its future growth prospects depend on A321neos, not A330neos.

All of this was bad enough for twin aisles. But now, Russia's Ukraine war is making the situation worse for twin aisles, and, strangely, even better for single aisles. Even though Russia itself is a tiny twin aisle market, global fear and uncertainty will likely slow the pace of the international travel market recovery.

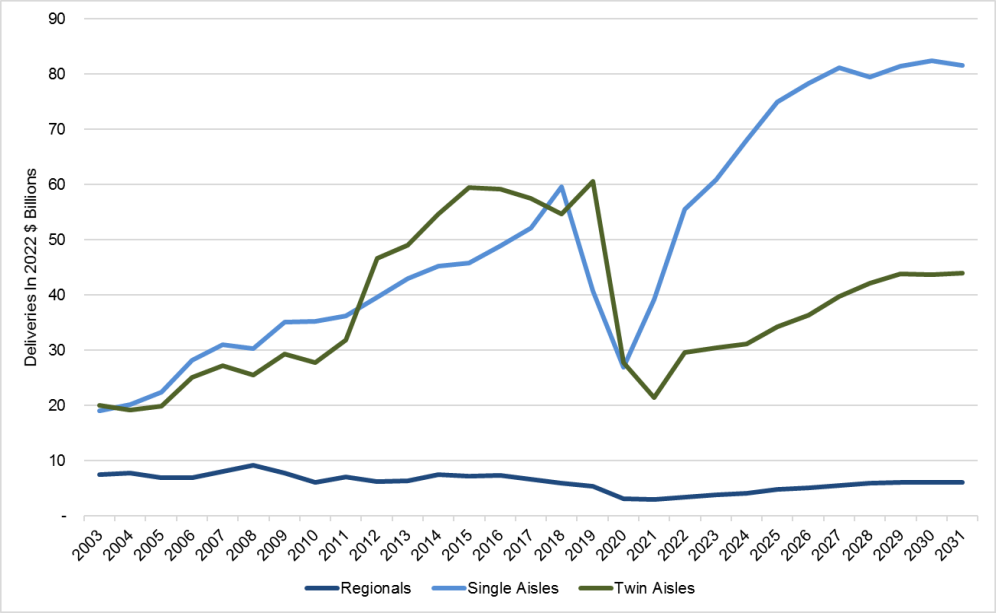
Strangely, single aisles are poised to benefit from the war. This is because aside from Russia's miniscule market, and China's hopefully short-term pandemic lockdown problem, domestic air travels are roaring back, and, more importantly, fuel prices have skyrocketed due to war- and sanctions-related supply issues.

Domestic routes are a commodity service, where airlines have basically minimal pricing power. Domestic service economics, therefore, depend on cost control. When fuel is $100/bbl, if one airline has a Neo or a MAX, and its competitor does not, then the airline with the modern jet can both out-price and out-profit the competition.

Obviously, there are many other variables here, but most airlines are mindful of the need to re-equip with single aisles that offer 12-15% lower fuel burn than their older jets. Thus, unlike twin aisles, single aisle output is governed partly by production constraints, not market demand.

The result is a very K-shaped market recovery, with twin aisles trending up and single aisles trending down. Our forecast, as indicated in our following chart, assumes that what was once a 50-50 single aisle-twin aisle market (by value) stays at 70-30 for most of this decade. This will have big implications for the two primes, and their suppliers and financiers. But again, looking at order numbers and announced fleet plans, it's quite possible that things get worse for twin aisles. A 75-25 market can't be ruled out.

The Air Transport Market by Segment



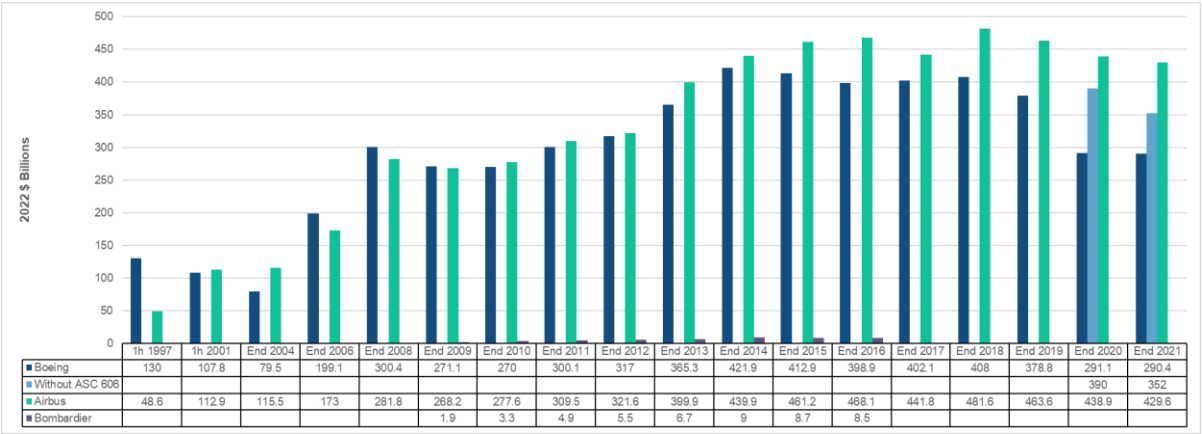
Boeing Commercial's Crucial Moment

Perhaps the biggest question for the aviation industry is whether Boeing will create a new jet, specifically, a mid-market one. The market clearly wants a new product in this class, and the company clearly needs one to compete against Airbus. But an examination of both the company itself and the market indicates that time is of the essence.

First, there's the market. The mid-market, 200/250-seat jets with 4,000-5,000 nautical mile range, is easily the healthiest part of the industry, in terms of orders. The order book for the A321neo, 4,079 jets, is now the same size as Boeing's entire MAX order book (686 delivered plus 3,405 on backlog, after ASC606 accounting adjustments, which consider customer risk). Notably, Airbus received 667 A321neo orders during 2020/2021, when orders otherwise collapsed, and over 1,000 in the last three years. While Boeing's MAX10 had a few good orders in 2021, the A321neo appears to be ahead of Boeing's largest single aisle by at least 7-1.

