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2019 PURCHASE PLANNING HANDBOOK

Production Aircraft Comparison
Performance Tables and a
Look at the Trends and New
Developments in Avionics

Rejected Takeoff Authority

Tragically Mis-set Trim

Hurricanes and Aviation

Charter, Fractional, Ownership and/or Managed?

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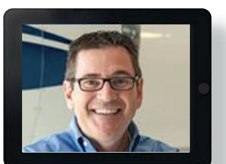

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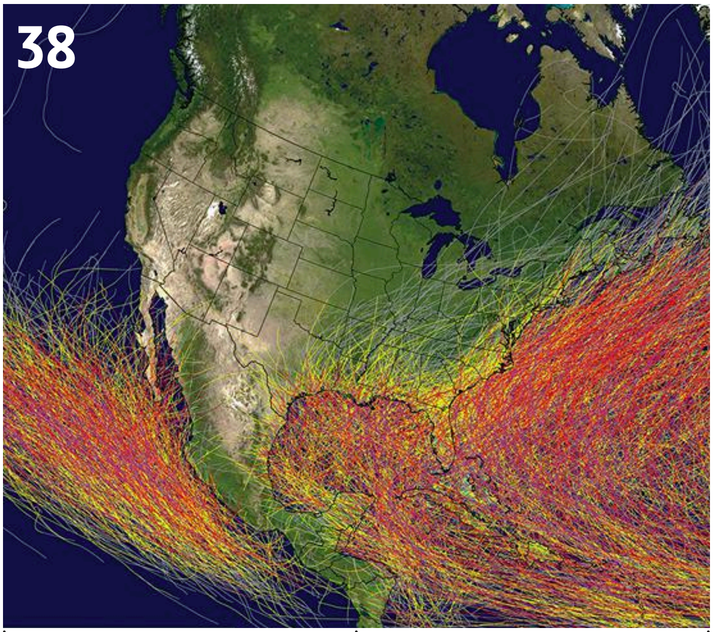
Photo illustrating feature "Rejected Takeoff Authority" from hxdyl/istockphoto.com



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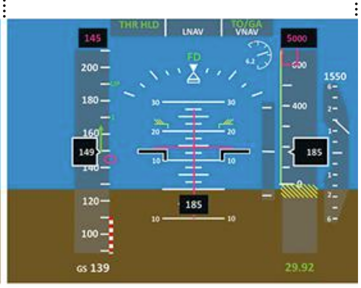

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Business & Commercial Aviation

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Viewpoint

William Garvey
Editor-in-Chief
william.garvey@informa.com

Data Collection

About racks, **money stacks and changing tacks** of a new generation

WE MEMBERS OF THE BUSINESS AVIATION COMMUNITY LOVE TO gather and flock together heartily throughout the year. But it seems to me that these usually annual reunions are front-loaded. To my point:

I've already checked off the Living Legends of Aviation gala; the National Aeronautic Association luncheon featuring Teal Group Richard Aboulafia's yearly assessment of civil and military aviation programs; the General Aviation Manufacturers Association's State of the Industry report; the NBAA's International Operations Conference in San Francisco; the Asian Business Aviation Conference and Exhibition in Shanghai; Aviation Week's Laureate Awards dinner; the Helicopter Association International's Heli-Expo; the MRO Americas conference and inaugural Urban Air Mobility meeting, also by Aviation Week; Dassault Falcon Jet's 22nd Aviation Professionals Conference; and the European Business Aviation Convention and Exhibition in Geneva. And that's just a partial list, and only through May. Whew.

This month I'm attending Jetnet's always informative iQ Summit on the eve of the NBAA Regional Forum at the nearby Westchester County, New York, Airport (HPN). Upon returning home from that, I think I'll cannonball into the pool and just soak there until the July 4th fireworks light up the summer sky. To be honest (inspired by Washington's current embrace of transparency), I didn't attend all those aforementioned events, just most of them. And while gatherings such as these vary in focus, size, length and delivery, I usually find them enlightening — some in surprising ways.

For example, at the recent Dassault event, I learned that it takes approximately 4 hr. and 28 min. to properly roast a rack of lamb; that even shockingly bald, John Travolta's image can draw applause; that two billionaires were hatched over the course of our meeting and quite likely one was fluent in Mandarin; and that Wall Street's excitement over Uber's initial public offering doesn't necessarily bode well for our special segment of aviation. Allow me to explain.

Days prior to the meeting at the Dupont Hotel, a century-old grand dame in downtown Wilmington, Delaware, and close by Dassault's expansive service center, the jet maker poked Santa Monica's anti-airport pols in their collective eye by launching an 8X from the shortened runway and flying nonstop to Teterboro in a record 4 hr., 38 min., and did so despite a negligible tailwind. Don Bass, Avpro's managing partner, learned from the hotel's kitchen that timespan was the same required to prepare a rack of lamb banquet. So, to commemorate the record flight, he grandly presented Dassault Falcon President and CEO John Rosanvallon with a meaty sampling.

Early this year, Rosanvallon was presented a Lifetime Achievement Award at the Living Legends event in Tinsletown, which was hosted by a chrome-domed Travolta. An image of the two together brought cheers when it was also announced that the Urban Cowboy had recently bought a Falcon, his second.

A presentation by Michael Cohn, a vice president with UBS-BlueSky Advisory Group, gave me pause. His bank had teamed with PricewaterhouseCoopers to conduct a kind of census of the world's billionaires in 2017. Their findings: In that year, 332 people became billionaires, 199 of whom were entrepreneurs and of those, 89 were Chinese, a rapidly growing demographic. It was an especially good year for the mega-rich ring, which totals some 2,500 members, as their combined fortunes increased from $1.4 trillion to $8.9 trillion. Historically, this group has been prime for business aviation's purveyors.

Chinese with new-found wealth have decided to eschew business jets as ownership **draws unwelcome attention from a government concerned about corruption.**

Notably, however, Cohn went on to say, "sustainability is not a buzzword" among the younger super rich. And that, among other things, could pose problems for those making, marketing and managing business aircraft. Among presenters and attendees there was commentary about members of the rising generation having different values, that they don't want to be constrained by possessions — be they McMansions, automobiles . . . or airplanes. They want the option to use such things as needed and quickly, but then walk away. And they're concerned about the environmental impact of their activities. Too, that Chinese with new-found wealth have decided to eschew business jets as ownership draws unwelcome attention from a government concerned about corruption.

We'll see. Money in abundance can alter one's perspective. Tesla/SpaceX's Elon Musk, 47; Amazon's Jeff Bezos, 55; Googlemen Larry Page, 46, and Sergey Brin, 45; and Paul Allen, the now departed cofounder of Microsoft, among many disrupters, all came to embrace business aviation in a big way. As Brad Hayden notes in this issue's *Fast Five,* unmanned aircraft systems are flourishing and they, including future electric air Ubers and eVTOLers, are likely to become a huge segment of aviation thanks to the tech-oriented, shared-service-loving digital generation — one promulgated by rich Chinese technologists.

But for moving key people between cities, countries or continents quickly, safely, securely and in comfort, I'll stake my money (albeit something pitifully south of a billion) on business aviation. **BCA**

Readers' Feedback

Thanks for Great Articles

Congratulations on another great issue. I especially want to commend James Albright for his thoughtful **"Staying On Glidepath."** Failing glidepath management is an all-too-common error in corporate operations, where the luxury of two-mile long runways is not the norm. His thorough review of the Global accident, the most in-depth I've seen in the press, was enlightening.

As usual, James' ability to blend storytelling with engineering analysis gives us food for thought, as well as the prescription for the cure.

I read each issue cover-to-cover, and always look forward to the next one!

Bob Lenox
Palo Alto, California

Paris Jet, Brief History

In **"Tracing the Single-Engine Turboprop"** (May 2019), the aircraft pictured on page 58 is incorrectly identified as the five-seat Morane-Saulnier MS.760C Paris Jet III. In fact, the photo shows the four-seat MS.760B Paris Jet II, an aircraft I had the pleasure of flying for several years. That model, along with its two-seat predecessor, the MS.755 Fleuret, both greatly influenced military and corporate aviation in the United States.

As for the Paris Jet III, only one was manufactured, and it was operated by the fascinating aerospace entrepreneur, former French fighter pilot and airline CEO, Alec Couvelaire, rightly given credit in the article for spurring development of single-engine turboprops.

In 1950, Morane-Saulnier entered its MS.755 design concept for the French Air Force trainer competition; one that lost to Fouga's CM.170 Magister. Powered by two Turbomeca Marbore II 880-lb./thrust turbojets, the company continued to build a prototype of the Fleuret ("foil") which made its first flight on January 29, 1953. Morane-Saulnier conducted successful flight demonstrations of the Fleuret to the U.S. Air Force and Navy, hoping to present the aircraft as one of the 15 entrants for the 1952 USAF "Trainer Experimental (TX)" solicitation. In 1954 Cessna Aircraft evaluated the Fleuret for possible production under license, as U.S.-manufacture was an Air Force program requirement.

RUTH AS/WIKIMEDIA COMMONS

Instead of building the Fleuret, Cessna decided to propose their first jet-powered aircraft, the Model 318, for the competition. USAF/ARDC awarded Cessna a contract to build three prototypes in the spring of 1954. The XT-37 made its first flight on Oct. 12, 1954, powered by two YJ-69 turbojet engines rated at 920-lb./thrust, which Continental built under license from Turbomeca.

As for the MS.760, the Paris Jet I influenced the market development of American corporate business aviation — this time on the other side of Wichita — at Beech Aircraft.

Beech marketed the CAA (FAA) Standard-Utility Airworthiness, single-pilot Paris Jet I through a 1955 joint venture with Morane-Saulnier. The 7,650 lb. MTOGW aircraft was to be offered by Beechcraft as U.S.-built with increased thrust Continental J69s. The price of $210,000 included pilot training and spares — making it corporate aviation's first business jet (See the cover photo of Flying January, 1956 for the Paris Jet sporting Franco-American flags and the Beechcraft logo). A 500-hr. flight demonstration tour resulted in few sales, (which included one to Louise Timken of roller-bearing fame). Beech dropped the marketing agreement in 1961.

In 1961 Morane-Saulnier began production of the MS.760B Paris Jet II with the 1,060 lb./thrust Turbomeca Marbore VIC. While 150+ MS.760s were built in France, another 66 military aircraft were built in-country for Argentine and Brazilian Air Forces, the last of which ended service in 2007. Perhaps a few dozen aircraft remain on the FAA registry.

The "cabin class" Paris Jet III (MS.760C) was built largely as the result of Alec Couvelaire's urging. The 760B's sliding canopy was replaced by an entrance door, and a 5th seat was added. (See *Aviation Week & Space Technology*, Nov. 8, 1965). The one prototype is now parked at Paris-Le Bourget Airport.

Following Morane-Saulnier's 1961 bankruptcy, the venerable aircraft manufacturer Potez acquired the company. The Paris Jet III made its first flight on Feb. 24, 1964, (under-) powered by the same Turbomecas used on the Paris Jet II. With a MTOGW of 8,820 lb. (nearly 1,200-lb. heavier than the 760B) the III sported an anemic thrust-to-weight ratio of 1:4, giving it an all-engine rate of climb under 2,400 ft./min. By way of comparison, Bill Lear's Swiss American Aviation Corporation 1963 Learjet Model 23, at 12,499 lb. MTOGW, had a thrust-to-weight ratio which was nearly double that of the Paris III, thanks to a pair of 2,850 lb./thrust GE CJ610s.

The Paris III was displayed at the June 1967 Paris Air Show and was operated as a corporate aircraft by Aerospatiale into the early 1970s.

Randall Greene
Safe Flight Instrument Corp.
White Plains, New York

> *"The FPA mode needs constant monitoring and some adjustment during the approach, because as you very well wrote, this function does not care where the runway is."*
>
> **Hugo Villanustre,** *Santiago, Chile*

A Must Read Article

I just finished your lengthy and detailed account of Ameristar Charter Flight 9363 (**Cause & Circumstance, May 2019).** It was both riveting and informative,

Cause & Circumstance

Incapable of Flight

All safeguards **failed**

BY RICHARD N. AARONS bcasafety@gmail.com

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aside from being very well written.

Our Hawker 900XP is no comparison to the MD-83 but I immediately called our pilots to determine what they do for prolonged stays on runways where wind conditions could adversely affect the elevators.

Thanks for a great article.

Paul Nietzel
Operations Manager
Everest Group
Omaha, Nebraska

Full of Surprises

I always enjoy very much reading James Albright's articles. I find them both pragmatic and technically thorough.

I was conceptually surprised, like he was, to read in **"Staying on Glidepath" (May 2019)** that the Air Canada crew corrected their flight path angle during the approach for cold temperature conditions, as per their FOM.

I understand the cold temperature correction to the approach altitudes, just to keep you on the same and safe vertical spot in space according to the approach design, maintaining the obstacle separation criteria, but you are not actually higher referenced to terrain than the standard designed approach. You are correcting your altimeter reading for the cold temperature condition. That is the general concept.

Given this, I find no reason to fly a steeper flight path angle on the approach other than some unknown limitation on the FPA function, which is not stated in Airbus manuals. I think that flying a 3.5 degree FPA on a 4.6 nm segment was a contributory factor in this accident, although it was not considered in the accident report.

Reading that report, one can see that the procedure of correcting the FPA according to cold temperature conditions was designed by Air Canada and approved by Transport Canada, but not published on Airbus manuals.

Another fact that surprised me was that Air Canada did not have a procedure in their SOPs to check altitudes and distances from the navaid once the FPA was established.

The FPA mode needs constant monitoring and some adjustment during the approach, because as you very well wrote, this function does not care where the runway is. In my opinion, this would be a much robust and safe procedure than correcting the FPA for cold temperature conditions, which I consider, if applicable, a finesse.

Congratulations for your excellent magazine!

Capt. Hugo Villanustre
B787/767/A320Fam/A340/Be1900
ATP, CFI, TRI
Santiago, Chile

Glidepath Clarification

"Staying on Glidepath" (May 2019) makes reference to Fox Harbour Airport (CFH4) in Ontario. It's not. It's in Nova Scotia. (And it's really pronounced 'Fox Harb'r.)

Operations

Staying on Glidepath

The dangers of **the duck-under**

BY JAMES ALBRIGHT james@code7700.com

Last Flight of Cobra Ball

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The resort and golf course was developed and owned by Ron Joyce, also known as the brains behind Tim Hortons donut shops, now numbering in the thousands in Canada and the U.S. and making him a billionaire. He died this past January; he was 88.

James R.O. McIntyre
Montreal, Quebec

Different Point of View

"Promising Alternatives" (Viewpoint, March 2019) was very well written as usual. However, I have a slightly different point of view. I applaud decreased fuel specifics (fuel consumption/thrust) since those make for longer range, lower cost, etc., etc. And of course there are also other emissions that we should strive to reduce. We all remember the noise and smoky takeoffs of early generation airplanes. Notable examples include the GII (an aircraft dear to my heart, but some — including me — say the smoke is HALF the fun!!), B-707 etc.

But I like CO_2. Without CO_2 all life would cease. Our food supply depends on CO_2. Historical data shows good times in the past when temperatures were higher, thus freeing up more CO_2 to be in the atmosphere. The global warming bunch don't care about the environment, they see it as a mechanism to further their anti-freedom agenda. I applaud actual environmental protection measures.

They have the drive/driven mechanism backwards. Rising temperatures cause increased levels of CO_2.

I'm glad we are getting some cost relief in the training segment. But the coal/natural gas-powered trainers, while lowering fuel costs, don't necessarily have zero emissions.

An article on electric cars, I would imagine that the logic would be similar for airplanes. The impact is dependent on the source of the electricity. Most of the power (63.5%) comes from burning fossil fuel:

https://www.eia.gov/tools/faqs/faq.php?id=427&t=3

Another consideration is the impact of manufacturing, and then disposing of the vehicle after it is no longer viable for its intended purpose. There would be several battery replacements during the lifetime, too, which would also have to be manufactured and dispose of.

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INTELLIGENCE

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NEWS / ANALYSIS / TRENDS / ISSUES

▶ **ACCORDING TO RON DRAPER,** Textron Aviation's new president and CEO, the company hired 1,000 employees in 2018 and plans to hire another 1,000 again this year. "We're staffing up," he said. Draper told 400 customers and 200 suppliers attending its Textron Aviation's recent Customer Conference in Wichita, Kansas, that **"2018 was a better year for us."** In fact, he said, it was the company's strongest year since the economic collapse in 2008. "It felt good to have a little bit of economic tailwind," he said, adding that 2019 was off "to a pretty good start."Draper took over as president and CEO last October following the departure of Scott Ernest, who left to lead the company's Textron Systems division. Draper has kept a low profile with the media since the change. An Idaho farm boy, Draper graduated from the U.S. Military Academy and flew Huey H-1 and Black Hawk helicopters. Upon leading the Army, he joined Cessna Aircraft. He then had stints at Textron subsidiaries Bell and EZ Go before coming back to Wichita to rejoin Cessna in 2011, where he led its operations and supply chain. "I fell in love with this company," Draper said. Some of the employees hired last year replaced those who retired or left. But most of the hiring was to keep up with growth, Draper said. The company currently employs about 9,500 in Wichita. The Citation Longitude is "a little bit late" in getting to market, he noted. The aircraft received provisional certification in December and now the company is "wrestling with all the paperwork" and with some of the FAA's new design assurances processes that have been put in place on the aircraft, he said. The goal is to complete the work in the second quarter. In the meantime, about 200 engineers are working on the Sky Courier twin turboprop utility aircraft and the Denali, a single-engine turboprop. More engineers will move to the programs once Longitude deliveries begin. **Going forward, Textron will continue with product development, but it is going to be "a little more balanced"** as it invests in current products, with software updates and other enhancements, Draper said. Textron Aviation delivered 44 business jets during the first three months of 2019, up from 36 a year earlier, and 44 commercial turboprops, up from 29 last year.

▶ **ITALIAN AIRCRAFT MAKER TECNAM** reports taking orders for 51 aircraft during the recent Aero Friedrichshafen show in Germany; the company did not break down the orders by model. During the show the company showcased its line of certified CS23 FAR23 aircraft, including the twin-engine P2006T in the civilian and special mission versions; the P2010 single-engine, four-seat aircraft and the new P2002JF two-seat IFR aircraft. It also premiered the P2002JF, which features the new Garmin G500 Txi. During the show, a number of flight schools, including three launch customers — F-Air from the Czech Republic, Bartolini Air from Poland and EAS Barcelona Europe from Spain — selected the P2002JF MkII as trainers, Tecnam said. It also reported positive reaction to the newest version of the P92 Echo MkII, shown for the first time. **And airlines and operators showed interest in Tecnam's 11-seat P2012 Traveller, which was certified in December.** The Type Certificate was presented during the show to Tecnam CEO Paolo Pascale by European Aviation Safety Agency (EASA) representatives. Tecnam also announced that it will research a marketable solution for a parallel hybrid aircraft based on the Tecnam four-seat P2010. First flight tests are scheduled for 2021. "We are so delighted to feel that we are so much in line with our customers, anticipating their needs and fulfilling their taste, providing safe aircraft with pleasant flying qualities, affordable in the acquisition and operating costs and with a pure Italian style," Pascale said.

Jet-A and Avgas Per Gallon Fuel Prices
May 2019

Jet-A

Region	*High*	*Low*	*Average*
Eastern	$8.91	$4.60	$6.35
New England	$7.84	$3.90	$5.25
Great Lakes	$8.43	$3.46	$5.60
Central	$7.81	$3.37	$5.02
Southern	$8.38	$4.35	$6.10
Southwest	$6.94	$3.40	$5.35
NW Mountain	$7.96	$3.60	$5.41
Western Pacific	$8.52	$3.80	$6.13
Nationwide	**$8.10**	**$3.81**	**$5.65**

Avgas

Region	*High*	*Low*	*Average*
Eastern	$9.14	$5.15	$6.69
New England	$7.45	$4.96	$5.93
Great Lakes	$8.59	$4.59	$6.09
Central	$7.59	$4.51	$5.51
Southern	$8.50	$4.30	$6.34
Southwest	$7.19	$4.00	$5.67
NW Mountain	$8.46	$4.75	$5.84
Western Pacific	$8.52	$4.15	$6.47
Nationwide	**$8.18**	**$4.68**	**$6.07**

The tables above show results of a fuel price survey of U.S. fuel suppliers performed in May 2019. This survey was conducted by Aviation Research Group/U.S. and reflects prices reported from over 200 FBOs located within the 48 contiguous United States. Prices are full retail and include all taxes and fees.

For additional information, contact Aviation Research/U.S. Inc. at (513) 852-5110 or on the Internet at www.aviationresearch.com

INTELLIGENCE

Forbes: FSI and Garmin Among Best Employers

FlightSafety International and Garmin have been singled out by Forbes Media as among the best U.S. Employers.

FlightSafety was named one of the country's best midsize employers, the second consecutive year for such recognition. Meanwhile, Garmin was ranked No. 5 among America's Best Employers with more than 5,000 workers.

Forbes America's Best Employers are chosen based on an independent, anonymous survey of more than 50,000 employees. The survey evaluation identifies companies that employees like to work for and would recommend to others based on questions about work-related topics including working conditions, salary, potential for development and company image.

Airlines Collect $5 Billion in Baggage Fees

According to the American Association of Airport Executives, U.S. airlines collected nearly $5 billion in baggage fees in 2018 along with $2.7 billion in reservation change and cancellation fees, which works out to more than $20 million daily. The association noted that although airlines have increased their bag fees and collect record amounts from their customers, they continue to oppose adjusting the federal cap on local passenger facility charges (PFC), a user fee that must be justified locally, imposed locally and used locally on FAA-approved projects that enhance local airport facilities. The federal cap on the local PFCs has not been adjusted since 2000.

THE AUSTRALIAN GOVERNMENT has taken delivery of the first of three Falcon 7X trijets from Dassault Aviation. The Royal Australian Air Force (RAAF) will operate the aircraft for government VIP service. Delivery of the other two Falcon 7Xs is expected in the coming months. The defense department cites the 7X's 6,800 nm range and short landing distance as advantages; the Falcons will replace the smaller Bombardier Challenger 604. Australia is fitting the aircraft with seats for 14 passengers. There will be three crewmembers, including a cabin attendant. RAAF's 34 Squadron, the home of Australia's VIP aircraft, also has two Boeing 737 BBJs, but their future is unclear. An Airbus A330 MRTT tanker, also on order, will be delivered with a cabin for transporting ministers and large groups accompanying them. Northrop Grumman has maintained the Challenger 604s and will also maintain the Falcon 7Xs, the department said.

THE JAPANESE GOVERNMENT IS PROMOTING BUSINESS AVIATION access to the country's secondary airports, setting aside funds to help pay for new facilities. To that end, the transport ministry is seeking proposals from airport authorities for establishing the facilities, said Ryota Nagao, deputy director of the ministry's policy planning and research office. Separately, the ministry is working on accommodating an anticipated surge in demand for access by private aircraft during the summer Olympic Games, due to be held in Tokyo in July and August 2020. The push for improving access to secondary airports is part of a wider government effort at promoting tourism and business visits to Japan, noting the especially high value of anyone who arrives in a personal aircraft. International business jet arrivals in Japan have been growing strongly, anyway — at an annual average of 13.1% during the five years to 2018, according to the Japan Civil Aviation Bureau. Tokyo's two airports — Tokyo International at Haneda and Narita International — have maintained a steady 60-65% share. Apart from those two, only two other Japanese airports have dedicated facilities for such travelers: Chubu Centrair International and Kansai International. At all four, a public terminal has space for users of private aircraft. The ministry expects that special channels, not separate buildings, could also be set up in public terminals elsewhere; the fund is to pay for modifications. The airport authority at Chitose on the northern island of Hokkaido, a popular skiing destination, sees potential in setting up such facilities, said Kazuyuki Tamura, vice chairman of the Japan Business Aviation Association.

MARIA DELLA POSTA WAS TO ASSUME THE PRESIDENCY of Pratt & Whitney Canada, effective June 1. A veteran executive with the engine maker, she succeeds John Saabas, who is retiring. Della Posta will report to Pratt & Whitney President Bob Leduc. "Pratt & Whitney Canada has a leadership position in all of its markets, with a portfolio of more than 64,000 engines in service and 13,000 customers worldwide," said Leduc. "Maria has been instrumental in building Pratt & Whitney Canada's portfolio throughout her career. Maria brings extensive experience and a deep understanding of our customers and the markets in which we operate. As leader of Pratt & Whitney Canada's global business, I am confident that Maria will continue to drive sustainable growth and deliver exceptional customer service while maximizing operational performance worldwide. I wish to thank John for his outstanding contribution to Pratt & Whitney." Della Posta joined Pratt & Whitney in 1985, and progressed through roles of increasing leadership in supply chain, finance and customer service. She was named vice president, Customer Support in 2001; senior vice president, Sales and Marketing in 2010; and senior vice president, Pratt & Whitney Canada in 2012.

Textron Sells Eight Citation XLS+ Aircraft to China's CAAC

Textron Aviation and China's Civil Aviation Administration (CAAC) opened the Asian Business Aviation Association Conference (ABACE) and Exhibition in Shanghai in April with the sale of eight Cessna Citation XLS+ aircraft to the agency's flight inspection (CFIC)

unit by the Cessna-AVIC Aircraft (Zhuhai) Co. joint venture. The flight inspection unit operates a fleet of eight Cessna XLS and XLS+ twinjets. The latest deal will double its fleet to 16 aircraft. The new aircraft will be delivered through 2021. The CAAC is expanding the CFIC fleet to fulfill inspection and certification missions for the communication, navigation, radar and flight programs of newly built airports, as well as to perform regular flight inspection missions for airports already in operation.

400th Diamond Delivered

Diamond Aircraft recently delivered the 400th Diamond DA40NG built in Austria as it celebrated the 20th anniversary of the aircraft prototype's first flight. The DA40 was certified in 2000 and serial production started in Canada. In 2001, the DA40 TDI, powered by rail diesel technology, flew for the first time in Austria, with certification in 2002. In 2010, the company received certification of the DA40 NG with a 168-hp Austro Engine jet engine.

NOW STRUGGLING WITH challenges in its rail transportation business, Bombardier recently announced it plans to divest its aerostructures businesses in Belfast, Northern Ireland, and Morocco and form an integrated Bombardier Aviation unit with manufacturing operations in Canada, Mexico and the U.S. The new unit will combine Bombardier Business Aircraft with what remains of the company's Commercial Aircraft and Aerostructures & Engineering Services businesses after the divestitures, transfer of the C Series program to Airbus and sale of the Q Series regional turboprop program to Canada's Longview Aviation. Bombardier Aviation will produce Global, Challenger and Learjet business jets as well as the CRJ regional jet, although the Montreal manufacturer has previously said it is assessing options for its remaining commercial aircraft operation. **Bombardier is in the final stage of a five-year turnaround plan initiated by Bellemare when he took over as CEO in 2015. On completion in 2020, the company plans to focus on business aircraft and rail transportation. But the revised revenue guidance for 2019 revealed the rail unit is struggling to ramp up** production under several contracts for trains. The aerostructures business has been growing with the ramp up of production of the Global 7500 and the C Series, now the Airbus A220. The Belfast plant makes composite wings for the A220 as well as the tail and fuselage sections for the Global 7500. The Belfast plant also is producing a new engine nacelle for Airbus for the A320neo, and Bombardier has been expanding its Casablanca, Morocco, site to produce parts for the new nacelle. But the Canadian manufacturer in January also acquired the Global 7500 wing production plant in Red Oak, Texas, from supplier Triumph Group, in a move to protect its most important new aircraft program. The new Bombardier Aviation unit will focus its aerostructures business on Montreal, where it makes forward fuselages for its business jets and the A220, and on Texas and Queretaro, Mexico, where it makes composite structures. In addition to transferring control of the C Series partnership to Airbus and agreeing to sell the Dash 8/Q400 program to Longview, other pieces of Bombardier's turnaround plan include the sale of its Downsview, Toronto, facility where Global business jets and Q400s are assembled.

PILATUS AIRCRAFT REPORTED DELIVERING 128 aircraft in 2018, including 18 PC-24 jets as well as 80 PC-12 NGs, 27 PC-21s and three PC-6s. It reported **revenues for the year of 1.1 billion Swiss francs (approximately $1.08 billion US).** At the end of 2018 the Pilatus Group employed 2,283 people, with 93% of those working in Switzerland. At the headquarters in Stans work was underway on building a new structure assembly hall, which is to open soon. The new completion center at Pilatus Business Aircraft Ltd in Broomfield, Colorado, opened in the last fall. In Adelaide, preparatory work continued for the construction of a new, company-owned building for the subsidiary, Pilatus Australia Pty Ltd. Commenting on the results, Pilatus Chairman Oscar J. Schwenk remarked: "I am pleased to note that financial 2018 was a very successful year for us. A year in which a great deal of energy went into performing much detailed work. Work which will take us forward throughout the coming year, creating added benefit for our customers. The good financial results of the past year will also benefit our employees under our profit-sharing program. In addition to an extra month's salary, they have also been paid a bonus. Our next challenge is already in sight: the imminent re-opening of the PC-24 order book. This is the year in which the reputation of the PC-24 and all other related services will be established."


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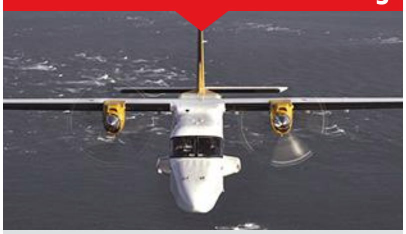
Garmins Gets STC for GFC 500 Autopilot

Garmin has received FAA Supplemental Type Certification for the GFC 500 autopilot in the Mooney M20 and 36/A36 Bonanza, the company said. The GFC 500 is designed for piston single-engine aircraft. The autopilot integrates with the G5 electronic flight instrument or a combination of the G5 and G5000 TXi flight display.

Japan's New Central Airservice Gets a Dornier 228 from Ruag



Ruag MRO International, based in Emmen, Switzerland, has delivered a new 19-passenger Dornier 228 to New Central Airservice in Japan. NCA accepted ownership of its fourth new Dornier 228 on March 29. It was then delivered to NCA and its partner, Sojitz Aerospace Corp. facilities in Ryugasaki, Japan, on April 27. NCA operates its Dornier 228 fleet in both passenger and cargo configurations. NCA maintains operations between the Japanese mainland the remote Izu Islands with the aircraft.

BUSINESS AVIATION CAN LOOK FORWARD to the easing of China's worst operational restriction next year, with the opening of a ground facility at the new airport at Beijing Daxing International Airport by state-owned Capital Jet. Capital Jet's FBO at Beijing's current airport, Capital International, handled 9,000 aircraft movements and more than 30,000 passengers in 2018, which, the company says, makes it the largest ground-support operation for business aviation in the country. But Capital International is the busiest airport and is operating beyond its designed capacity pending the opening of Daxing International. Runway slots and parking space are both in short supply. Capital Jet, also known as CJet, belongs to Capital Airport Holding Co., the state company that is the operator of both airports and also a major shareholder in them.Daxing International is due to open no later than Sept. 30. Capital Jet says it will start operations there sometime in 2020. The company will have an 86,000-sq.-ft. terminal with a expansive ramp devoted exclusively for business aviation use. That includes 85 parking stands, and able to accommodate narrow- and widebody jets. In addition, there will be five business aircraft hangars providing enough space to house 15 Gulfstream G650s.

THE ROLLS-ROYCE'S TAY 611-8 ENGINE, which entered service in 1987, recently achieved a significant milestone when the fleet reached 10-million flying hours in nearly five million flights. The engine powers a range of Gulfstream's large-cabin business aircraft, including the GIV, GIV-SP, G300 and G400, and has established a reputation for outstanding dependability, efficiency and low noise generation. The performance of the Tay 611-8 enabled the Gulfstream GIV to revolutionise the business aviation market with its high cruising speed and 4,300 nm range. These achievements have been perpetuated by its successor, the Tay 611-8C, powering the Gulfstream G350 and G450. There are over 1,700 Tay 611-8 and -8C engines in service today, with many of these supported by Rolls-Royce's CorporateCare. The background to the first Tay order contract is part of aviation history. In December 1982 the basic details – **engine price, quantity, payment terms – were written on a napkin in less than 10 minutes by Sir Ralph Robins, who at the time was the company's Managing Director, and Allen Paulson, Gulfstream's founder and then Chairman and CEO.** The deal was formally settled in March 1983.

CHINESE AIRFRAMER COMAC IS BUILDING an executive version of the ARJ21 regional jet which it plans to complete it next year and demonstrate it to prospective customers. The variant, called the Comac Business Jet (CBJ), features an additional fuel tank and Fokker Technologies has helped develop the aircraft's cabin. The model has long been part of Comac's planning. Over the past decade the state company has often showed models of the concept at air shows, but engineers could presumably make little progress with it before the ARJ21 entered airline service. That did not occur until June 2016, about 14 years after development was launched. Comac said it is marketing the CBJ internationally but mainly domestically. "Since 2018, Comac has communicated with a number of potential customers [about the] CBJ business jet, and conducted in-depth discussions on aircraft purchase, subsequent operation modes and support programs," the company said. With the additional tank and the light passenger load of a private aircraft, the CBJ has a range of 3,000 nm (5,500 km) and cruises at Mach 0.78.

CORPORATE ANGEL NETWORK

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ACJ319neo Sets Record

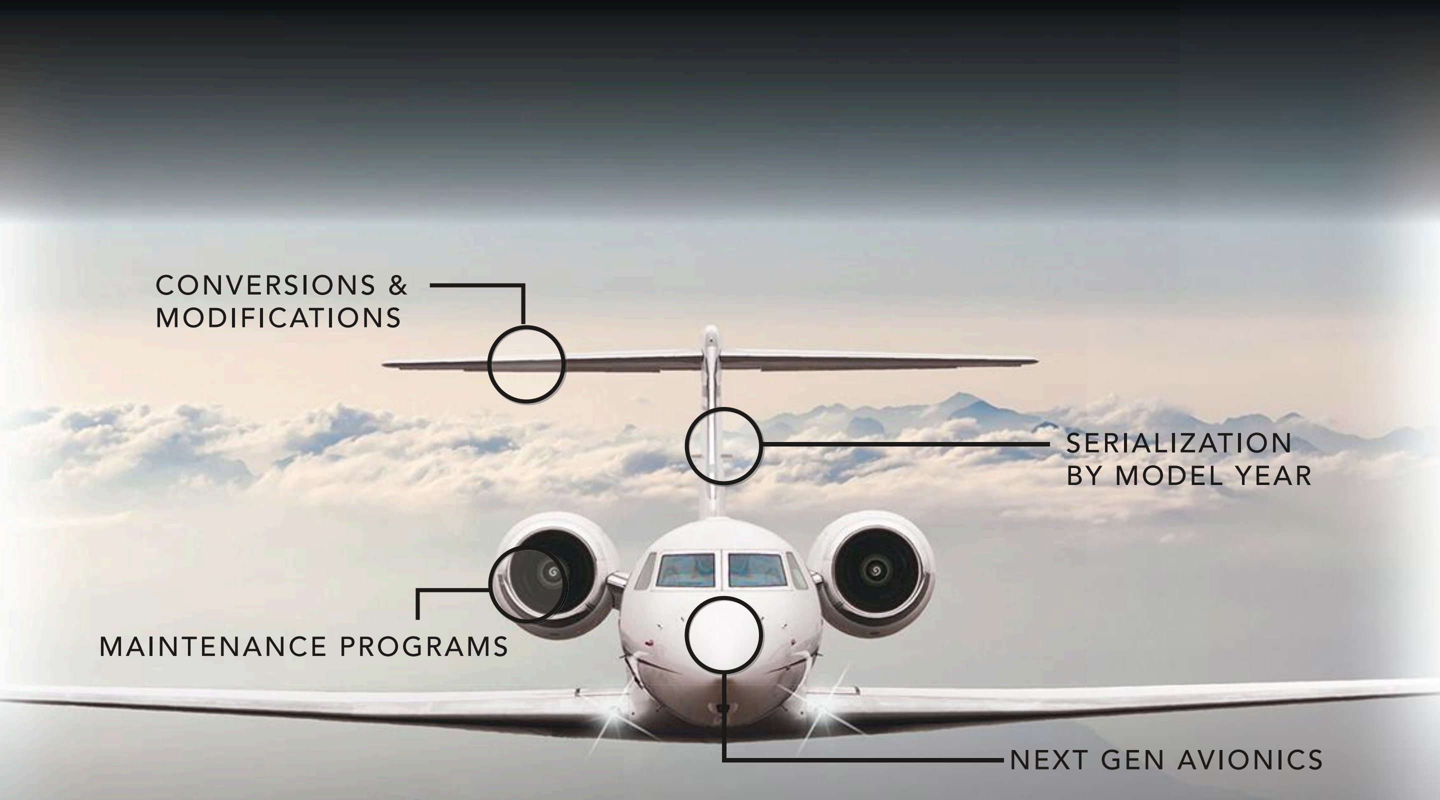
The first Airbus ACJ319neo business jet completed a 16 hr. 10 min. flight test flight Apr. 26, setting a record for the longest flight by an Airbus crew on the A320 airliner family of aircraft. The test aircraft flew from Toulouse, France, to northern Greenland and back in an endurance flight that included a simulated diversion under the 180-min. ETOPS rules, for extended range twin-engine operations. Airbus has orders and commitments for 14 A320neo family derived business jets.