Our first chart looks at total backlogs, with Boeing's backlog shown with and without ASC606:

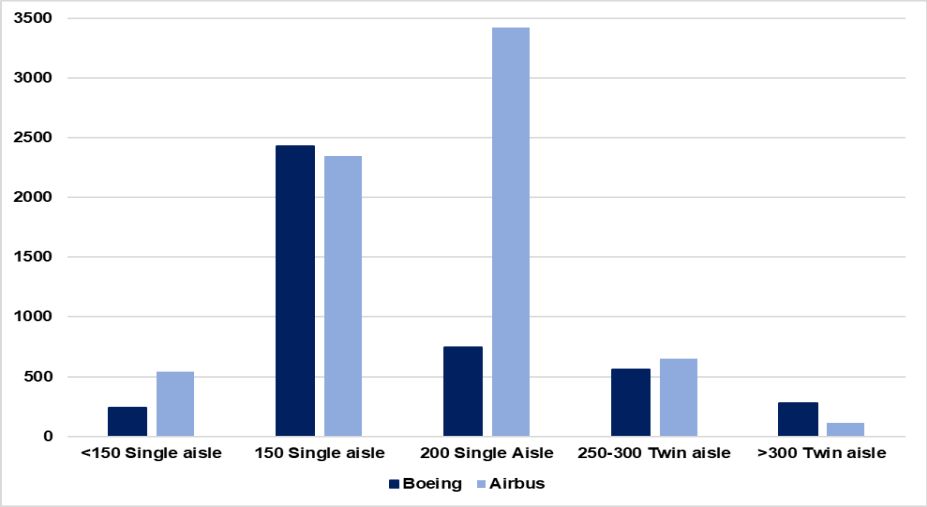
Firm Order Backlog Values (Without ASC606)



	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	End 2019	End 2020	End 2021
Boeing	130	107.8	79.5	199.1	300.4	271.1	270	300.1	317	365.3	421.9	412.9	398.9	402.1	408	378.8	291.1	290.4
Without ASC 606																	390	352
Airbus	48.6	112.9	115.5	173	281.8	268.2	277.6	309.5	321.6	399.9	439.9	461.2	468.1	441.8	481.6	463.6	438.9	429.6
Bombardier						1.9	3.3	4.9	5.5	6.7	9	8.7	8.5					

Our second chart shows these backlogs by segment, as of mid-2022:

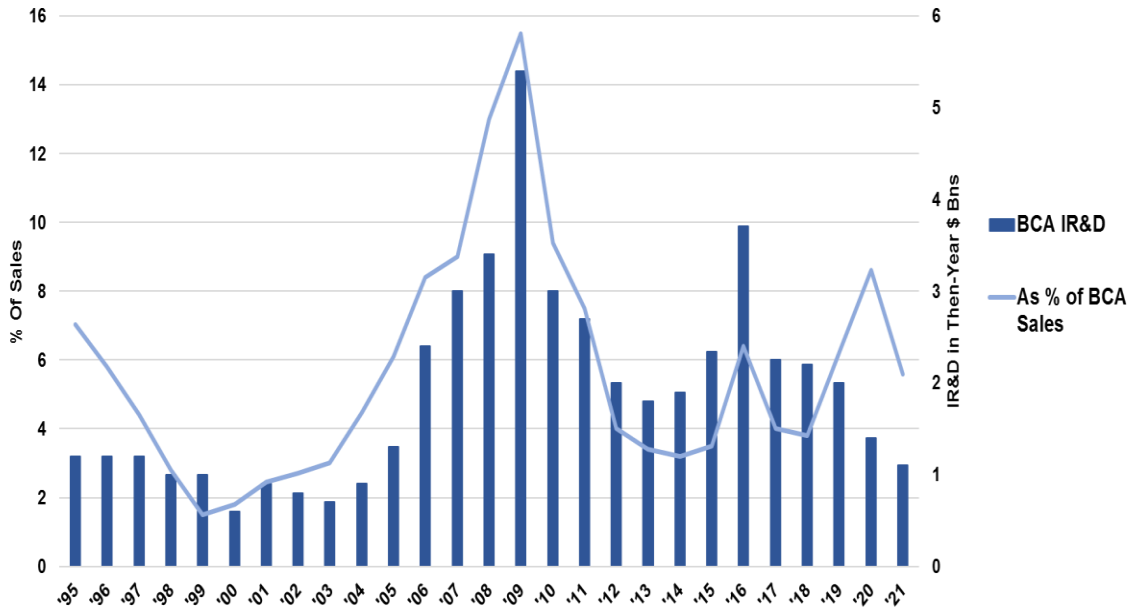
OEM Backlogs by Aircraft Size



The A321neo is far from perfect for the mid-market segment, but many airlines seem to have concluded that this segment is the future, and the Airbus jet is the best option available. Boeing needs a more robust response, before the A321neo tips what was a duopoly into a 60-40 Airbus victory, or even a 65-35 outcome. Given current trends, and given the market's impressive post-COVID recovery, it's likely that the 321neo order book tops 5,000 jets by mid-2023.

Second, there's Boeing's ability to create a new jet, and the broader context of workforce trends. Boeing last launched an all-new jet, the 787, in 2004. This 18-year gap is a record in Boeing's history. As seen in our chart below, BCA's independent R&D funding fell 30% in 2020 from 2019, and in 2021 it fell 21% from 2020. Boeing claims this key metric will start to grow again this year.

BCA IR&D by Value and Percent of Sales



While engineering headcount didn't fall precisely in line with these cuts, it has fallen markedly – between early 2020 and mid-2021, BCA lost roughly 18% of its engineering and technical workforce, according to Bloomberg, following serious cuts in the previous decade. Here again, Boeing says it is starting to hire engineers; this is another key metric to watch in 2022.

When, or if, Boeing does launch a new jet, it will be difficult to restore their engineering headcount, thanks to inflationary salary trends. A strong tech sector is paying very high salaries. SpaceX and other new space ventures are aggressively hiring, as are many well-funded Urban Air Mobility schemes. A record high US defense R&D budget doesn't help – new programs such as the B-21 are hiring engineers, and with government development contracts they can generally outbid commercial employers. This problem will only worsen as Boeing's engineering workforce ages.

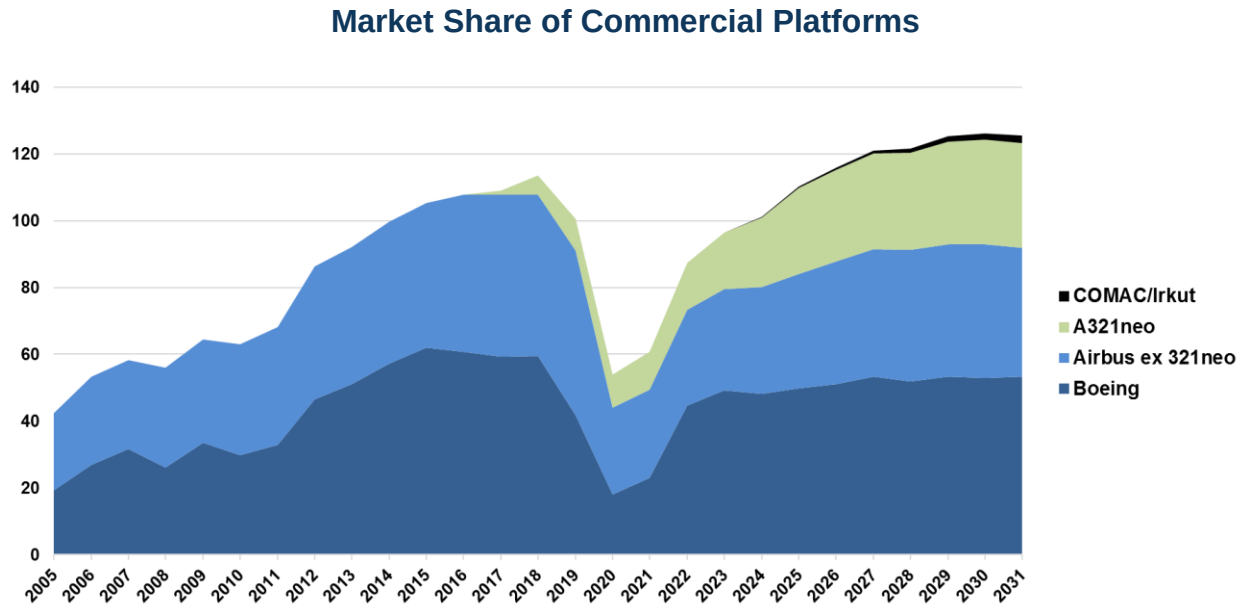
The good news for Boeing is that the very same airlines and lessors who are eagerly ordering A321neos, and other financiers, would cheer a new Boeing mid-market jet, and provide hundreds of up-front orders. Boeing also has a history of arriving late to a segment, but with a winning aircraft, as with the 777 (after the MD-11 and A330/340) and 787 (after the A330-200). With the right jet, Boeing could even recover its lost position as the world's biggest jetliner company.

Mitigating against a Boeing new jet is the company's difficult financial state. While the company does have $16.2 billion in cash, it also has $58.1 billion in debt. But there are few doubts about Boeing's ability to access additional cash through debt or equity. And in the broader context, starting a new program with $500 million per year, say, in incremental spending simply wouldn't make a serious difference to the company's financial position.

Boeing cites the wasted time and money associated with the New Midsized Airplane (NMA), which Boeing pursued before it became clear that a twin aisle jet would have a hard time competing with a single aisle one. Boeing now regards the NMA experience as a reason to proceed cautiously with new products.

But caution can be a rationalization for inaction. Considering market trends, and the company itself, the logical conclusion is that if Boeing doesn't begin a new program this year, its ability to launch one will be increasingly constrained. Customers will simply get in line for more A321neos, and Boeing will have a harder time reconstituting the design team needed to create something new.

Our following chart shows market shares for the next ten years, assuming that Boeing does not launch anything that arrives before 2030. It shows Airbus getting to 65% of the market by the end of our forecast period, on the strength of the A321neo (deliveries of all other Airbus jetliners are in the "ex 321neo" segment).



But again, it is within Boeing's power to avoid this future, and restore the duopoly to 50-50. With the right new product, they could even get back to the number one market position by early in the next decade.

Three Important Factors: Clusters, Defense Crowding, Manufacturing Changes

Three important factors impact aerospace manufacturing site selection decisions: the presence of a dominant incumbent, crowding out related to military aircraft production, and access to technical skills required for Industry 4.0, including Model-Based Systems Engineering.

Aerospace Clusters

This report defines aerospace clusters as zones where there is a high level of concentrated aerospace industrial activity. One way to further characterize these clusters is the extent to which they are dominated by a single prime contractor, or by other major systems contractor (usually engines), as opposed to a cluster being a region where multiple contractors play important roles.

This distinction is important. If a prime contractor effectively dominates a cluster, it can play a large role in setting labor rates and other conditions, relative to a cluster that has multiple large and medium contractors and therefore has a more "fluid" market for labor. "Fortress clusters," as we can term clusters that are dominated by one large contractor, also contain multiple suppliers that are heavily tied to these primes. Here too, labor rates and other costs are subject to terms set by the primes, and by their most dominant programs.