Cirrus SF50 AOA Sensor Problems

In April, the FAA grounded the fleet of Cirrus Vision SF50 light jets because of issues with the aircraft's angle of attack (AOA) sensor. The FAA issued an Emergency AD on April 18. The action followed three incidents in which the aircraft's stall warning and protection system or electronic stability and protection system engaged even though there was sufficient airspeed and proper AOA for normal flight. Potential erroneous AOA indications may occur before, during and after unintended automatic control system engagement, the AD said. Before further flight, the aircraft's AOS sensor must be replaced with an improved AOA sensor.

NORWAY-BASED OSM AVIATION, a provider of air crew to the airline industry, has placed an order for **60 all-electric two-seat aircraft from Bye Aerospace** for use as trainers. Meanwhile, Bye has rebranded its family of electric aircraft, formerly known as the Sun Flyer, to the eFlyer. Initial design of the Sun Flyer included solar panels, but that feature was abandoned for pure battery power. Bye is developing the eFlyer 2 and the four-seat eFlyer 4. **To date, the company has received customer commitments for 294 aircraft.** Elfly AS, another Norwegian trainer, has added 10 new deposits for eFlyer aircraft, for a total of 18 deposits, Bye said. OSM Aviation will use the eFlyer 2 for training at OSM Aviation Academy flight training centers. Bye Aviation plans to begin initial customer deliveries of the $349,000 eFlyer2 in 2021, but declined to say when deliveries to OSM would begin. "We're proud to take the lead in the future of green aviation," said Espen Hoiby, OSM Aviation Group CEO. "It's important that the airline industry steps up to the challenge of developing more environment-friendly transport." The eFlyer 2 offers zero emissions and nearly silent flight. Last November, Bye Aerospace, based at the Centennial Airport south of Denver, received venture capital funding from Subaru-SBI Innovation Fund, advancing certification of the aircraft. In March, Bye announced it was expanding its engineering and operations departments to a larger hangar at the airport. The number of employees over the past 12 months has doubled. The aircraft flew for the first time Feb. 8, 2019 with a Siemens electric propulsion motor.

COLORADO-BASED START-UP XTI AIRCRAFT has completed the first series of test flights of a 65% scale proof-of-concept prototype of its TriFan 600 ducted-fan vertical takeoff and landing (VTOL) business aircraft at Placerville, California, last month. The flights, which were tethered because of FAA restrictions on flight testing at a public airport, were successful according to XTI CEO Robert LaBelle. "We did a lot of liftoffs to hover. The aircraft was very stable and there was no glitch with the electrics." XTI says over the space of a day-and-a-half the TriFan 600 prototype completed multiple takeoffs, hovers, and landings, which tested the aircraft's electrical propulsion system and flight controls. The aircraft is equipped with batteries that allow 15-20 min. hover time at high power. The battery system incorporates a portable rapid recharger. Further unrestricted flight testing is planned to begin this month at Deseret UAS test site in Utah, north of Salt Lake City. Testing will take place at the former Thiokol (now Northrop Grumman) Box Elder site which has a runway and where XTI has a hangar. Although XTI has announced early reservations for 77 aircraft from customers on six continents, representing $500 million of future revenue, the company is still looking for additional funding to sustain development. "It's not ideal, we don't have tens of millions of dollars, but it's not exactly hand to mouth," LaBelle says. "We hope the prototype will be a catalyst [for more funding]. We have investors waiting [for it to fly]." The company also continues to run crowdfunding initiatives. XTI is targeting certification and initial production starting around 2023. The battery-powered demonstrator will pave the way for a full-scale, six-seater version powered by a 1,000-shp turboshaft engine driving three generators. These will power dual 250-kW motors on each of two 6-ft.-dia. wing-mounted ducted, pivoting fans and a counter-rotating, 5-ft. diameter fan mounted in the aft fuselage.



CONVERSIONS &
MODIFICATIONS
SERIALIZATION
BY MODEL YEAR
MAINTENANCE PROGRAMS
NEXT GEN AVIONICS

AircraftBluebook

Five Learjet 75s Sold to Unnamed Customer

Bombardier announced that an unnamed customer had purchased five Learjet 75s in a transaction valued at approximately $69 million based on 2019 prices. The model, which entered service in 2013, was recently upgraded with a Garmin G5000 flight deck, a feature that will be offered as a retrofit package as well. The manufacturer noted that recurring major inspections of the aircraft's Honeywell TFE731-40BR turbofan engines have been extended from 3,000 to 3,500 hr. The company further notes that the Model 75 is the only business jet in its class to feature an eight-seat double-club configuration, a flat floor throughout the cabin and a pocket door for reduced noise levels. Earlier this year, the Learjet fleet, which began service in 1964, passed the 25 million flight-hour mark.

UAM Market to Grow Through 2030

The urban air mobility (UAM) market is forecast to expand at a compound annual growth rate of 11.33% through 2030, a report from Markets and Markets said, driven both by consumer demand for alternative transportation as well as advances in unmanned and other technologies. The UAM market was estimated to be $5.3 billion last year and is projected to reach $15.2 billion by 2030.

VISTA GLOBAL, OWNER OF CHARTER PROVIDERS VistaJet and XOJet, recently revealed plans to acquire troubled JetSmarter, an online jet sharing provider and digital technology developer. Terms of the deal and selling price, which was expected to close by the end of this May, were not disclosed. **The transaction with JetSmarter follows a spate of customer lawsuits and reports that the company agreed to settle a class action arbitration case.** JetSmarter was founded in 2012 in Ft. Lauderdale, Florida, by Sergey Petrossov. The acquisition allows Vista Global to integrate JetSmarter's digital booking app into its VistaJet, Vista Lease and XOJet brands, the company said, creating a "global on-demand digital marketplace. The acquisition "is an important milestone for Vista Global — accelerating and executing our vision of digitizing the entire private aviation offering," said Thomas Flohr, Vista Global founder and chairman. "Customers today want speed, reliability and value, which in today's world is only possible with technology." As part of the transaction, JetSmarter investors, including Clearlake Capital and Jefferies Financial Group, will become investors in Vista Global. JetSmarter had fought a class action suit and lawsuits alleging fraud, breach of contract and deceptive trade practices. **JetSmarter's per-seat charter sales model and offers of free seats attracted members, who lashed back after the company changed its policies and started charging them for flights.** The backlash drew negative publicity, including a critical CNBC investigative report. Through their initiation and annual fees, members received discounts and deals on empty legs from charter operators partnering with JetSmarter to provide the travel. The company had also offered free seats to members and perks such as free helicopter transfers to and from airports in some areas. But members complained after the company said it had changed its business practices, and they were charged significant additional fees.

BLACKHAWK MODIFICATIONS, A PROVIDER OF ENGINE UPGRADES for turboprops based in Waco, Texas, is doubling the size of its facilities and aligning several companies under one umbrella that will be branded as Blackhawk Aerospace. Blackhawk Aerospace will include Blackhawk Modifications, Blackhawk Aerospace Composites in Morgantown, Kentucky, Blackhawk Aircraft Sales in Waco, and Blackhawk Aerospace Solutions, formerly Vector-Hawk Aerospace, based in Huntsville, Alabama. The change allows for streamlined consistency among the companies with new logos, websites, graphics and marketing materials, the company says. In addition, Blackhawk has purchased an adjacent 10,000-sq.-ft. hangar and offices in Waco to meet growth in its sales and marketing teams, it said. The new facility doubles its presence on the Waco Regional Airport. It will also showcase aircraft for sale that have been refurbished by the company. **The changes come as Blackhawk Modifications celebrates its 20th year in business**. "Blackhawk Aerospace represents the culmination of each company's core competencies coming together to make a sum that is greater than the parts," Blackhawk president and CEO Jim Allmon said. "The physical expansion and brand unity is a milestone that successfully positions us for our next 20 years." Blackhawk moved its headquarters to the Waco airport in 2006. Six years later, it built a new east wing that doubled its office space.

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INTERVIEW BY **WILLIAM GARVEY**

Brad Hayden
Founder, President & CEO
Robotic Skies LLC
Albuquerque, New Mexico

The son of the owner of an avionics shop, where he worked before heading off to the University of Utah, Hayden began his career working in various high-tech and web outfits in San Francisco. However, he missed being a part of the aviation world and landed a marketing position with newly formed Aspen Avionics to help establish its brand recognition and product strategy. A private pilot, he also became interested in remote control aircraft, built his own multicopter and marveled at first-person-view drones in which the ground operator sees through the aircraft's camera lens. He left Aspen to found Robotic Skies and today also serves as a voting member of ASTM Committee F38 on Unmanned Aircraft Systems, the chair of the NBAA Unmanned Aircraft Systems Working Group, and secretary of the Helicopter Association International's UAS Committee.

TAP HERE in the digital edition of ***BCA*** to hear more from this Interview or go to **aviationweek.com/fastfive**

Questions for Brad Hayden

1 What service does your company provide?

Hayden: We broker maintenance services for unmanned aircraft systems, and we help operators and manufacturers develop their maintenance programs and then train our service center's technicians to maintain UASes. We focus on commercial UASes, which can range in value from $20,000 to several millions of dollars. And the service network we created now includes over 170 FAR Part 145 repair stations or their equivalent in 35 countries. So, we provide a global solution. We are the ones who interact with the service centers, freeing the operators and manufacturers from managing that.

2 Is the UAS fleet large enough to support such a network?

Hayden: Having experience in the high-tech world, I liken it to the early web. At the time, we had no idea what it might become and now it's part of all our daily lives. As of last year, the FAA reported 150,000 commercial drones were registered and by 2023 it's forecasting something like four million. And that's just in the U.S. This isn't evolutionary, it's more of a revolution. Currently, operators are using them in specialized applications — moving supplies from ship to shore, transferring medicines and blood, assessing crops, inspecting towers. But at some point, there's a use out there that hasn't yet been identified that will become the industry's killer app. And then the market will gain true momentum. And I'm not referring to the urban air mobility or eVTOL segment, but we see that as huge as well. The technologies are converging.

3 Last year you teamed with Boeing. What's the nature of that partnership?

Hayden: We see opportunity in supply chain management. It involves data integration, after-market infrastructure and a different mindset. Teaming with Boeing will allow both companies to elevate the commercial UAS customer experience and deliver operations solutions that would be difficult to achieve individually. It's a foundational step to meet today's requirements and help shape the future of unmanned flight. Many operators don't understand the importance of performance data for parts or their traceability. There are lots of manned aviation requirements that apply here and we intend to be that focal point.

4 Should helicopter operators worry or business flight departments be involved in UASes?

Hayden: Initially, helicopter operators saw UASes as a threat to their business and corporate flight departments saw them as a threat to their safety of flight. But that's changing. More and more commercial helicopter and Part 135 operators are realizing they need to add unmanned systems into their toolbox. And for some business flight departments, a UAS could be used to deliver value to the company and, if controlled or directed by the department, could help it transition from a cost center to participating in the front end of the business. I consider it a huge opportunity for a flight department.

5 So, how is it you chose to work in the back end of the segment?

Hayden: As a high-tech veteran, I recognized UASes as disruptive technology and I had to get involved. I wasn't sure in what capacity, but in researching, I realized many of those developing these aircraft had little or no aviation experience and had given no thought to maintenance. I grew up in the MRO environment and knew they'd need maintenance. Now we've put together a robust, global network to do just that. No one will ever build an unmanned air system we can't repair. BCA

Richard N. Aarons
Safety Editor
bcasafety@gmail.com

Tragically Mis-set Trim

Checklist adherence a **key to survival**

BY **RICHARD N. AARONS** bcasafety@gmail.com

Beechcraft King Air B200 VH-ZCR (ZCR) operated by Corporate & Leisure Aviation, was scheduled to take four charter passengers from Essendon Airport (YMEN), Victoria, Australia to King Island, Tasmania, on Feb. 21, 2017. The aircraft had been removed from a hangar and parked on the apron the previous afternoon in preparation for the flight.

The 67-year-old pilot arrived on the apron at about 0706. He walked around the aircraft and entered the cabin, apparently conducting a preflight inspection.

At about 0712, the pilot walked into ZCR's maintenance provider's hangar. He chatted with the staff for a couple minutes — all conversations unrelated to the flight.

The pilot returned to the aircraft a few minutes later and walked around it again. He climbed into the cabin, then exited and walked around the aircraft one more time before re-entering the cabin and closing the airstair door. At about 0729, he started the right engine and, shortly thereafter, the left.

At 0736, the pilot contacted air traffic control (ATC) and requested a clearance to reposition ZCR to the southern end of the passenger terminal. ATC provided the clearance and the pilot taxied to the terminal.

There the aircraft was refueled on the terminal ramp and the pilot was observed on closed-circuit television (CCTV) to walk around the aircraft, stopping at the left and right engines before entering the cabin. He then left the aircraft and entered the terminal. The passengers arrived at 0841 and were escorted by the pilot directly to the aircraft. At 0849, he started the engines.

The pilot requested taxi clearance at 0853 for an IFR flight to King Island with five persons onboard. ATC instructed him to taxi to holding point "TANGO" for Runway 17 and provided an airways clearance to King Island with a visual departure. The pilot read back the clearance.

A minute later, the pilot taxied directly to the holding point; however, the aircraft did not enter the designated engine run-up area positioned near the holding point.

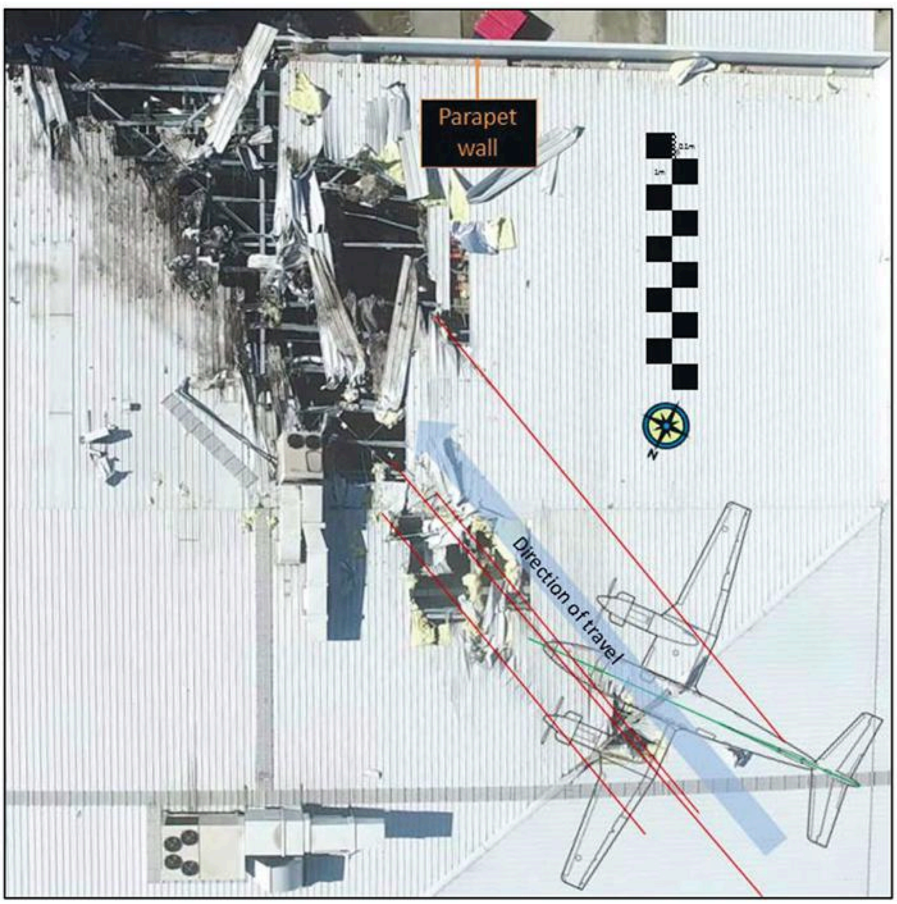
At 0855, while holding at TANGO, the pilot requested a transponder code and repeated the request 2 min. later stating that he was ready to go. The controller responded with the code and a clearance to line up on Runway 17.

At 0858, ATC cleared the B200 for takeoff on Runway 17 with departure instructions to turn right onto a heading of 200 deg. The pilot read back the instruction and commenced the takeoff roll.

Witnesses familiar with the B200 later said the takeoff roll along Runway 17 was longer than expected. They observed the aircraft yaw to the left after rotation. The aircraft entered a relatively shallow climb with the landing gear down. The sideslip seemed substantial. The roll attitude was relatively level — less than 10 deg. to the left.