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

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

The Puget Sound area, of course, is a classic fortress cluster, with Boeing dominating economic terms and conditions. There are other parts of Washington state, however, where Boeing is considerably less dominant.

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

- Dallas / Fort Worth - Although the F-35 ramp-up has come to play a strong, and perhaps eventually dominant role in local aerospace economic conditions and labor costs, which will lead to a de facto Lockheed Martin fortress cluster
- Southern California
- Montreal, Canada
- Wichita, KS
- 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 kept both lines going until the pandemic obliterated widebody demand.

By contrast, it is very unusual, if not unprecedented, for somebody 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 that the local aerospace labor market was heavily dominated by Gulfstream. It would be very difficult compete for labor (and government incentive packages) when Gulfstream is in such a dominant position in this region.

The newcomer company might be able to find local 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 labor costs and 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 company.

For this reason, these fortress clusters would be very unlikely sites for a new aircraft production line. As a side note, Boeing's canceled 80% acquisition of Embraer's jetliner unit would have meant that Sao Jose Dos Campos was no longer out-of-bounds for Boeing, as it would have become effectively another one of their fortress clusters. The cancelation of this deal means that

Sao Jose Dos Campos has reverted to a pure Embraer fortress cluster. Obviously, it is no longer a possible site for a new Boeing jetliner.

Defense Crowding

The nature of aerospace clusters also illustrates the impact and threat of crowding out. Crowding out is a term we use to describe military investment that makes commercial manufacturing economics, particularly labor costs, more burdensome for manufacturers.

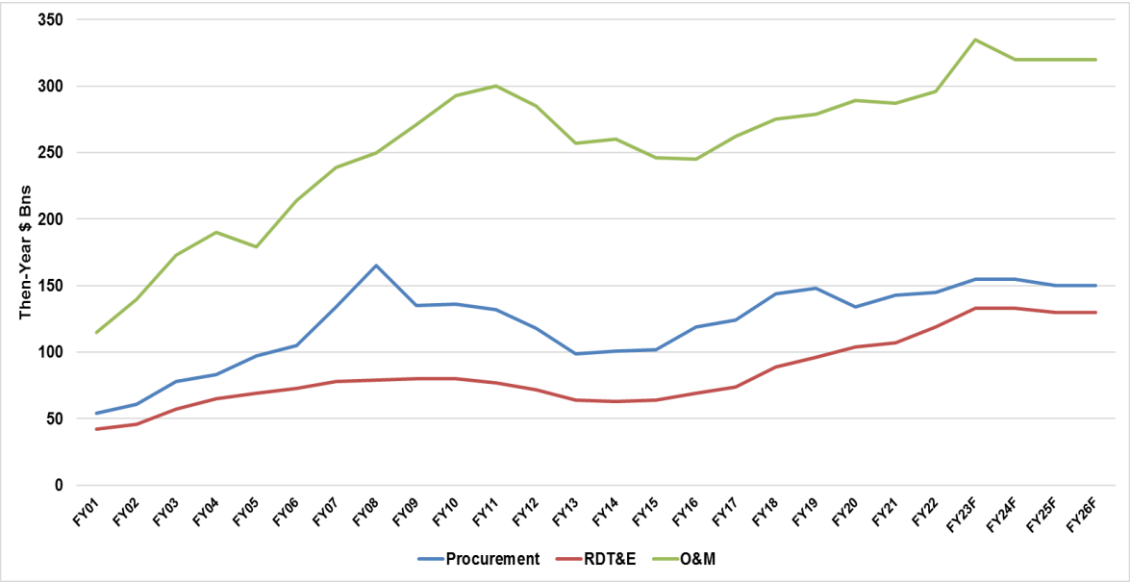
The process of crowding out occurs because defense contracts allow for a degree of cost inflation, particularly for labor costs. Cost-plus procurement contracts, which are still largely the norm in defense, reimburse contractors for all costs.

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 expectations for even higher levels in the coming years, it represents an issue that civil contractors need to deal with in particular regions.

For the purpose of understanding crowding out, it's important to look at the two investment accounts that benefit the aerospace industry: Research, Development, Test and Evaluation (RDT&E), and Procurement. It's also useful to look at Operation and Maintenance (O&M) which also benefits the aerospace industry in the form of aftermarket products and services. Together, these three budget accounts are more than twice as large as they were when Boeing launched its last all-new jetliner, the 787.

US Military Spending on Procurement, RDT&E, and O&M



The engineering picture (associated with that RDT&E budget) is particularly challenging, since creating a new jetliner requires many of the engineers paid from this account. Earlier in 2022 Air Force Secretary Frank Kendall said, “One thing that I think we need to do is make sure we have more engineers…We’re in a technological competition, in part, and developing technologies and then applying them more effectively than our potential adversaries is key to success.”

This isn’t just a defense requirement. That military RDT&E ramp means strong demand, which means higher salaries, since the US isn’t great at creating engineers. The big question is whether civil aero can pay equivalent wages, even when they won’t be reimbursed by government cost-plus contracts? The answer to this will vary by region.

Crowding out is more than just a defense-related phenomenon. New space market ventures, with companies such as SpaceX, Blue Origin, and Rocket Lab, are growing fast and need aerospace engineers. Advanced Air Mobility is turning into a giant source of demand for engineers too. This AAM bubble may well burst in a few years, but cash flowing to scores of speculative new-start companies will help inflate aerospace engineer wages for years to come. For young, newly-minted engineers, AAM is the shiny new object.

Sometimes, defense 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, and 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 too. Also, Bell decided to put the V-22 line in Amarillo as a further cost-control measure. Bell’s civil departure didn’t help either.

But by the late 2000s, Lockheed Martin’s F-35 program began ramping up in Fort Worth. Deliveries rose from six aircraft in 2008 to 91 in 2018 and 142 in 2021. They are scheduled to rise to 156 aircraft in 2023, and possibly to higher numbers after the middle of the decade. This represents a major source of demand for aerospace workers and for supplier companies (and for workers in supplier companies located in the region, too).

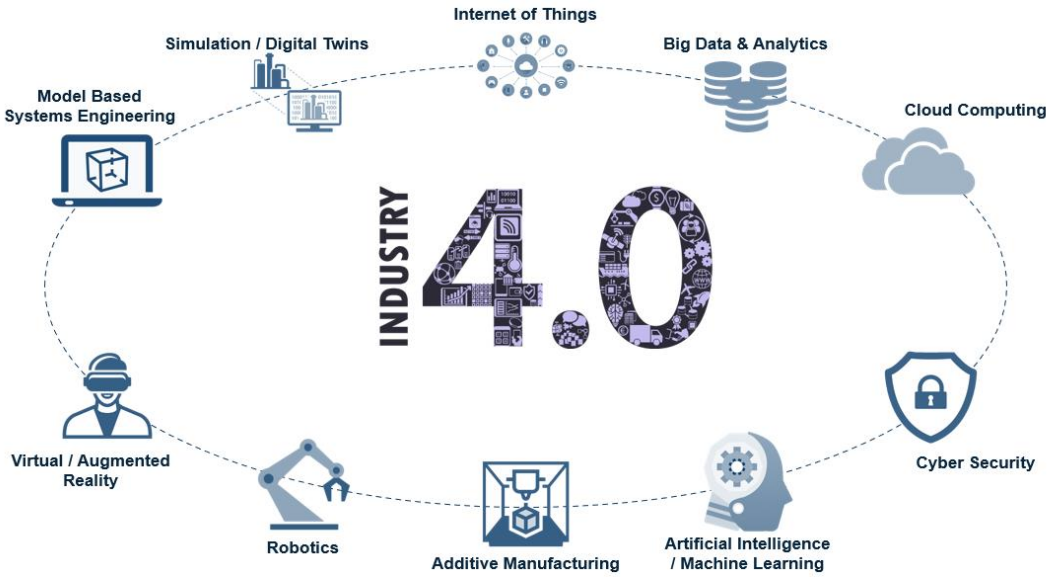
Each F-35 has a higher unit price than the likely commercial cost of a new single aisle jetliner, and it should be noted that the F-35's customers are far less cost-sensitive than airlines and thus willing to reimburse higher manufacturing costs. Clearly, Lockheed will set the price, terms and conditions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

Crowding out is also more of a problem in regions where labor rates are already high. Southern California has done reasonably well with defense projects – Northrop Grumman's new B-21 stealth bomber will be built there. While regional labor rates are rather high, cost-plus defense contracts cover them. 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 term of Boeing's next jetliner production line 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 any new Boeing jetliner.

Manufacturing Changes – Industry 4.0

Industry 4.0 is a popular topic in the aerospace industry today, but it's not always clear what it encompasses and how aerospace companies are applying it. In its broadest sense, Industry 4.0 is the newest phase in the Industrial revolution – one focused on automation, real-time data, and connectivity. The chart shows the primary 10 interrelated areas of study included in Industry 4.0. These topics span all phases of the aircraft lifecycle, from design through production and even into the aftermarket.



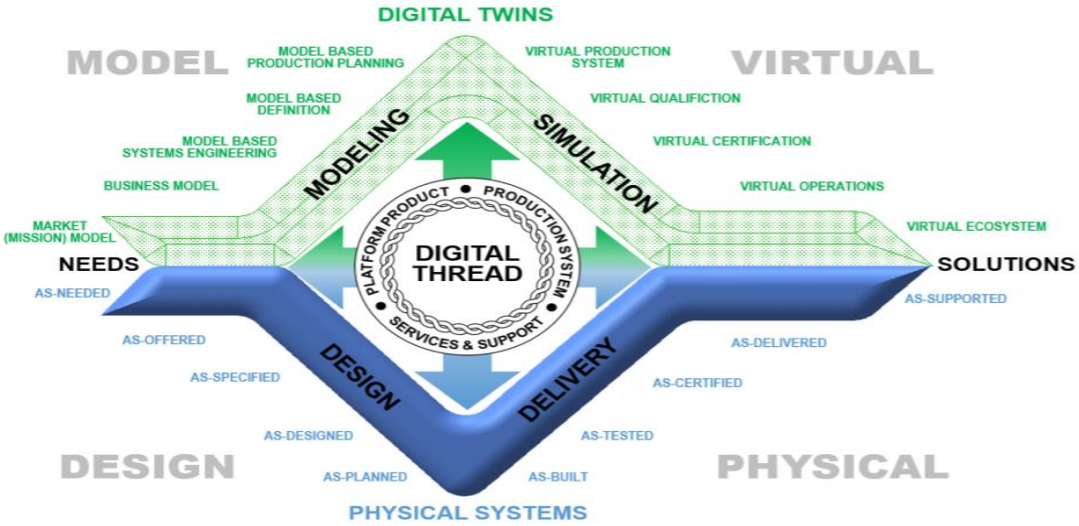
Within aircraft design, Model Based Systems Engineering (MBSE) and Digital Twins are at the forefront, aimed at reducing the risk of development delays and reducing the overall time and cost of development. MBSE is the use of modeling through the full systems requirement authoring, analysis, verification, and validation process. It's rooted in traditional systems engineering but allows for dynamic requirements communication between all stakeholders. Model Based Systems Engineering requires increased upfront investment to clearly define both high- and low-level requirements and how they link together.

Digital twins work in parallel with MBSE by providing a digital representation of a product and/or production system which can be used for validating requirements and simulating the impact of changes in the digital world. Digital twins require better digital models of physical systems as well as in-production and lifecycle data from the physical objects to inform and refine the models, once the physical objects are produced. Put together, MBSE and Digital Twins are expected to reduce development time and cost by 25-30%. A summary of Boeing's overall objectives of Industry 4.0 is shown to the left.