ADS-B data indicated the aircraft reached a maximum height of approximately 160 ft. AGL while tracking in an arc to the left of the runway centerline. The aircraft's track began diverging to the left of the runway centerline before rotation and the divergence increased as the flight progressed.

The King Air began to descend as



Outlet center roof impact damage with scaled aircraft aligned with impact marks.

the sideslip increased, and at 0858:48, the pilot transmitted the word "MAYDAY" seven times in rapid succession. Approximately 10 sec. after the aircraft became airborne, and 2 sec. after the last "MAYDAY," the aircraft collided with the roof of a building in the Essendon Airport Bulla Road Precinct - Retail Outlet center, coming to rest in a loading area at the rear of the building.

First responders arrived on site within 2 min. The pilot and passengers were fatally injured and two people on the ground suffered minor injuries. The aircraft was destroyed; significant structural, fire and water damage were done to the building. A number of parked vehicles were damaged as well.

The Investigation

Australian Transport Safety Bureau (ATSB) investigators determined that impact marks from the landing gear and slash marks from the left propeller's blades on the building's roof showed:

▶ The aircraft had a heading of about 86 deg. (T).

▶ The ground track was about 114 deg. (T).

▶ The aircraft was at a sideslip angle of about 28 deg. left of track.

▶ The aircraft was slightly left-wing and nose-low with a shallow angle of descent at the initial roof impact.

▶ After the initial impact, the aircraft rotated left on its vertical axis until the fuselage was about parallel with the building's rear parapet wall.

The last 2 sec. of ADS-B data indicated ZCR's ground speed was about 108 kt. This information and measurement of the propeller slashes were consistent with the aircraft's nominal takeoff setting of 2,000 rpm.

Impact breakup and fire damage precluded a complete examination of many aircraft components and systems; however, all major parts of the aircraft were accounted for at the accident site. On-site examination identified no pre-impact faults.

The majority of the vertical stabilizer had been destroyed by fire. Some of the rudder surface was still attached to what remained of the vertical stabilizer. Investigators examined the rudder control cables, bell cranks and push-pull tubes from the cockpit through to the tail with no pre-impact faults identified. The rudder trim actuator screw jack was found extended 43 mm when measured from the actuator body to the center of the rod end, which equated to the rudder trim being in the full nose-left position at impact.

The rudder boost control system was destroyed by fire; however, sections of the rudder boost actuators were located within ZCR's empennage. No anomalies were identified in the remaining sections of the actuators.

Both the left and right elevator trim actuators were found in a position that equated to a full nose-up trim position. Witnesses, CCTV and ADS-B evidence either opposed or did not support ZCR having full nose-up trim at takeoff. Investigators said it is possible that the elevator trim was moved to this position by the pilot in an attempt to control the aircraft's flight path or that the trim may have moved as a result of impact forces. The ATSB determined that it was unlikely that the elevator trim was in the full nose-up position at takeoff.

Initially, the flaps seemed to have been extended approximately 10 deg. More detailed analysis of the left inboard and outboard actuators, however, found they were likely in the fully retracted, UP position when the aircraft collided with the building.

Remnants of the flight control locks, including the locking pin for the control column, some chain and the "remove before flight" warning sign, were located to the rear of the copilot seat in the cockpit. In addition, the area surrounding the rudder locking pin receptacle was searched and the pin was not located.

Due to significant fire damage, the cockpit switch positions, instrument settings and cockpit trim indicator positions could not be determined. The available cockpit instruments were inspected, and none retained any useful information. No pre-impact anomalies with the two Pratt & Whitney PT6A-42 engines or their propellers were found during examination and teardown.

Essendon Airport has two runways — 17/35 and 08/26. Runway 17/35 was 1,504 meters (4,934 ft.) in length, with a 0.9% slope down to the south.

An Airservices publication, En Route Supplement Australia (ERSA), indicated that a bird hazard existed at the airport. Pilots operating in the area at the time of the accident saw no bird activity near the B200's flight path.

The wind was reported as 340 deg. at 5 kt. — all tailwind on Runway 17. The conditions were CAVOK, and the temperature was 12C. Subsequent ATIS information issued after the accident indicated the airport was closed, due to the accident, and the wind was variable at 5 kt.

Two witnesses, both of whom were pilots familiar with the B200, watched ZCR's departure from their vantage points on the eastern side of Runway 17/35. They recalled the wind was "fairly calm" and there was no adverse weather present at the time. Images of the smoke plume and video footage of the windsock adjacent to the northern end of Runway 17/35 taken shortly after the accident also showed that the wind at ground level was negligible.

The ATSB said, "Overall, the wind conditions around the time of the accident were likely to have been calm. However, it could not be ruled out that the wind conditions ranged to a maximum of 5-kt. tailwind on Runway 17, which was within the aircraft's limitations."

The Pilot

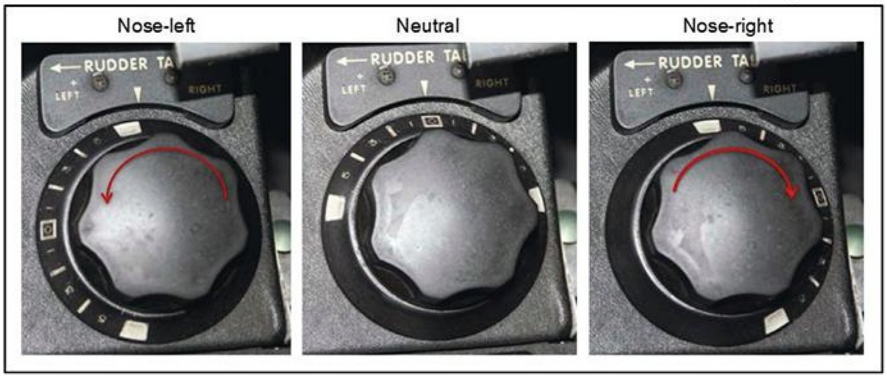
The pilot held a commercial license and was rated on the B200 aircraft. His flying experience totaled 7,681 hr., 2,400 of them in the B200. He had flown 66 hr. in the previous 90 days and 16 hr. in the previous 30 days. He had flown 73 hours in VH-ZCR (ZCR) and last flew the aircraft on Jan. 3, 2017.

The pilot had completed a multiengine flight review on Oct. 7, 2016, valid to Oct. 31, 2017 in ZCR. Records supplied by the operator also showed that the pilot had satisfactorily completed an emergency procedures proficiency check in March 2016, valid until March 2017.

The pilot's logbook showed that he had conducted a flight from King Island to Essendon on Feb. 18, 2017. He was then away from flying duties for two days. The pilot also was holder of an air operator's certificate (AOC) and, as such, was required to manage the business, including ensuring regulatory compliance. It is not known how much time he spent managing his aircraft charter operation during his two days away from flying duties.

The pilot normally went to bed between 2030 and 2100 or earlier if an early flight was scheduled for the next day. The pilot's National Aeronautical Information Processing System (NAIPS) user account was accessed at 2356 on Feb. 20, 2017, to obtain forecasts and NOTAMs for Essendon and King Island. The account was accessed again on the morning of the accident, between 0456 and 0458, to obtain aerodrome forecasts and NOTAMs for both

ATSB



Rudder trim indicator in the full nose-left, neutral and nose-right positions.

locations along with Launceston, and Devonport, Tasmania. The pilot reportedly woke around this time and had breakfast before leaving home for the 90-min. drive to Essendon Airport.

Investigators believe the pilot had a sleep window of approximately 8 hr. but had a period of wakefulness during the night when he checked NAIPS. "It is not known how long the period of wakefulness was," said the Safety Bureau, "and therefore not possible to assess the potential for it to have resulted in acute fatigue. Fatigue is a function of both sleep obtained and time awake, however, and the pilot had been awake for about 4 hr. at the time of the accident. That period of wakefulness is unlikely to have aggravated any feelings of fatigue associated with the previous night's rest period."

The pilot's post-mortem examination established that he succumbed to impact injuries. Toxicology tests revealed no substance that could have impaired his performance. "While post-mortem results for the passengers were not provided to the ATSB at the time of writing, given the injuries sustained by the pilot and the results of his post-mortem, the accident was not survivable."

Checklist Discipline

When discussing checklists during previous correspondence with the ATSB, the pilot stated that ". . . you don't get complacent as a pilot, but you get into a routine. The same as your pre-takeoff checks — you get a routine and you don't need to use a checklist because you are doing it every day, you are flying it every day . . . I take off with one stage of flap because it gets me off the ground quicker. And I never change my routine."

The ATSB collected information from numerous persons who flew with the pilot in order to establish his use of checklists. A summary of their comments follows:

▶ An engineer who flew with the accident pilot on a post-maintenance check flight reported that the pilot elected not to conduct the BEFORE TAKEOFF (RUNUP) checks as they had already

Accidents in Brief

Compiled by Jessica A. Salerno

Selected accidents and incidents in April 2019. The following NTSB information is preliminary.

▶ **April 23 — At an unknown time, a** Bellanca 17-30A (N9693E) was heavily damaged after crashing at the Henderson City-County airport (EHR) Henderson, Kentucky. The student pilot and passenger were killed. It was VFR, and no flight plan was filed for the Part 91 personal flight. The flight departed from Mid Carolina Regional airport (RUQ), Salisbury, North Carolina.

According to the airplane owner, the airplane was for sale and the student pilot was interested in purchasing it. The student pilot had flown the airplane earlier in the day with a flight instructor. According to the student pilot's logbook, he and the instructor flew a cross-country flight from RUQ, to Spartanburg Memorial airport (SPA), Spartanburg, South Carolina, and back to RUQ. The flight time was logged as 1.4 hr. Airport personnel at HER discovered the airplane shortly before 0700 CDT on April 24 as they prepared to open the airport. The airplane was in a grass area about midfield, 200-ft. left of the Runway 27 centerline. The airport had closed the previous evening at 1930. When closed, the pilot controllable runway lighting remains activated on its "low" setting, and the airport rotating beacon remains on from sunset to sunrise.

No eyewitnesses were identified; however, the state police received several calls the following day from witnesses who reported hearing either a low flying airplane or a "boom" sound at times between 2000 and 2230 on April 23, 2019.

▶ **April 22 — At 0851 CDT, a Beech 58** (N501CE) crashed during approach to Kerrville Municipal Airport (ERV), Kerrville, Texas. The pilot and five passengers were killed, and the airplane was substantially damaged. The airplane was registered to and operated by the pilot under Part 91 as a business flight. It was VFR for the flight that departed on an IFR flight plan from West Houston Airport (IWS), West Houston, Texas, at 0730.

According to preliminary ATC information, the airplane approached ERV and was cleared to fly the RNAV (GPS) Approach Runway 12. The controller advised the pilot that the cloud bases were reported at 2,400 ft. MSL and subsequently directed him to switch to the common traffic advisory frequency at ERV. While on final approach, the airplane descended and the last location recorded by ATC was about 6 mi. prior to Runway 12, about 2,050 ft. MSL and about 65 kt. groundspeed.

Three witnesses noticed the airplane flying at a low altitude and a spiral descent. The airplane crashed into a rocky ravine with a low forward groundspeed and came to rest upright. The wreckage was contained within the footprint of the airplane and there was no post-impact fire. The airplane was retained for further examination at the recovery location.

▶ **April 22 — About 1210DT, a** Northrop N9M airplane (N9MB) was been done earlier in the day. The engineer also commented that they took off with the pressurization system incorrectly set, and during the flight he noticed that the right-wing locker was open. Reportedly, the pilot did not refer to a checklist throughout the flight.

▶ A previous passenger reported that the pilot did not close the main cabin door until he was prompted by that passenger just prior to takeoff. The cabin door is required to be checked in the BEFORE ENGINE STARTING checklist. Further, when the door is open, a red DOOR UNLOCKED warning light will illuminate on the annunciator panel in the cockpit to alert the pilot.

▶ Another pilot reported having a conversation with the accident pilot about the use of checklists when he was leasing another B200 aircraft. When confirming if there was a checklist in the aircraft, the accident pilot indicated that he did not believe in checklists. He further commented that he felt comfortable with flying the aircraft and did not believe the checklist was necessary. However, the ATSB was unable to establish if the accident pilot was indicating that he would use his own checklist or would rely on memory to perform the checklist items.

▶ The accident pilot's government-approved testing officer advised that the pilot would use a checklist the majority of the time, though he could not recall if the pilot used the aircraft's checklist or his own.

▶ Another pilot who flew with the accident pilot on occasion indicated that he had observed the pilot using the checklist that was approved in his operations manual at that time.

▶ A copilot who flew with the accident pilot on the last flight recorded on ZCR's cockpit voice recorder (CVR) also stated that they had used a checklist. A review of that recording showed the captain and copilot appeared to be using the challenge and response checklist methodology. The copilot read the item to be checked and the captain confirmed the status of the item.

▶ During the conduct of the pilot's instrument proficiency checks in October and November 2015, the flight operations inspector noted that the pilot was using a laminated checklist with what appeared to contain the abbreviated normal procedures.

"While there was variable evidence showing the pilot's checklist discipline, the ATSB was unable to establish if he was using a checklist on the accident flight or if he relied on memory to action checklist items," said the Safety Bureau's report.

Safety Analysis

The ATSB established that the pilot was appropriately qualified, and that the airplane was appropriately maintained. The Safety Bureau found no evidence of pilot incapacitation, nor did it find a mechanical fault with the aircraft. Weather conditions did not influence the development of the accident.

The Safety Bureau was unable to establish if the pilot had verified the aircraft's weight and balance prior to departing — ZCR's maximum takeoff weight (MTOW) was exceeded by 240 kg (529 lb.). The corresponding ground roll distance for this weight was only 5% more than that calculated for the MTOW. Similarly, ZCR's climb performance would have reduced only slightly with the additional weight.

ZCR's actual takeoff roll was

destroyed when it crashed near Norco, California. The airline transport pilot was killed. The airplane was registered to and operated by the Planes of Fame Air Museum under Part 91. Visual meteorological conditions prevailed, and no flight plan was filed for the personal flight. The local flight originated from the Chino Airport, Chino, California, about 1202.

Multiple witnesses located near the accident site reported seeing the airplane flying on a north eastern heading at a low altitude when it performed a "barrel roll." Several witnesses reported that after the maneuver, the airplane "wobbled [from] side to side" before the airplane's canopy separated. Shortly after, the airplane entered a steep right turn, and descended into the ground in a nose low attitude.

Examination of the accident site revealed that the airplane impacted the outpatient housing yard of the California Rehabilitation Center. The debris path was about 474 ft. in long, 200 ft. wide, and oriented on a magnetic heading of about 124 deg. All major structural components of the airplane were observed within the wreckage debris path.

▶ **April 15 — At 0351 EDT, a Bell** 206-L1+ (N395AE) sustained substantial damage when it made a hard landing after a total loss of engine power on takeoff from the Fairview Park Hospital Heliport (48GA), Dublin, Georgia. The airline transport rated pilot, flight nurse, and paramedic were not injured. The helicopter was registered to and operated by Air Evac EMS, Inc., Part 135 emergency medical services flight. Visual nighttime meteorological conditions prevailed, and no flight plan was filed for the flight destined for Macon, Georgia.

The pilot stated that the purpose of the flight was to pick-up a patient in Macon, Georgia, and transfer them to a hospital in Augusta, Georgia. He said he completed a preflight inspection and the engine start was normal. Once the preflight checklists were completed, the pilot applied power, and pulled the helicopter into a hover. He then turned the helicopter into the wind and prepared to make an "altitude or airspeed" takeoff. The pilot said, "I completed a power check with the torque reading of 74.8%. I then used about 86% torque to accomplish the altitude over airspeed takeoff to clear obstacles. As I started to accelerate forward and gain climb-out airspeed, a loud report was heard from the engine deck area followed by an announcement/question from the flight nurse, 'What was that bang?'" The engine then made a "clicking" noise that sounded like paper on fan blades. The pilot said the helicopter immediately began to descend and hit the ground and bounced. It translated to the right (direction of travel), before it came to rest upright. The pilot rolled the throttle to idle and shutdown the engine.

▶ **April 21 — At 1443 CDT, a Rans** S-7S airplane (N25TX) impacted the ground after takeoff from Shirley Williams Airport (44TE), Kingsland, Texas. The pilot and pilot-rated-passenger were fatally injured and the airplane was destroyed by a post-impact fire. The airplane was registered to and operated by the pilot under Part 91 as a personal flight. It was VFR and no flight plan was filed. The local flight was departing at the time of the accident.

A witness reported that the pilot had just completed a few touch-and-go landings at 44TE before he landed and the significantly more, and its climb performance was significantly less, than could be attributed to the extra weight.

The aircraft reached the required rotation speed of 94 kt. when about 730 meters (2,395 ft.) from the threshold of Runway 17. It then remained on the ground for an additional 285 meters (935 ft.) and rotated at 111 kt. At some point between 470 meters (1,542 ft.) and 920 meters (3,018 ft.) from the threshold, ZCR's ground track began to veer left from the runway centerline.

A witness familiar with the aircraft type observed a yaw to the left at rotation followed by a relatively shallow climb. The ATSB's analysis of ZCR's flight path profile and the impact sequence found that the aircraft had minimal sideslip for the initial climb, followed by substantial sideslip for the later part of the flight and at impact. Left roll did not exceed 10 deg. throughout the flight.

ZCR's takeoff roll, to the required rotation speed of 94 kt., was about 136 meters (446 ft.) longer than the Airplane Flight Manual-estimated distance of 594 meters (1,949 ft.). "However, the estimated distance did not account for the rolling takeoff conducted by the pilot or possible drag penalties resulting from the misset rudder trim. Considering these factors, it was likely that ZCR accelerated as expected, with both engines producing takeoff power, to 94 kt.," said the Bureau.

ADS-B data showed the King Air reached a maximum height of no more than 160 ft. ADS-B barometric altitude data became unreliable following the onset of the sideslip at 125 ft., but CCTV footage and GPS rate data indicated ZCR maintained a brief and shallow climb after this point. The initial climb rate was broadly consistent with the expected performance of the aircraft with the landing gear down, allowing for a minor out of balance condition, not maintaining the best rate of climb airspeed and tolerances in the data.