Boeing Industry 4.0 Primary Objectives

- Centralize information into a "single source of truth"
- Increase first time quality of design
- De-risk development programs by highlighting disconnects between functions sooner
- Shorten customer-specific aircraft configuration timelines
- Reduce development costs and schedule
- Shorten manufacturing learning curve

Boeing has been an early adopter of MBSE and has applied it in small scale pathfinders such as the 777X wing tip and in larger applications like the T-7 development in conjunction with Saab. Boeing has even reinvented the traditional systems engineering "V" diagram to represent MBSE, seen below.



To develop an aircraft using MBSE, new product lifecycle management (PLM) and Manufacturing Execution System (MES) tools are required, along with other new tools for requirements collaboration and linkage. These tools, such as Dassault's 3DExperience package and CAMEO systems modeler, may sound like off-the-shelf solutions but in actuality require significant integration with OEM work breakdown and product structures. On the OEM side, teams of systems engineers must trial the systems and give feedback on how the tools can be integrated and what improvements must be made, and thousands of design engineers and manufacturing engineers must be trained on the tools. Culture change – first convincing everyone that the tools are here to stay and getting them to see their benefits – usually takes the longest.

Several companies, including Aernnova, Saab, and Liebherr, identified their MBSE capabilities as giving them an advantage in bidding on new aircraft programs, including the NMA prior to its cancellation. Their MBSE skillset allowed them access to the program earlier than other suppliers, and helped them shape requirements, find ways to hone their own production systems and cost competitiveness, and generally entrench themselves in the program.

Other commercial and military aircraft OEMs are actively investing in Industry 4.0 as well. Airbus has gone through an enormous digital transformation over the past four years and has a "Digital Design Manufacturing and Services" initiative to develop and integrate digital engineering and manufacturing tools. Northrop Grumman has also been an industry leading in MBSE, utilizing it for the Ground-Based Strategic Deterrent (GBSD) development, OmegA Rocket engine bid, and Next-Generation Interceptor (NGI).

Impact on New Program Timing

Once requirements are written and drawing are released in a system, it's time and cost prohibitive to convert everything to a new system. This is why Boeing wants to get their tools in order prior to the launch of a new aircraft. Dave Calhoun was quoted in The Seattle Times saying that it will take "at least a couple of years before I'm confident that those tools are tested and mature enough to implement on the next airplane. When that happens, then we design the next airplane. We don't do it the other way around." If a new CEO replaces Calhoun before the tools are ready, though, they could have a different perspective.

Boeing likely *needs* MBSE and digital twins to close the business case on a new program, though, especially if the next aircraft is a twin aisle. Prior to its cancellation, Boeing expected a 2-year reduction in development time and 30% reduction in NRE with MBSE on the NMA, which was critical to closing the business case to produce a small composite widebody with total expected demand of only about 2,500 aircraft over 20 years. This was before the COVID-19 pandemic, too, which has accelerated a secular trend towards narrowbodies. Independent of if it's a narrowbody or widebody, the groundwork will need to be laid for MBSE before Boeing will be able to make their go no-go decision.

Impact on Site Selection

MBSE and the broader Industry 4.0 landscape impact the aerospace manufacturing site selection for Boeing, all other OEMs, and tier 1 suppliers. Industry 4.0 requires a different set of skills than is typical for aircraft development and manufacturing: MBSE requires systems engineering, big data and analytics require data scientists, and almost everything requires computer and software engineers. Aerospace companies will place more emphasis on locating in areas with large sources of talent in these fields and shift emphasis away from aerospace engineering talent. Ohio benefits from this trend with top industrial & systems engineering programs at both the Ohio State University and the University of Michigan nearby.

Industry 4.0 is also a driving factor in co-locating engineers with production. OEMs already understand the benefit of placing engineers where they can quickly and easily see how their designs impact production. Boeing established an Engineering Design center and Research and Technology center in South Carolina after the 787 production line became operational, for example. The interconnectedness of design and production models, production data analytics, and automation, though, all further increase the need for engineering support directly on-site.

This means that engineering labor costs of a region will have a greater impact on site selection than they have in the past.

The linkage of requirements and models across the aircraft performed in MBSE, in its ideal state, will be done from the OEM all the way down the supply chain. In actuality, though, this is extremely difficult given the plethora of design tools used at suppliers and the hesitancy for bidirectional information sharing given the risk of IP leakage. These issues will likely get worked out over time, but the first complete aircraft programs to be developed using MBSE will have a tendency towards insourcing so a greater share of the aircraft can be linked into the “single source of truth” models.

This means a new production site would need to be larger to house the in-sourced manufacturing, so land costs and tax breaks become even more important. In-sourced manufacturing does not need to be done on the same site, but Boeing has entertained the idea of a supersite in the past given theoretical just-in-time and transportation cost benefits. As this report has noted in the past, though, there are numerous downsides to supersites including wage inflation, and given Boeing’s cash challenges they will likely be forced to partner with risk-sharing super tier 1 suppliers on their next program.

ACES Full Results

Category Rankings

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

Individual Metric Rankings

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

Category 1: Cost

Labor Cost
The average annual wages for aerospace production workers

Labor Productivity
The amount of value added per $1 of labor

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

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

Category 2: Labor & Education

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

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

Category 3: Aerospace Industry

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

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

Category 4: Infrastructure

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

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

Category 5: Risk to Operations

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

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

Category 6: Economy

GDP Per Capita
Gross Domestic Product per Person

Growth in GDP Per Capita
5-Year Growth Rate in GDP per Capita

Manufacturing Industry
Durable Goods Output / State GDP

Global Manufacturing Connectivity
Durable Goods Exports / State GDP

Unemployment Rate
The percentage of the working population looking for work that is unemployed

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

Category 7: Research & Innovation

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

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

Category 8: Taxes & Incentives

Total Taxes / GDP
Total taxes as a percent of state GDP

Workers' Compensation
Workers' Compensation Premium Rate

Corporate Income Tax
Top Corporate Income Tax Rate

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 2022 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 2022 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.

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.

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

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. 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 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 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 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.

Changes to the Methodology: Updated Metrics

Two metrics from the Cost category were updated for this report: Unit Labor Cost and Unit Material Cost. They were replaced with Labor Cost and Labor Productivity

Unit Labor Cost is defined as [Total Aerospace Payroll] / [Total Aerospace Revenue]. This is meant to calculate how many dollars of payroll are required to produce one dollar of revenue. Upon further review, the team determined that this would provide an unfair advantage to integrators. For example, if a company received a nearly complete aircraft and only provided a

small amount of value-added work before completion, it would have a very small payroll, but get to claim the complete aircraft as their total revenue. The updated measure, Labor Productivity, is defined as [Total Aerospace Value Add] / [Total Aerospace Payroll]. This is the amount of value added per dollar payroll and more accurately measures labor efficiency or productivity.

Unit Material Cost was defined as [Total Aerospace Material Spend] / [Total Aerospace Revenue]. This is meant to calculate how many dollars of material are required to produce one dollar of revenue. Upon further review, the team determined that for this to be a fair measure, states (or companies) would have to be producing the same thing, as some production simply has higher material costs. A state that happens to have a higher concentration of material intensive production should not be punished. Instead, the team added a Labor Cost measure, which is the [Aerospace Production Workers Annual Wages] / [Aerospace Production Workers]. This is effectively the annual wages for production workers, and directly measures Labor Cost.

Categories & Metrics Included in ACES 2022

Category	Metric	Description	Source
Cost	**Labor Cost***	The average annual production wages per production worker (2019)	US Census Bureau
	Labor Productivity*	The amount of value added per $ of labor (2019)	US Census Bureau
	Energy Cost	The cost (cents/kilowatt hour) for the Industrial end-user sector (2021)	US Energy Information Administration
	Construction Cost	The national association of builders modifiers for construction cost for building by state (2020)	National Building Cost Manual
Labor & Education	**Aerospace Engineers**	The Aerospace Engineers per 1000 Jobs (2020)	US Bureau of Labor Statistics
	Aerospace Production Workers	The Aerospace Production Workers Hours/(Total Employees x Average Hours) (2019)	US Census Bureau US Bureau of Labor Statistics
	Engineering BAs	The percentage of population 25+ with an engineering B.A. (2020)	US Census Bureau
	Graduate Degrees	The percentage of population 25+ with an advance degree (2019)	US Census Bureau
	High School +	The percentage of population 25+ with at least a high school education (2019)	US Census Bureau
	Education Spending	Primary and Secondary education spending per pupil (2020)	US Census Bureau
Industry	**Aerospace Sales**	Aerospace Parts and Manufacturing Total value of shipments and receipts for services (2019)	US Census Bureau
	Aerospace Value Added	Aerospace Parts and Manufacturing Value Added (2019)	US Census Bureau US Bureau of Labor Statistics
	Aerospace Exports	Aircraft, Spacecraft and Parts Exports (2021)	US Census Bureau USA Trade
	Employee Growth	Pct Increase in Aerospace Employees (2015-2020)	US Census Bureau
	Supplier Density	Aerospace Parts and Manufacturing establishments/Total establishments (2020)	US Census Bureau
	Crowding Out	Federal Aerospace Manufacturing Contracts/Total value of shipments and receipts for services (FY 2019)	USA Spending.gov US Census Bureau
Infrastructure	**Airports**	Airports per Sq Mille (2022)	US Department of Transportation
	Freight Railroad	Total Freight Railroad miles per Sq Mile (2020)	Association of American Railroad
	Port Volume	Total Container Traffic at U.S. Ports (2020)	AAPA
	Road Condition	Index of Road Quality (2020)	Bureau of Transportation Statistics
	Transportation Funding	Total Airport, Highway, Seaport, and Transit spending/Population (2019)	US Census Bureau
Risk to Operation	**Insurance Premiums**	Average Homeowners Insurance Premiums (2019)	Insurance Information Institute
	Insurance Losses	Incurred Losses by State, Commercial Insurance (2016-2019) / Current GDP (2016-2019)	Insurance Information Institute
	Earthquake Premiums	Total Earthquake Premiums/Population (2019)	Insurance Information Institute
	Extreme Weather	Total number of storm events per Sq Mile (2021)	US National Oceanic and Atmospheric Administration
Economy	**GDP per Capita**	Real GDP Per Capita (2021)	US Bureau of Economic Analysis
	Growth in GDP Per Capita	Real GDP Per Capita 5-Year Growth (2016-2021)	US Bureau of Economic Analysis
	Manufacturing Industry	Real Durable Goods Output/Real State GDP (2020)	US Bureau of Economic Analysis
	Global Manufacturing Connectivity	Current Durable Goods Exports/Current State GDP (2020)	US Bureau of Economic Analysis
	Unemployment Rate	Unemployment Rate (April 2022)	US Bureau of Labor Statistics
Research & Innovation	**Patents per Capita**	Patents issued to residents/total population (2020)	Science & Engineering State Indicators
	Public R&D	Current federal R&D spending for selected agencies/current state GDP (2020)	National Science Foundation
	Private R&D	Current Private R&D from all sources/current state GDP (2018)	National Science Foundation
	High Tech Establishment	Pct. of business in industrial with high science, engineering, and technology (SET) employment (2014)	National Science Foundation
Taxes & Incentives	**Total Taxes /GDP**	Current Total Taxes as a pct of Current State GDP (2020)	US Census Bureau US Bureau of Economic Analysis
	Workers Compensation	Workers' compensation premium rate (2020)	Oregon Department of Consumer and Business Services
	Corporate Income Tax	Actual corporate income tax rate (2022)	Tax Foundation
	Personal Income Tax	Top individual income tax rate (2022) - High Tax Rate	Tax Policy Institute
	Manufacturing Tax	Current Taxes on Production and Imports Less Subsides for Durable Goods Mfg/Current GDP for Durable Goods Mfg (2019)	US Bureau of Economic Analysis
	Property Tax	Current State & Local Property Tax Collection Per Capita (2019) / Current GDP Per Capita (2019)	Tax Policy Institute US Bureau of Economic Analysis
	Sales Tax	General Sales Tax Rate (2022)	Tax Policy Center