Following the onset of the sideslip, ZCR began a descent followed by the collision with the outlet center building. The data also showed an increased divergence from the runway centerline when airborne and a reduction in aircraft acceleration, rate of climb and airspeed following the commencement of the sideslip. This was consistent with the theoretical effects of a substantial left sideslip on ZCR's performance.

The ATSB pointed out that asymmetric engine power can result in a yawing moment in a twin-engine aircraft, so investigators considered the possibility of a left-engine power reduction. Such a power reduction would have exacerbated the left yaw; however, this was discounted because key witnesses reported that the engines sounded normal and the ATSB's audio frequency analysis detected no change in engine sound. In addition, engine and propeller impact evidence support the left engine producing takeoff power at impact.

So, the problem had to have been with the rudder. The ATSB considered various inputs to the rudder system that could induce the sideslip. These included:

- The yaw damper system.
- The rudder boost system.
- Manipulation of the rudder pedals by the pilot.
- Rudder trim position.

Wreckage examination produced no evidence to support a yaw damper or rudder boost malfunction. Additionally, the aircraft manufacturer told the ATSB that these systems could be physically overpowered by the pilot or

Accidents in Brief

passenger boarded the airplane. He saw the airplane taxi back to the runway then shortly after heard it impact the ground.

April 18 — At 1953 PDT a Beech B60 (N65MY) collided with the ground after takeoff from Fullerton Municipal Airport (FUL), Fullerton, California. The private pilot sustained fatal injuries and the airplane was destroyed. The airplane was registered to KMA Technology Solutions LLC., and operated as a personal flight by the pilot Part 91. The flight had a planned destination of Heber City Municipal Airport-Russ McDonald Field (HCR), Heber, Utah. It was VFR and an instrument flight plan had been filed.

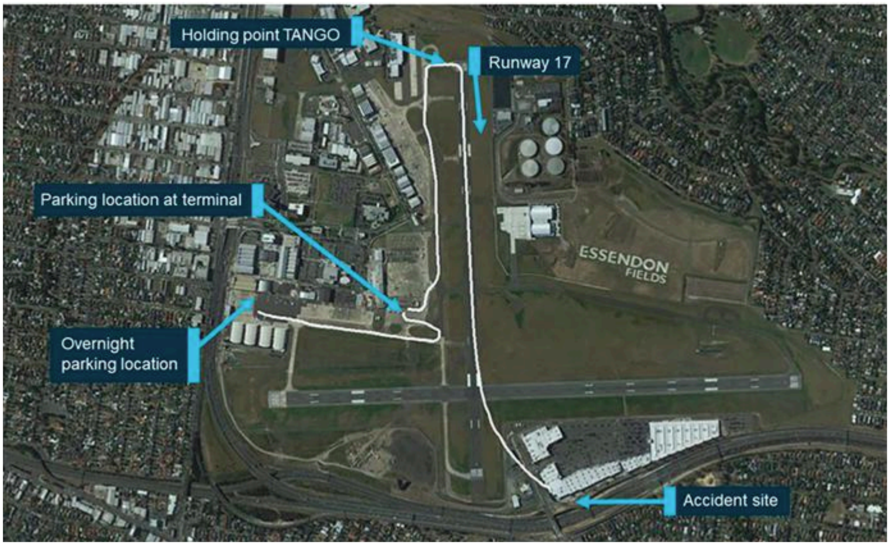
According to relatives of the pilot, he had moved with his family from Southern California to Utah at the end of 2018. He continued to maintain a business in California, and would work there during the week, and return to Utah at the weekends. His typical routine would be to depart Heber City for Fullerton on Monday morning and then return Thursday night. He would use the accident airplane to make the trip, unless weather was bad, in which case he would fly via commercial airline.

The accident sequence was captured by a series of surveillance video cameras located at multiple vantage points within the airport. Preliminary review of the video data revealed that the pilot boarded the airplane at his hangar at 1930. He started the engines, and taxied to the Runway 24 runup were the airplane remained for the next 11 1/2 min. During that time, he was provided his IFR clearance by the tower controller. The airplane then taxied to the hold short line on taxiway A at the approach end of Runway 24, and after the pilot was given the takeoff clearance, the airplane began the takeoff roll. The airplane was airborne after traveling about 1,300 ft.down the runway, and about 2 sec. after rotation it began to roll to the left. Three seconds later, the airplane had reached an altitude of about 80 ft. AGL, and was in a 90-deg. left bank. The nose then dropped as the airplane rolled inverted, and struck taxiway E in a right-wing-low, nose down attitude.

The first identified point of impact was located on the centerline of taxiway E, about 100 ft. south of the runway centerline. The impact was composed of a set of four gouges, oriented diagonally across the centerline, and spaced about 8 inches apart. The gouges matched the approximate dimension of the right propeller blades, and a similar set of gouges were present on the tarmac, about 18 ft. to the southwest. Fragmented sections of the outboard right wing were distributed around the impact point and on the adjacent runway surface.

The main wreckage came to rest on taxiway A, about 100 ft. beyond the second set of gouges. The main wreckage was composed of the pressurized section of the cabin, both engines, the left wing and tail section, all of which sustained extensive thermal damage. Examination of video footage indicated that the landing gear was in the extended position at the time of impact, and the flaps appeared to be partially extended as the airplane taxied onto the runway. **BCA**

Aircraft taxi and flight track from Airservices Australia ADS-B data.



GOOGLE EARTH/ATSB

the respective systems could be turned off. Investigators considered application of left rudder by the pilot unlikely as there was no evidence to support, or plausible reason identified to account for, the pilot applying left rudder and maintaining this input until impact.

The on-site and post on-site examinations of the aircraft found that the rudder trim was in the full nose-left position at the time of impact. This was consistent with the substantial sideslip at impact, derived from the roof collision marks. The Safety Bureau established that ZCR's engines were capable of normal operation and were operating at similar settings, thus there was no apparent reason identified, such as an asymmetric power condition, that would have required the use of full rudder trim by the pilot.

A malfunction of the rudder trim system resulting in a full nose-left setting was also considered unlikely, because the rudder trim control system is manually operated by the pilot. The system has no connection to the autopilot/yaw damper or electric trim systems.

In the end, investigators decided that the rudder trim was probably mis-set in the full nose-left position prior to takeoff.

Mis-set Rudder Trim

The ATSB found in its files previous incidents in which a mis-set trim situation occurred as a result of maintenance performed on an aircraft immediately prior to the flight. It was considered unlikely in this occurrence, however, because maintenance had not been performed on ZCR since Feb. 5, 2017, and the aircraft had flown without incident in the intervening time.

"While the ATSB could not exclude the possibility that the rudder trim had been manipulated by unknown persons prior to the accident flight," said the Bureau's report, "the aircraft had been stored in a secure hangar until the previous afternoon. After this, ZCR was parked outside the hangar within the confines of the airport. Consequently, the ATSB considered actions performed by the pilot prior to takeoff."

The pilot had several opportunities in the preflight inspection and BEFORE TAKEOFF checklists to set and confirm the position of the rudder trim. A review of the CCTV footage showed the pilot moving in and around ZCR when parked outside the hangar, consistent with performing a preflight inspection. The preflight inspection required the rudder trim to be set in the cockpit and the external trim tab to be visually inspected. The ATSB was unable to determine if the rudder trim was in full nose-left prior to the pilot's arrival at the aircraft or if the pilot inadvertently left the trim in that position. In any case, the visual inspection of the rudder trim tab was an opportunity to identify the mis-set trim. From the footage, it could not be established if the PREFLIGHT INSPECTION checklist was followed completely.

The Safety Bureau found no evidence on CCTV or in witness statements that the pilot completed BEFORE TAKEOFF (runup) checks but admits they could have been done while the aircraft was parked at the terminal or during taxi. The pilot's practices with regard to setting and confirming the position of the rudder trim, such as performing a function check, could not be established. Further, while there was some evidence to indicate that the pilot may have relied on memory to perform checks rather than reference to physical checklists or that he did not always complete checklists, it was unknown if this practice was applied on the accident flight.

"As research has shown, a diverse range of factors can lead to checklist deviations, such as distractions, interruptions, time pressures, expectations and relying on memory," said the ATSB. "While the ATSB was unable to establish why the rudder trim on ZCR was in the full nose-left position, a distraction or interruption may have influenced the pilot's check actions. Despite this, however, there were several opportunities in the preflight and before-takeoff checklists to check and correct the trim position.

"Of note, the on-site examination of ZCR also found the flaps in the UP position, though it was the pilot's normal practice to use APPROACH flaps for takeoff. It could not be discounted that the pilot retracted the flaps after takeoff, but that seems unlikely given the short time frame from takeoff to the accident, and the pilot's likely focus of attention on attempting to control the aircraft with the mis-set trim condition. However, the ATSB was unable to establish if the pilot had purposely elected not to use flaps for takeoff in this case or if this item was possibly missed or forgotten when performing his checks."

Loss of Control

ATSB performance engineers studied the control issues. What follows is from their analysis:

As the aircraft's airspeed increased during the takeoff roll, and airflow over the control surfaces increased, the rudder trim would have become more effective. It is likely this would have resulted in an increasing tendency for the aircraft to veer or yaw to the left. This would have required the pilot to apply right rudder pedal input to maintain the runway centerline using the nosewheel steering. The divergence left of centerline observed on the ADS-B data could support the rudder trim having an influence on ZCR's heading during the takeoff roll.

FLIGHTAWARE.COM

Beechcraft B200 King Air, VH-ZCR

ZCR accelerated as expected to the rotation speed of 94 kt. The aircraft was not rotated at this point, however, but rather at 111 kt. and 1,015 meters (3,330 ft.) along the runway. For the B200 aircraft, the rotation speed is also the takeoff decision speed, by which time any decision to reject a takeoff must be made.

It was possible that the pilot expected, either through training or previous experience, that the most likely reason for a yaw on the takeoff roll was due to asymmetric engine power rather than a mis-set trim. This would not have been reflected on the cockpit instruments, however, as the engines were likely to have been operating normally.

This conflicting information could have confused or distracted the pilot, resulting in a delay in rotating while troubleshooting. Diagnosing an unknown issue during a critical phase of flight would have been challenging. As the aircraft approached 111 kt., the pilot may have considered that there was insufficient runway remaining to safely reject the takeoff without the risk of a runway overrun. There was insufficient evidence to determine why the pilot delayed rotation from 94 kt. to 111 kt. or why the takeoff was not rejected. "This accident highlights the decision-making challenges during critical stages of flight, especially when faced with a novel or unusual problem."

After takeoff, it was likely that the pilot was applying right rudder pedal in an attempt to compensate for the yaw induced by the mis-set rudder trim. The mis-set trim would have had a stronger influence on the aircraft's heading once airborne due to the loss of directional control provided by ZCR's nosewheel steering. While the ATSB was unable to quantify the rudder pedal forces required to overcome the mis-set rudder trim, when tested in a B250 class-D simulator, the forces could only be countered by the pilot for a short period of time. The pilot who flew the simulator commented that he was able to offset the rudder force "until his leg gave out." This happened on three consecutive attempts.

Given the simulator results, once the pilot of ZCR was no longer able to counteract the rudder forces, the yaw resulting from the mis-set trim likely had a significant effect on the aircraft's climb performance and controllability. The ATSB's analysis of the ADS-B data and CCTV footage found a clear correlation between ZCR yawing and a reduction in performance. The performance degraded to the point at which

Why Checklists Are Not Completed

The Australian Transportation Safety Bureau (ATSB) looked into studies of checklist use during its investigation of a Beechcraft King Air B200 that crashed during an attempted takeoff with full-left rudder trim. The pilot and his passengers were killed (See main story.) Here's what the ATSB found in its checklist review:

Checklists are an essential defense against pilot errors. However, this can sometimes fail. Various research studies have provided insights as to why checklist procedures may not always be completed, including:

▶ **Attitude:** Hawkins (1993) highlighted that, "probably the greatest enemy of error-free, disciplined checklist use is attitude — a lack of motivation . . to use the checklist in the way it should be used."

▶ **Distractions and interruptions:** Distractions and interruptions can result in a disruption to the sequential flow of the checklist. This not only means that the pilot will have to memorize the location of that disruption, but it may also lead to a checklist error or omission (Degani & Wiener, 1990).

▶ **Expectation and perception:** Degani & Wiener (1990) found that, when the same task is performed repetitively, such as a checklist, the process becomes automatic. The user will create a mental model of that task, and with experience, this model will become more rigid, leading to faster information processing and the ability to divide one's attention. While this will ultimately reduce the user's workload, this model may adjust or even override "seeing what one is used to seeing." In the study conducted by Degani & Wiener (1990), many of the pilots interviewed commented that they had seen a checklist item in the improper status but perceived it to be in the correct status. For example, the flaps were set at zero, but the pilot perceived them to be at the 5-deg. position as this was what they were expecting to see.

▶ **Time pressures:** The speed of performing the checklist may affect the accuracy of the check. For example, if a pilot scans the item to be checked quickly due to time pressures, the accuracy of the pilot's perception will degrade and the possibility of error will increase (Degani & Wiener, 1990).

A study was conducted by Dismukes & Berman (2010) to explore why checklists (and monitoring) sometimes fail to catch errors and equipment malfunctions. One of the study's authors conducted 60 observation flights from the cockpit jump seat of three airlines. These observations identified 899 deviations, of which 22% were related to checklist use. Checklist deviations were mainly associated with the pre-taxi, taxi-out, descent and approach phases control could not be maintained and the aircraft subsequently collided with the outlet center.

The adverse effect on performance and control of a mis-set rudder trim during takeoff has also been shown in previous similar occurrences. While these occurrences varied, they all resulted in significant control difficulties and a loss of performance. This was consistent with the results of the B250 simulator flights, where each flight resulted in a loss of control.

No CVR data was available to investigators. While ZCR was equipped with a CVR, its impact switch had tripped before the accident flight and had not been reset. The ATSB could not determine why the impact switch had not been reset. However, it was likely that the checklist being used in ZCR did not alert the pilot to the requirement to check the CVR.

B200 checklists reviewed by the ASTB all included identical checks for setting and confirming trim positions. While the ATSB was unable to establish what checklist was being used by the pilot, an appropriate flight check system was unlikely to have varied the checks related to ZCR's rudder trim. Therefore, it is unlikely that the inappropriate flight check system influenced the accident. It may, however, have been a missed opportunity to ensure the CVR was operational and would have ensured any other checks required as a result of any modifications to ZCR were included in the checklists used by the pilot.

Operating speeds for the B200 are as follows: takeoff (flaps UP) rotation speed (VR), 94 kt.; 50-ft. speed, 103 kt.; takeoff (flaps APPROACH), 96 kt.; 50-ft. speed, 105 kt.; two-engine best-rate-of-climb speed, 121 kt. The B200 POH does not stipulate a maximum tailwind component. However, the maximum allowable tailwind component on the applicable performance charts is 10 kt.

Findings

Ultimately, the ATSB made findings of these contributing factors:

▶ The aircraft's rudder trim was likely in the full nose-left position at the commencement of the takeoff.

▶ The aircraft's full nose-left rudder trim setting was not detected by the pilot prior to takeoff.

▶ Following a longer than expected ground roll, the pilot took off with full left rudder trim selected. This configuration adversely affected the aircraft's climb performance and controllability, resulting in a collision with terrain.

Other risk factors included:

▶ The flight-check system approval process did not identify that the incorrect checklist was nominated in the operator's procedures manual and it did not ensure the required checks, related to the use of the CVR, were incorporated.

▶ The aircraft's CVR did not record the accident flight, resulting in a valuable source of safety-related information not being available.

▶ The aircraft's maximum takeoff weight was likely exceeded by about 240 kg (529 lb.).

In the end, it seems that the use of a checklist — any checklist that touches the basics — could have prevented the accident. Checklists work. We all get tired and forgetful at times. Checklists are lifesavers. The lesson here is simple: Use checklists. **BCA**

of flight. The identified deviations were categorized into six types and the results are presented here:

▶ **Flow-check performed as read-do:** Normal checklist procedures generally require pilots to check and/or set the items in a sequence or flow. After completing this flow, the checklist is performed to confirm that the critical items have been correctly actioned. However, if the flow is not performed and only the checklist is completed, items not on the checklist will be omitted.

▶ **Responding without looking:** The authors described two situations when this may occur. The first is when a pilot responds from memory of having recently set or checked that item as part of the flow. Basically, the current situation may be confused with the previous situation. Secondly, a pilot may look directly at the item to be checked but perceive it to be in the correct position when it is not. A pilot may respond without looking due to habit or when under time pressures.

▶ **Checklist item omitted, performed incorrectly or performed incompletely:** The pilot's response is incorrectly worded, one or more elements of a multi-item response are omitted or combined into a single response, or the checklist is not verbalized completely. The research found that, while in some cases the checklist item was deferred and later forgotten, in other instances the checklist was interrupted by external influences and an item was disregarded. In contrast, on many occasions an item was omitted when no external disruption occurred.

▶ **Poor timing of checklist:** The checklist is conducted at the wrong time or at a time that interfered with higher priority tasks, or it was self-initiated at the incorrect time.

▶ **Checklist performed from memory:** Similar to that identified by Degani & Wiener (1990), when a pilot has completed a checklist many times, performance becomes mainly automatic, fast and fluid, and requires minimal cognitive effort. Forcing oneself to read each checklist item may be awkward, effortful and time-consuming. Therefore, pilots may be inclined to perform the checklist from memory rather than from the physical checklist.

▶ **Failure to initiate checklists:** Failing to initiate a checklist may be the result of distractions, other competing demands on the pilot's attention, or due to circumstances forcing procedures to be performed out of sequence.

The lessons here are obvious. Use checklists and pay attention when you are using them. Taking a few minutes to complete checklists can save lives and hardware. **BCA**

Rejected Takeoff Authority

Is dividing the captain's command **ever a good idea?**

BY **JAMES ALBRIGHT** james@code7700.com

GREG BONGIORNO

A view from the power levers.

If you are the pilot in command (PIC) and the pilot flying (PF) in the left seat, can the second in command (SIC)/pilot monitoring (PM) call for a takeoff abort? If he or she does that, will you abort? Even more interesting (and controversial) is the opposite scenario. If you are the PIC/PM in either seat, can the SIC/PF initiate a rejected takeoff (RTO) without your consent? You probably think both answers are obvious. You may be surprised that not everyone agrees.

The answers depend more on who you are flying for than what you are flying. At one extreme, the captain has total and absolute abort authority and the first officer (F/O) can do nothing more than offer an opinion. On the other extreme, both pilots can call for the abort and the other pilot must comply. Which way is right? It depends.

A Matter of Philosophy

Most experienced captains don't think there is any debate here at all, even if our view is diametrically opposed to the captain in the very next airplane. But consider that there are pros and cons to each philosophy, that each carries with it a risk during high-speed aborts you may not know about, and many high-speed aborts are a result of decision-making delays that could happen to you.

The core of your abort authority philosophy is how much faith you are willing to place in your first officer versus how sure you are that the captain can make a timely decision in either the PF or PM role. If you are in a situation where the captain has lots of experience and the first officer has only a little, then your choice may be cut and dried. But even in this "ideal" situation, there are costs measured in seconds. And those seconds can be crucial.

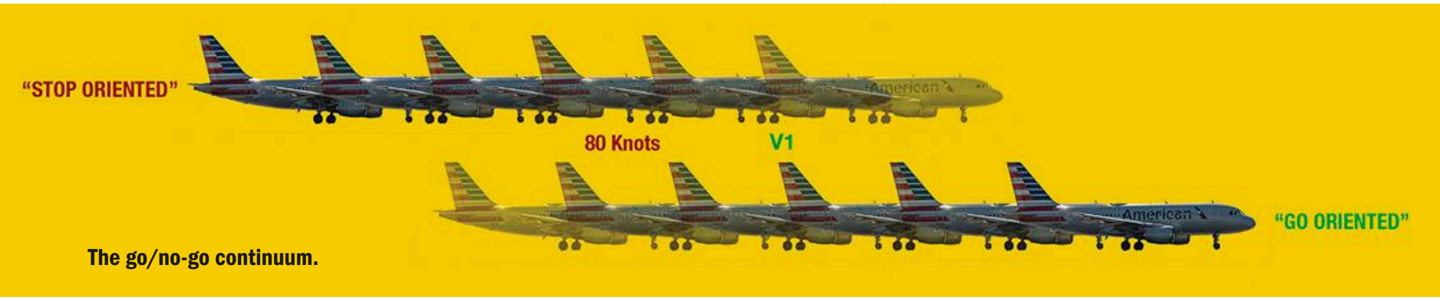
There are three basic models to describe who has abort authority in a two-pilot cockpit crew and quite often the model determines who has control of the throttles, power levers or thrust levers. (I'll call them thrust levers from this point forward.)

▶ Captain has complete abort authority/first officer only allowed to announce the nature of the problem. Many major airlines use this philosophy, but it can also be found in business aviation flight departments. Some operators will have the captain retain control of the thrust levers during the takeoff with the first officer flying, while others may relinquish control at certain points during the takeoff roll or once the aircraft is airborne.

The primary reason given for this autocratic philosophy is that there can be no confusion about who is making the decisions. But removing the first officer from the decision-making process can necessarily add time to whatever decisions are made.

▶ Captain can always call for an abort/first officer can only call his own abort. Some airlines and many regional airlines seem to have adopted this philosophy. Once again, there is no confusion about who is making the decision. But allowing the first officer to call his or her own abort facilitates faster execution if the F/O detects a problem and executes the abort without waiting for the captain's approval.

▶ Either pilot can call for the abort and must execute it when called. A few airlines use this philosophy and it is the prevalent philosophy for most business aviation flight departments with highly experienced pilots. The PF, even if that



The go/no-go continuum.

JAMES ALBRIGHT

pilot is not the captain, will normally have control of the thrust levers by the time the takeoff has progressed into the high-speed regime. Decision-making and execution is faster than with the previous philosophies, but there are risks of decisions with which the captain disagrees.

So, it seems we have two issues with which to contend. First, we worry about confusing command authority in the cockpit, especially when we are not fully confident about the F/O's ability to make a timely and correct decision. Second, we worry about extending the delay from when a problem is first detected until taking corrective action.

How Much Decision Time?

So, what's the big deal? Many pilots think they have 2 sec., and 2 sec. is a long time! Well, no, you don't have 2 sec., and even if you did, it isn't enough.

From a regulatory standpoint, there is no specified decision-making time. But the decision must have already been made by V_1. From 14 CFR §1.1: "V_1 means the maximum speed in the takeoff at which the pilot must take the first action (*e.g.,* apply brakes, reduce thrust, deploy speed brakes) to stop the airplane within the accelerate-stop distance. V_1 also means the minimum speed in the takeoff, following a failure of the critical engine at V_{EF}, at which the pilot can continue the takeoff and achieve the required height above the takeoff surface within the takeoff distance."

While we've labeled V_1 "decision speed" it would be more correct to call it "action speed." By the time you reach V_1, you will have either begun action to abort the takeoff or committed to continuing the takeoff. So, where does the so-called 2-sec. decision time come from?

Transport category airworthiness standards (14 CFR §25.109) define takeoff accelerate-stop distance by adding a safety factor to the distance required to accelerate on a dry runway from a standing start with all engines operating until a point known as Vef (engine failure speed), having the pilot take the first action to reject the takeoff at V_1, and then come to a full stop. The safety factor distance is determined by using a distance equivalent to 2 sec. at the speed achieved at V_1.

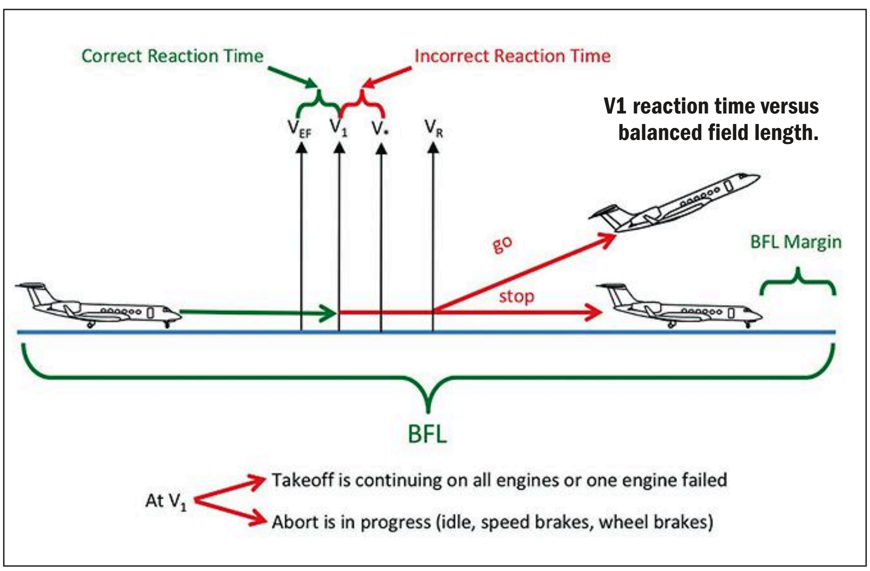
It may seem like we are splitting hairs here; isn't 2 sec. at V_1 the same as 2 sec. after V_1? It is not and learning this shows just how thin the margins can be. Every millisecond you continue accelerating, you are (1) eating into that safety margin and (2) invalidating the math because you are accelerating.

Let's say you are taking off in a Gulfstream GV on a balanced field at maximum weight on an ISA day at sea level where the balanced field length is equal to the runway length. If you begin the abort right at V_1, you should have just over 400 ft. in front of you when you come to a complete stop, based on having 2 sec. margin at your top speed of 130 kt. when you began the rejected takeoff. Starting the abort 2 sec. after V_1 adds 500 ft. to your distance. You are now off the runway.

But wait, you say, your manufacturer says you have 2 sec. It might. My manufacturer (Gulfstream) varies reaction time from as little as 1 sec. to as much as 1.25 sec. Whatever your manufacturer says, the reaction time comes before V_1. So, it is clear you don't have a lot of time to make your decision, as little as 1.00 sec., depending. Furthermore, this decision to reject the takeoff must be completed before V_1. So, how long does it take to make a decision in the most obvious case of an engine failure? (I say obvious because it is the one takeoff failure we practice the most.)

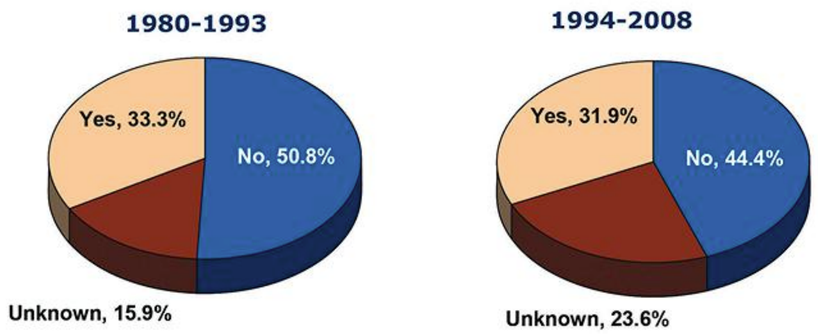
In 2010, the National Aerospace Laboratory (NLR) of the Netherlands issued a study of high-speed rejected takeoffs by analyzing accidents and serious incidents before and after a 1993 joint industry study, led by Boeing, known as the Takeoff Safety Training Aid. The NLR study found that the accident/serious incident rate of high-speed rejected takeoffs had dropped by 24% but was still too high.

According to the study, "Each takeoff includes the possibility that the pilot needs to stop the aircraft and reject the takeoff. Analysis of pilot reported rejected takeoff occurrences showed that the rejected takeoff maneuver occurs approximately once in every 1,800 takeoffs. With this rate, a pilot who flies primarily long-haul routes may be faced on average with a rejected takeoff only once in 25 years. In contrast, a pilot on a regional jet may face a rejected takeoff every four years on average. The pilots in each of these fleets must be prepared to make an RTO decision during every takeoff. Even to the regional pilots it will not be a common thing to do other



JAMES ALBRIGHT

Correct Decision to Abort or Not



Source: National Aerospace Laboratory of the Netherlands 2010 study.

than in the simulator. Analysis of pilot reported rejected takeoff occurrences showed that about 56% of the rejected takeoffs occurred at speeds lower than 60 kt. and almost 90% below 100 kt. Even if a pilot faces the decision to reject, it is most likely at a low speed. To reject a takeoff at high speeds is very rare.

"Some operators and aircraft manufacturers have defined a speed up to which a takeoff should be rejected for all observed failures or warnings. Above this speed and to the takeoff decision speed V_1, the takeoff should be rejected only in case of an engine failure and conditions affecting the safe handling of the aircraft. However, amongst the operators different policies exist regarding these takeoff rejection criteria. The speed up to which a takeoff should be rejected for all observed failures varies between 70 and 100 kt. with a typical value of 80 kt. or 100 kt. In the high-speed regime, the pilot's bias should be to continue the takeoff, unless there is a compelling reason to reject."

The study concludes, however, that in many cases pilots make an incorrect decision to abort.

The study did not speculate as to why we are getting (marginally) better, but I suspect it mostly has to do with better simulator training and cockpit electronics that inhibit nuisance warnings at higher speeds. But the fact we continue to get nearly half of these decisions wrong is worrisome. Most of us employ two-stage RTO criteria, typically saying we will only abort for critical items above 80 or 100 kt. The report states the obvious that these decisions are easy at lower speeds. But when the runway is racing by at 200 ft. per second (120 kt.), it is no wonder the decision becomes more difficult nearing V_1.

The same study cites a Qantas Airlines simulator test that measured the time between an engine failure and the first callout, and then the time between that first callout and the pilot's first reaction to initiate the abort. These data show that the time between the engine failure and pilot's reaction can be very long.

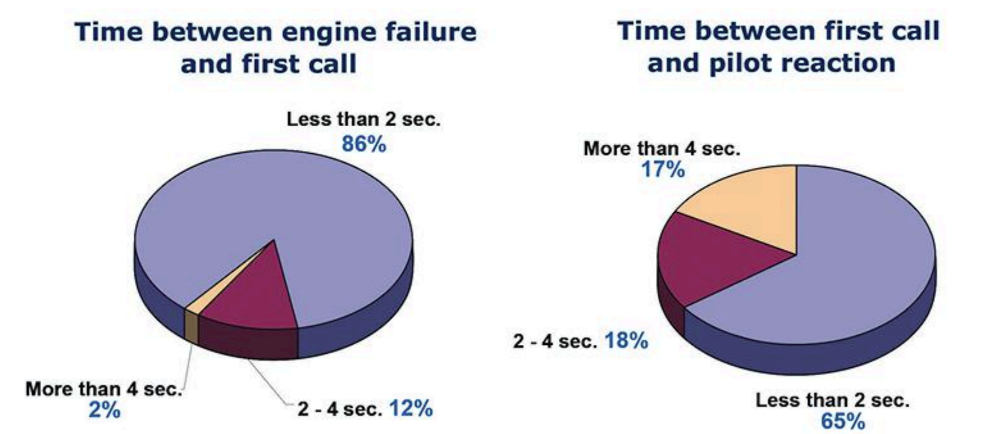
For the most part, we do indeed react very quickly (in less than 2 sec.) when it comes to recognizing the problem and making the abort callout. We also react to the callout fairly quickly (in less than 2 sec.).

For the sake of argument, let's say we have a sharp crew and our reaction time is 1 sec. for evaluating the problem and making the callout. We will also say our pilots are on their game and it only takes 1 sec. to initiate the RTO. So, in theory, we can go from problem to abort in 2 sec. But consider a few hypotheticals where the F/O does not have the authority.

First, let's say the captain is the PF (attention is outside) and the F/O is monitoring crew alerting systems (attention inside). If the issue is apparent from outside the cockpit, it takes the captain 1 sec. to evaluate and decide to abort, and 1 sec. to react, for a total of 2 sec. between problem and RTO initiation. If the issue is apparent from inside the cockpit, it takes the F/O 1 sec. to evaluate and make the callout, the captain 1 sec. to evaluate the callout, and 1 sec. to react, for a total of 3 sec. between problem and RTO initiation.

Now, let's say the F/O is the PF (attention is outside) and the captain is the PM (attention inside). If the issue is apparent from inside the cockpit, it takes the captain 1 sec. to evaluate and make the callout, the first officer 1 sec. to evaluate the callout and 1 sec. to react, for a total of 3 sec. between problem and abort initiation. If the issue is apparent from outside the cockpit, it takes the first officer 1 sec. to evaluate the problem and 1 sec. to make the callout. It then takes the captain 1 sec. to look up, evaluate and make the abort callout, the first officer 1 sec. to evaluate the callout, and 1 sec. to react, for a total of 5 sec. between problem and RTO. Of course, you can argue the captain might spot the problem as quickly as the F/O or that the captain could decide to initiate the abort while simultaneously making the

Reaction Times After Engine Failure



Source: National Aerospace Laboratory of the Netherlands 2010 study.

callout. There can be a number of variations, but not allowing the F/O to make the decision or initiate the abort will cost time. I think we all understand this situation lengthens the time needed to initiate the RTO and this puts enormous pressure on the captain to make these decisions quickly.

Case Study: Lonely at the Top

A high-speed abort happens very quickly and usually as a result of something else going wrong. It may seem unfair to second-guess a crew's actions when the decisions came so quickly and the causal factors can be interrelated. But we should look at a few cases just to stimulate the thought process needed to evaluate our own abort authority philosophy.

On May 25, 2008, the captain of Kalitta Air Flight 207, a cargo Boeing 747, aborted his takeoff from Brussel-Zaventem Airport (EBBR), Belgium, after his No. 3 engine ingested a bird, causing a momentary compressor stall. On the face of it, this may seem cut and dried. Pilots who have experienced a compressor stall in this situation have said the bang is louder than any noise they have ever heard in a cockpit. But the compressor stall occurred 5 sec. after V_1 and the engine recovered immediately. Two seconds later the captain brought all four thrust levers to idle and initiated braking. He did not deploy the thrust reversers or speed brakes. The aircraft left the runway still doing 72 kt., dropped into an embankment, and broke into three parts. The crew of four and one passenger escaped uninjured but the aircraft was damaged beyond repair.

The accident investigation revealed the initiating cause was a 6-oz. kestrel that left feathers and other remains in the engine but did not damage any part of it. Analysis also confirmed the engine recovered from the compressor stall immediately. It is apparent, therefore, that the captain made the wrong decision at the wrong time. But what isn't apparent is why.

I first assumed the title of "captain" of a multi-pilot aircraft in 1984, flying an U.S. Air Force Boeing 707 (EC-135J). Our rules gave absolute abort authority to the captain, and other cockpit crewmembers could only state the nature of the problem, leaving the decision on the shoulders of the captain. We required our captains to recite a very limited list of reasons to abort prior to every takeoff, but we were "stop oriented." In other words, when in doubt, abort the takeoff. I worried that one day I would face a problem above V_1 and make the wrong decision. During my last year flying that airplane, I did experience an engine failure right at V_1 and elected to continue the takeoff.

My next airplane was the Air Force version of the Boeing 747 (E-4B) where we adopted a new philosophy of designating a second speed to divide the low-speed and high-speed regimes. We were "stop oriented" below 100 kt. and "go oriented" above. We also allowed either pilot or the flight engineer to call for the abort. I soon realized my go/no-go decisions were being evaluated by the rest of the cockpit crew. I think this had the subconscious effect of helping me to rule out any actions that violated our Standard Operating Procedures (SOPs).

The Kalitta Air General Operations Manual could have been written by my Boeing 707 squadron. Only the captain could make the decision to continue or abort the takeoff. First officers and flight engineers were forbidden from using the words "reject" or "abort," except to confirm the captain's decision. When given this amount of solitary power, a captain can become stricken by indecision or the tendency to second-guess his or her decisions. Having a crew back up those decisions as they happen can reassure the captain that following SOPs is the right thing to do.