*Labor Cost and Labor Productivity are updated metrics for this report. See the Updated Metrics section for details

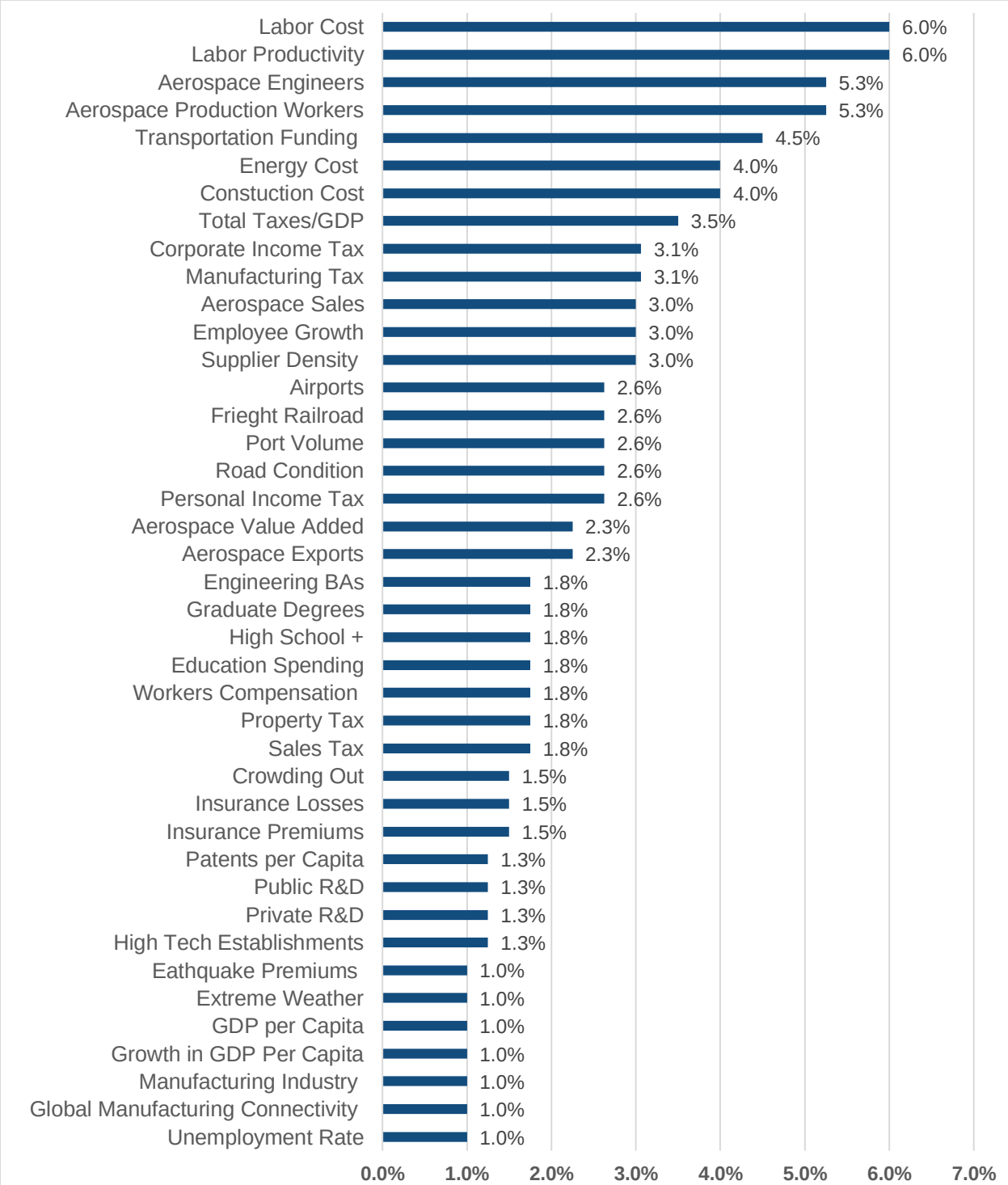
Weights For Categories & Individual Metrics

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
Cost	**20%**	**Labor Cost**	30%
		Labor Productivity	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 +	10%
		Education Spending	10%
Industry	**15%**	**Aerospace Sales**	20%
		Aerospace Value Added	15%
		Aerospace Exports	15%
		Employee Growth	20%
		Supplier Density	20%
		Crowding Out	10%
Infrastructure	**15%**	**Airports**	17.5%
		Freight Railroad	17.5%
		Port Volume	17.5%
		Road Condition	17.5%
		Transportation Funding	30%
Risk to Operation	**5%**	**Insurance Losses**	30%
		Insurance Premiums	30%
		Earthquake Premiums	20%
		Extreme Weather	20%
Economy	**5%**	**GDP per Capita**	20%
		Growth in GDP Per Capita	20%
		Manufacturing Industry	20%
		Global Manufacturing Connectivity	20%
		Unemployment Rate	20%
Research & Innovation	**5%**	**Patents per Capita**	25%
		Public R&D	25%
		Private R&D	25%
		High Tech Establishment	25%
Taxes & Incentives	**17.5%**	**Total Taxes /GDP**	20%
		Workers Compensation	10%
		Corporate Income Tax	17.5%
		Personal Income Tax	15%
		Manufacturing Tax	17.5%
		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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