JELLE VANDEBEECK

Kalitta Flight 207 after the high-speed abort.

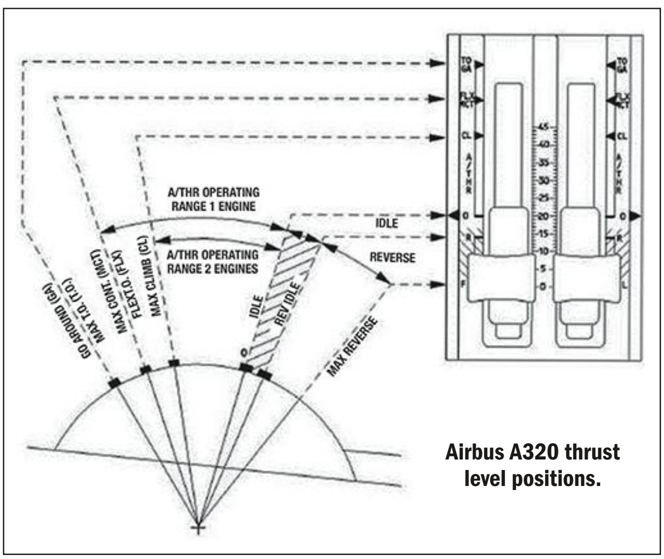
Case Study: A Silent First Officer

Regardless of who is flying the airplane during takeoff, even a few seconds of delay can mean the difference between an easy low-speed abort and one at high-speed when everything has to go just right. There are times when the PM has a clearer idea of the problem than the captain. The captain also carries the ultimate responsibility of making sure the flight succeeds in its Point A to Point B mission, possibly placing a go-oriented bias in his or her decision making. No matter the motivation, removing the F/O from the decision-making process can cripple the captain's effectiveness under pressure.

On March 13, 2014, the F/O of US Airways Flight 1702 made a minor mistake in programming the aircraft's flight management computer (FMC) that cascaded into a series of errors by the captain that ended in a high-speed abort and substantial damage to their Airbus A320. A video taken from the ramp at Philadelphia International Airport (KPHL) clearly shows the airplane's nose come up, the aircraft become airborne, but then immediately return to the runway with enough force to collapse the nose gear. The NTSB correctly notes the accident was caused by the captain's decision to abort the takeoff after rotation. But that is what happened, not why it happened.

I think to understand why this accident happened we need to dive into the realm of pilot psychology. As is common with many airlines, US Airways vested total abort authority with the captain. Both pilots on Flight 1702 were highly experienced in terms of hours in type and years with the airline. But one was an experienced captain and the other had been an F/O in the A320 for seven years. Reading through the cockpit voice recorder transcripts, it becomes clear the captain is the assertive decision maker and the F/O is a timid assistant.

It was a clear and cold day in Philadelphia and everything about the day's flight was routine. The first officer's initiating mistake was to enter Runway 27R as their takeoff runway into the FMC, instead of their actual assignment of Runway 27L. Both runways were more than adequate in length, but it was a mistake worth correcting. The captain didn't notice the error until they were cleared onto the runway. He asked the first officer to make the change. After the fact, both pilots acknowledge that making the change was routine, something they had done before many times. The F/O made the change but forgot to reenter the assumed temperature. (The assumed temperature tells the FMC that a reduced thrust setting was planned.) The first officer failed to notice a "Check Take Off Data" FMC message and both pilots failed to notice the V-speeds normally shown on their pilot flight displays had dropped out.



Airbus A320 thrust level positions.

NTSB

Once cleared for takeoff, the captain placed the thrust levers into the FLEX detent, causing the electronic centralized aircraft monitoring (ECAM) system to chime and issue the message that the thrust levers were not set. The crew didn't know that without the assumed temperature, the ECAM was expecting the thrust levers to be in the Take Off/Go Around (TOGA) detent, or that the corrective action was to select the TOGA detent. The first officer reported, "Engine thrust levers not set." Contrary to procedures, the captain retarded the throttles below FLEX and back to FLEX and said, "They're set." At this point they were still in the low-speed regime and would have had the perfect opportunity to discontinue the takeoff and sort things out.

Before they got to 80 kt. the F/O noticed their V-speeds had disappeared, a situation for which she wasn't prepared. She failed to make the required "80 kt."callout and, while accelerating through 86 kt., an aural "Retard" sounded in the cockpit. The "Retard" call is normally made during landing; post-accident interviews with several US Airways pilots confirmed none had ever faced this situation.

As the airplane continued to accelerate, the captain said, "What did you do? You didn't load. We lost everything." At 143 kt. he said, "We'll get that straight when we get airborne." The first officer said, "I'm sorry."

The captain rotated the nose at 164 kt., but his pitch became erratic, cycling between 16 deg. nose up and 16 deg. nose down. The main gear left the runway for 2 sec. and the radio altimeter height reached 15 ft. Surveillance video from the airport ramp shows the airplane impacted the runway first with the tail, then the main landing gear, and then rotated onto the nose gear with enough force to cause it to collapse. There were no fatalities, but the aircraft was substantially damaged.

When asked why he didn't push the thrust levers to TOGA after receiving the "Engine Thrust Levers Not Set" ECAM message, the captain said there was "no harm" in not doing so. Asked why she didn't say anything when she had noticed the V-speeds had dropped out, the first officer said she "assumed [the captain] wouldn't continue the takeoff if he didn't know the V-speeds."

The captain said he aborted the takeoff after rotation because he "had the perception the aircraft was unsafe to fly." But he also acknowledged that everything was normal except the chime and "Retard" aural alert, and that the main landing gear "came off the ground fine and the initial pitch felt fine."

So, once again the flight data and cockpit voice recorders help us to understand what happened; we are left looking at pilot psychology to understand why this accident happened. I think we can trace this to a captain who didn't react favorably to bad news and a first officer reluctant to offer any.

The F/O was rushed into making the FMC runway change after they had already been cleared onto the runway. She made the proper callout upon discovering the thrust levers were not set, but the captain's dismissive tone, "They're set," failed to extinguish the warning but served to shut down further communication. When looking to her PFD for the V-speeds, she was confused momentarily because they were gone.

The aural "Retard" message had to have been monumentally confusing, given that neither pilot had ever experienced it on the line or in training. It appears the F/O had already made an internal decision that the takeoff should be aborted but didn't feel free to say so. It appears the captain had made the decision to go but had enough doubts to later abort after takeoff rotation.

My first takeoff attempt in the Boeing 747 resulted in a low-speed abort. I was getting my initial type training from United Airlines and the aircraft was extremely light. We didn't have any passengers, we had a minimal fuel load and both galleys had been removed. The flight engineer's takeoff data placed the stabilizer trim at an extreme end of the green band, but we didn't know that. My simulator instruction introduced the idea that below 100 kt., any vote to abort meant we aborted. But above 100 kt., the list of causes to abort for became very short.

The captain on Flight 1702 was go oriented and in the absence of effective CRM, the crew became go oriented. I believe the captain's decision making became corrupted by panic that is a problem unto itself. For the purpose of deciding who should have RTO authority, however, our focus should be on the F/O. In an environment where she wasn't allowed to utter the words "abort" or "reject," she may have become unpracticed in the art of making these kinds of decisions. I think had she been schooled by the airline to command a rejected takeoff when she thought it necessary, the outcome of this flight would have been nothing more than a low-speed abort and FMC reprogramming.

Case Study: When CRM Empowers the Crew

I am as guilty as the next Monday morning quarterback when it comes to reading headlines about aircraft failing to stop on the paved surface of a runway after a high-speed abort. But I also realize there are times a high-speed RTO is unavoidable. Not only is the case of Ameristar Charters Flight 9363, detailed in last month's Cause & Circumstance (page 20), just such an incident, it provides a textbook lesson about how a crew that adheres to SOPs and utilizes effective CRM can turn a potential catastrophe into a survivable incident.

On March 8, 2017, the crew of an Ameristar Charters McDonnell Douglas MD-83 rejected their takeoff from Willow Run Airport (KYIP), Ypsilanti, Michigan. One of the two elevators was jammed and 3 sec. after the PF realized the aircraft could not leave the ground, he aborted. Despite the fact the aircraft did not stop on the paved surface, this crew did everything right before, during and after the decision was made.

Unlike the previous case studies, the left-seat pilot flying was upgrading to captain with a check airman in the right seat. So, in this case the acting F/O was the PIC. Like the accidents already cited, the moment of the abort was highly stressful and the pilots did not have a clear idea of what was causing the problem. Unlike the first two events, however, the Ameristar crew's strict adherence to SOPs allowed CRM to maximize the chances of a successful outcome.

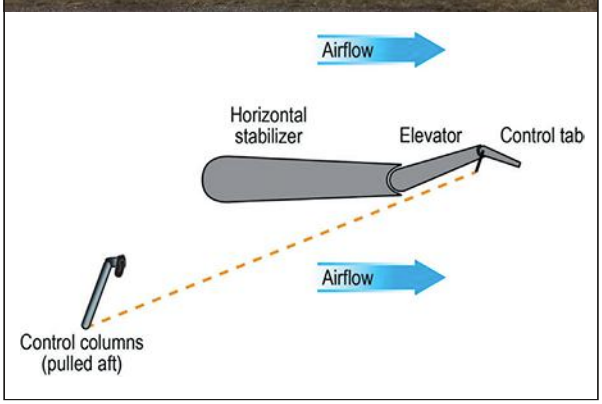
Six seconds after the check airman/first officer called V_1, he called rotate. The captain pulled back with normal forces at first and then increasing force. Four seconds later, the captain (not the PIC) realized full aft forces on the yoke were not changing the pitch of the aircraft and called "Abort." The check airman said, "Don't abort above V_1," but the captain had already begun executing the RTO. From that point both pilots acted as a team to execute the abort according to SOPs. The NTSB concluded:

"The flight crew's coordinated performance around the moment that the captain rejected the takeoff showed that both pilots had a shared mental model of their responsibilities. By adhering to SOPs — rather than reacting and taking control of the airplane from the captain trainee — the check airman demonstrated disciplined restraint in a challenging situation. Had the check airman simply reacted and assumed control of the airplane after the captain decided to reject, the results could have been catastrophic."

The crew of six and 110 passengers were able to walk away from what could have been a catastrophe. It took the pilot flying 4 sec. to decide the takeoff had to be aborted. Their speed at the time was 150 kt.; they were covering 253 ft. every second. Had the captain deferred to the check airman, the results could have been very different.


NTSB

The wreckage of Ameristar Flight 9363 following its high-speed abort.



Simplified diagram of an MD-83 elevator control.

My Answer: It Depends

So, up for debate, which abort philosophy is best? Should the captain have absolute authority while allowing the rest of the crew only the power to recommend? Or should the rest of the cockpit crew be allowed to say "Abort!" and expect the PF to do just that? As with many things in aviation, the answer is, "It depends."

I realize this is an issue that divides the professional pilot population into two distinct camps, so my answer is likely to generate responses in opposition and support. Keep in mind, what follows is opinion. (But, ahem, the right opinion!)

When simulator training is unavailable and a first officer's experience is limited, it may be appropriate to withhold abort authority during operational flying. In this case, it would be wise to require the captain to fly every takeoff when close to a balanced field condition and emphasize to the F/O that any callouts must be short, succinct and forceful. For example: "Overtemp, right engine" and not "I think the right engine has a problem."

When simulator training is available, F/Os should be well-schooled on the dangers of a high-speed abort and the need to become go oriented at higher speeds except for specific instances the aircraft manufacturer or operator agree upon. At our company, for example, we would condone an abort above 80 kt. and below V_1 for a loss of directional control, a fire anywhere on the aircraft or other conditions that make the aircraft unflyable.

Once an F/O becomes fully qualified (either through an in-aircraft or simulator training program), he or she should have abort authority. The first officer should be allowed to call for the rejected takeoff and, if acting as the pilot flying, should be able to initiate it. The captain should initiate the abort when the F/O calls for it.

When I was first assigned to crewed aircraft, the standing philosophy held that only the captain had abort authority. Our simulators were laughable by today's standards and we did most of our training in the aircraft. But once I progressed to modern-day aircraft and simulators, I was schooled to become stop oriented at low speeds and go oriented at high speeds. As a first officer I was well trained to make the go/no-go decision. As a captain, I expect nothing less from my first officers. If the first officer calls for an abort, that's what I do. **BCA**

Hurricanes and Aviation

These oceanic cyclones are **growing larger, more frequent and threatening** to flight missions

BY **DAVID ESLER** david.esler@comcast.net

The most-violent weather phenomena on Earth are hurricanes and tornados, the two often related.

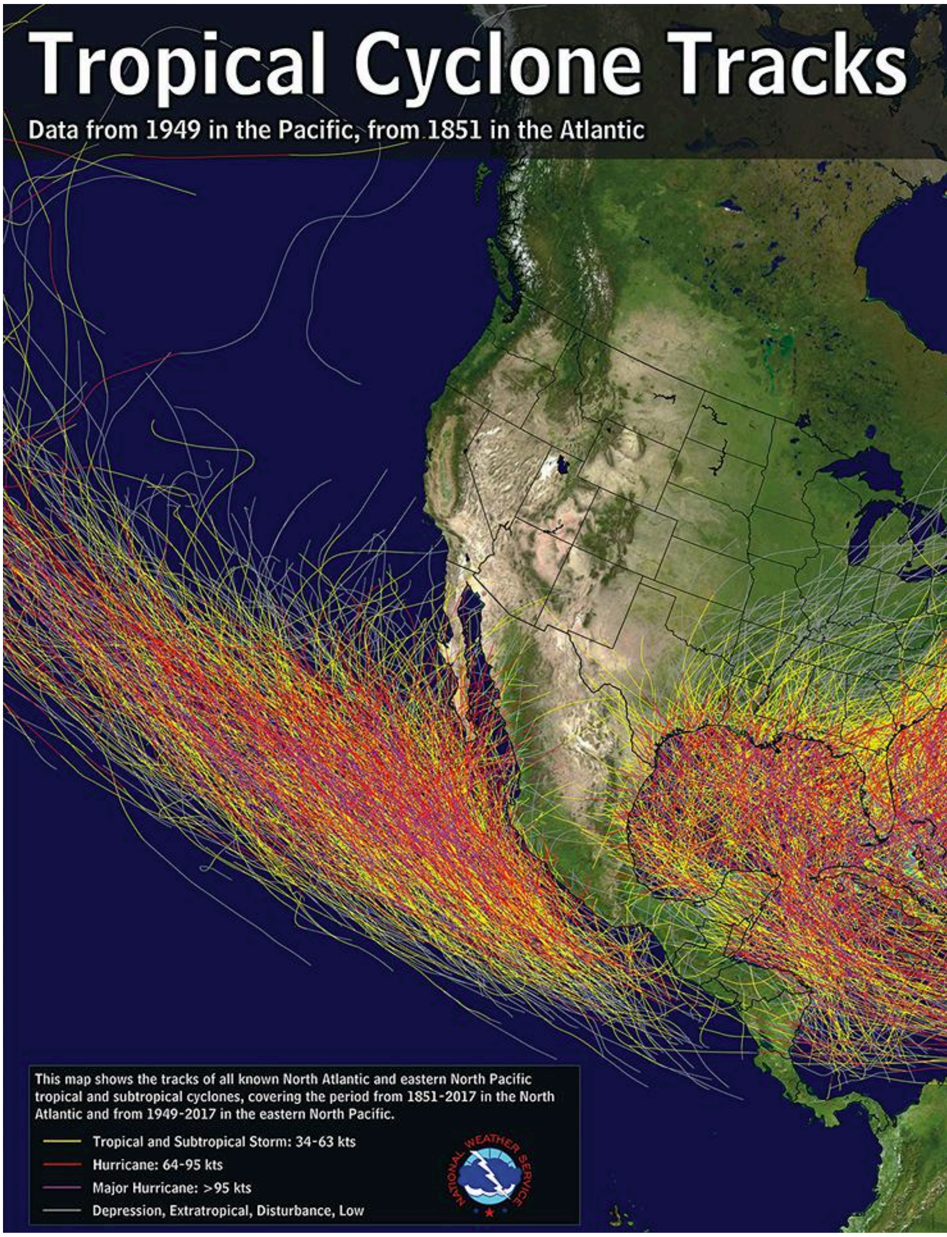
The mother of convective storms, hurricanes, once they reach maturity, can generate wind speeds as high as 190 mph. Hurricane Maria leveled Puerto Rico with maximum sustained winds of 155 mph that, on Sept. 20, 2017, even took out the island's sole weather radar station. And these cyclonic storms can be huge, too, averaging 150 sm from the edge to the eye, or 300 sm total diameter. "But we have seen systems twice as large," meteorologist Mike Wittman at EVO Jet Services told *BCA*.

And they're getting bigger and more frequent throughout the world due to climate change. "It is verified that in recent years the intensity of these storms is increasing due to the warmer ocean water and more evaporation and thus more energy to feed them," Wittman said. "We are seeing hurricanes that are larger in size with higher winds and increased amounts of rainfall."

Meteorologists are recording unprecedented wind and gust speeds and more moisture that is resulting in flooding. Hurricane Harvey delivered a total of 60.58 in. of rainfall to Houston in August 2017, setting a U.S. record. "The storm meandered very little and stalled out, remaining over one place from Friday, Aug. 24, to Tuesday, Aug. 28," Wittman recalled. In one 24-hr. period alone, the storm dumped 40 in. on the city and its environs. "Bayous were 20 ft. above normal in some places," Wittman continued. "Overall, the frequency of these storms has increased, as well."

(The Western Hemisphere record for rainfall in a single event is 64.33 in., recorded over a 24-hr. period during the passage of Hurricane Wilma, Oct. 21-22, 2005, at Mujeres Island in the Caribbean Sea off Mexico's Yucatan Peninsula.)

The most expensive hurricane season in U.S. recorded history occurred in 2017 with damage from three Category 4 storms that made landfall — Harvey, Irma and Maria — totaling $202.6 billion ($180 billion alone attributed to Houston). Producing winds up to 185 mph, it's easy to see how these storms could wreak so much havoc. Meanwhile, six other hurricanes exceeding Category 3 rampaged through the Atlantic that year.



Crews Must Be Vigilant

Typically, the hurricane season runs from late May to as late as early November in the Northern Hemisphere, as solar radiation heats up the tropical latitudes, peaking in July and August or September when the tropics are receiving maximum heating. (Historically the season was June to September.) Also, strong tropical storms and hurricanes have been known to develop out of season, but rarely. Because the storms are forming more frequently, flight crews engaged in oceanic operations will have to be more vigilant of the elements and trends that result in cyclonic storms and, once they have formed, track them carefully, adjusting their flight planning accordingly.

According to Wittman, director of operations at the EVO flight planning company, crews also "need to consider that these storms can take days to move in and finally out of a destination area to which they intend to fly. Then there is the disaster left behind — is the airport going to be open, will there be electric power, hospitals open, and so forth? As av managers, we have to warn our principals early about these things and assist them with their planning. As part of their planning, smart flight crews will watch their regions often and early, consult with meteorologists, and maintain contact with principals and passengers about the situation."

And by the way, before we begin to examine the formation criteria for cyclonic storms, we need to clear up the difference between a hurricane, typhoon and cyclone. In fact, there is none; they're all the same thing: deep low-pressure cyclonic storms that originate in the tropics. They're just uniquely named in the oceanic regions where they mature. In the Caribbean Sea, North Atlantic and Gulf of Mexico, they're hurricanes. In the Indian Ocean, they're cyclones. And in the North and South Pacific, they're typhoons. While the names are interchangeable, for most of this report we refer to the storms as hurricanes. And by the way, tornados are often — but not always — associated with cyclonic storms, as the latter's severe atmospheric conditions can spawn the destructive funnels.

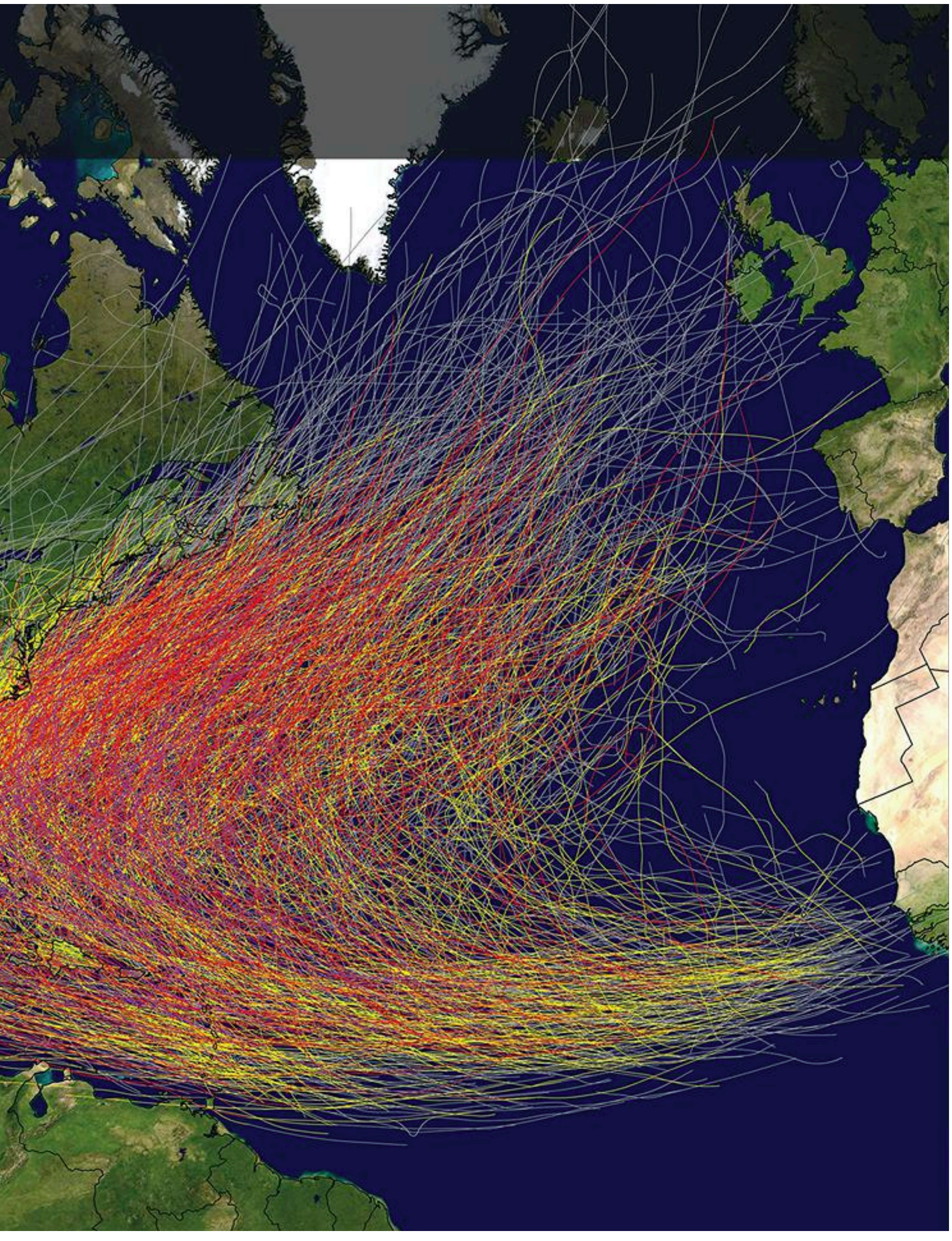
There are three growth phases of hurricanes:

- Tropical depressions, with wind speeds less than 31 kt.
- Tropical storms, wind speeds up to 64 kt.
- Hurricanes, wind speeds up to 165 kt.

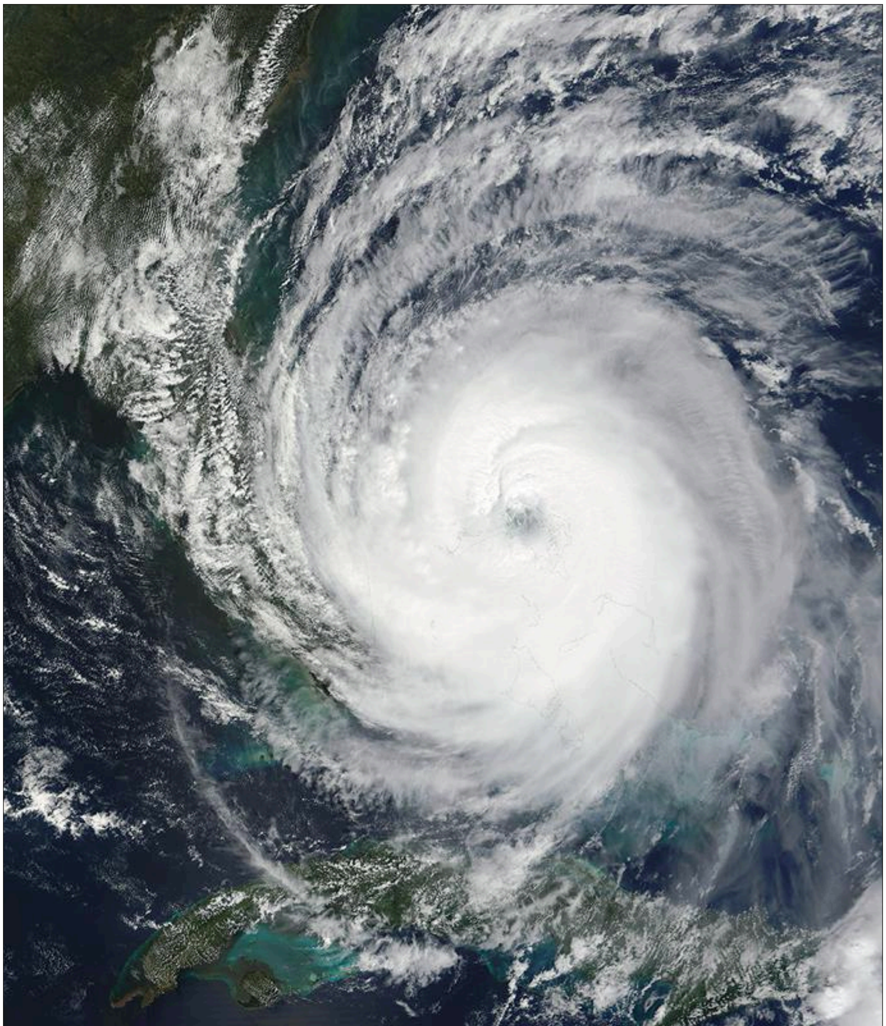
The starter for this process is warm ocean waters, specifically greater than 26C (79F) temperature. Below this threshold, hurricanes cannot form, and once congealed, if they pass over water below 26C, they will weaken rapidly.

Distance from the equator plays a factor, too, due to the Coriolis force. As detailed in "Understanding the Inter-Tropical Convergence Zone" (*BCA,* June 2017, page 40), the Coriolis force derives from the rotation of the Earth, and without it, hurricanes wouldn't exist. It imparts a counterclockwise rotation around low pressures in the Northern Hemisphere and a clockwise spin around lows in the Southern Hemisphere. Because the Coriolis force maximizes at the poles and is at a minimum at the equator, hurricanes cannot form within 5-deg. latitude of the equator.

A saturated lapse rate gradient near the storm's center of rotation, or eye, releases latent heat from the condensation of water vapor, creating convection, or lift, around the eye wall, where the lapse rate must remain unstable to ensure air will continue to rise and condense



In this multi-century compilation of storms from NOAA, note the tracks of Atlantic hurricanes from the west coast of Africa to mainland U.S., and from the west coast of Mexico into the Pacific.



‘A Strong Wakeup Call’

On March 28, the World Meteorological Organization (WMO) released its latest report on global temperatures, extreme weather and indicators of climate change.

Titled “The WMO Statement on the State of the Global Climate in 2018,” the report was characterized by U. N. Secretary-General Antonio Guterres as “yet another strong wakeup call” on the need for more ambitious action to mitigate global warming. (The WMO, like the International Civil Aviation Organization [ICAO], is an agency of the U.N.)

Noting that climate change continues to accelerate, the report claims that the WMO is seeing ever more examples of the dramatic impact of extreme weather conditions like hurricanes, heat waves and prolonged droughts. In 2018, in the U.S. alone, there were 14 weather- and climate-related disasters with combined destruction totaling $49 billion. Worldwide, more than 35 million people were affected by flooding. “Cyclone Idai in Southern Africa is a particularly stark recent example, as it was demonstrated,” Guterres said, referring to the storm that devastated Mozambique in March.

As this is written in April 2019, a second cyclone was bearing down on the country, with winds of 136 mph. **BCA**

water vapor. The storm “feeds off the warm temperatures of the equatorial waters, which enhance the condensation and provide energy as the moisture gets up into the atmosphere,” Wittman observed.

Another necessary factor is a low, vertical wind shear, or a change in wind speed at height, especially in the upper levels of the atmosphere. If there is little or no circulation aloft at higher altitudes, Wittman continued, “that air can get very thick and moist [and] the top of the troposphere can rise to 50,000 ft. or higher.” Under such conditions, the air mass and convective weather are very unstable and can reach “free convection.” Troposphere height is low at the poles and higher at the equator, where the atmosphere is so thick and warm that it can capture large quantities of moisture. But above the troposphere the warming ceases.

High relative humidity levels from the surface to mid-levels of the atmosphere also contribute to hurricane formation. But if dry air exists in the mid-levels, development can be impeded. First, dry air encourages evaporation of liquid water, and since evaporation is a cooling process, it reduces the warm core structure of the storm, limiting vertical convection development. Second, mid-level dry air can result in trade-wind inversion, inhibiting deep convection and stabilizing the all-important unstabilized lapse rate.

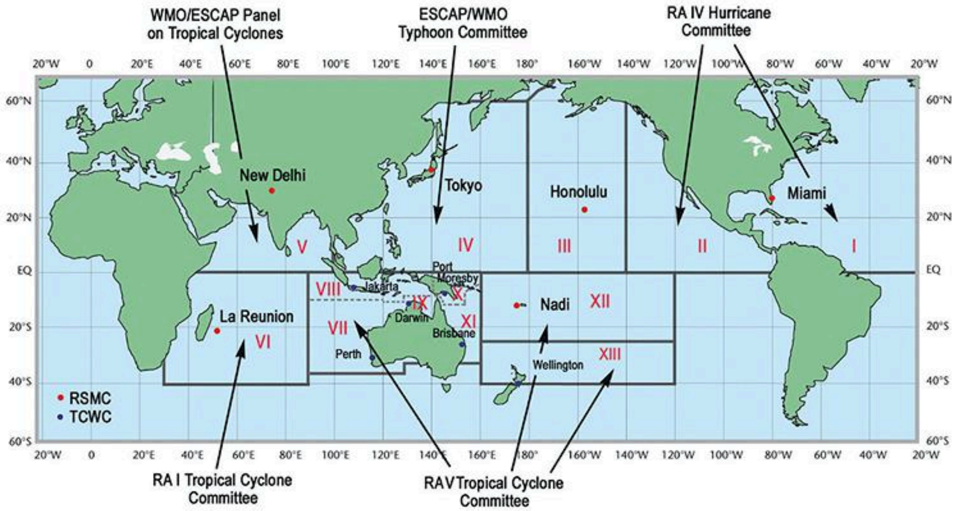
Finally, another element that can convert a gathering of unorganized thunderstorms into a tropical storm and thence to a hurricane is a “midtropospheric wave.” If the wave encounters the aforementioned conditions, it will amplify into a tropical storm or hurricane. This is common in the Mid-Atlantic region as thunderstorms move off the west coast of Africa and in the East Pacific, where the midtropospheric wave takes the form of a monsoonal trough.

A Region of Calm

While the winds generated by a hurricane may be circulating at hundreds of miles per hour around the dense clouds of the eye wall, the eye itself is relatively calm and clear and about 20 to 40 sm in diameter. Hurricane-force winds can extend outward to more than 150 mi. in a large storm, although the highest winds are concentrated in the eye wall.

As the storm rotates, its outer clouds trail off as bands like the arms of a stellar galaxy (see satellite photo

Hurricanes, cyclones and typhoons are monitored by these worldwide Tropical Cyclone Centers coordinated by the World Meteorological Organization, an agency of the United Nations.



of Hurricane Jeanne this page). "It looks like a big spring or helix that gets tighter toward the center," Wittman said. "Toward the outside of the hurricane there is further distance between the bands. Often, these bands are lines of thunderstorms." Tornado-producing "super cells" are also found in these outer rain bands. In the Northern Hemisphere, the strongest winds are typically found in the right half of a hurricane relative to the direction of motion. This is also where the storm surge (or the "piling up" of water as pushed by the high winds) is the strongest.

There can be a difference between "the biggest" and "the meanest" in terms of hurricanes, in that the former may not always be the latter. "That's not to say that the biggest systems are the meanest," confirmed Wittman. "If you remember Andrew back in 1992, it was not as large as some we've seen recently, but it was wound up very tightly and left a lot of disaster in its path." The difference in pressure from the center to the ambient atmosphere can be very deep, a "lower low" where surface pressure in the center is much lower than outside the system, "so the distance between them has a lot to do with the gradient and intensity of the system. Pressure force makes the wind blow, so it makes sense that, if the hurricane is very low in the center, you will get much stronger winds in the system."

Today's sensing and observation tools allow meteorologists to monitor the conditions that can spawn tropical storms and to track them once they've begun to form. Satellite imagery has been one of the most effective tools for watching these low-pressure systems develop and to track them as they initially move around. A hurricane's speed and path depend on complex oceanic and atmospheric interactions, including the presence or absence of other weather patterns, making the storms' directions difficult to predict.

"They can meander randomly and even retrogradely [flowing backward, or against their typical vectors] during the first stages of development until a steering mechanism emerges to control movement — a wind flow aloft — which then becomes predictable," Wittman explained. Weather models then become reliable, and movement can be forecasted.

Hurricanes in the Atlantic Region

The violent hurricanes experienced in the Caribbean islands and on the U.S. mainland are products of weather systems whose formation began 3,000 sm away. The storms form off the west coast of Africa 10 to 15 deg. north of the equator and gradually move west. "Orientation of the land mass gets it started," Wittman said, "North Africa, with heat from the desert rising out over the water to the west and the solar radiation providing the energy to increase the low pressure system and deepen it. It progresses from a low pressure system to a tropical storm and then intensifies into a hurricane."

The storms move west, often to the Caribbean Sea just off the equator, absorbing ever greater amounts of energy from solar radiation and the warm water. Easterly Caribbean trade-wind patterns further encourage the systems to drift west. Eventually, they get steered north by the upper-level wind flow and can make landfall in the Southern U.S. or plow through the Caribbean islands. Weather models provide meteorologists with more reliable guidance on movement, as the storms proceed into the higher latitudes, and timing also becomes more predictable.

According to the U.S. National Hurricane Center, of 10 tropical storms developing over the Atlantic Ocean, Caribbean Sea and Gulf of Mexico, six will grow to hurricane strength. In an average three-year period, about five hurricanes cross the U.S. coastline, killing approximately 50 to 100 people anywhere from Texas to Maine. Typically, two are major storms with winds exceeding 110 mph.

Hurricane Michael, which ravaged the Florida panhandle in 2018, was one of those. Initially classified as a Category 4 hurricane, in April this year it was reclassified as a Category 5 after National Hurricane Center scientists studied data collected during the storm. This meant that Michael was the first Category 5 hurricane to make landfall in the U.S. since Hurricane Andrew 27 years ago and only the fourth on record. Data showed that the storm's maximum wind speed was 160 mph, 5 mph over its previously calculated velocity. It was directly responsible for 16 deaths and $25 billion in damage.

Hurricanes in the Pacific and Indian Oceans

Typhoons build in the same way as the African development. They generally are born off the Mexican mainland at around 15 deg. north latitude as low pressure systems. As they develop, they move west over the water, deepening to become tropical storms that can eventually evolve into hurricanes. Eventually, the storms get caught up in the light easterly trade winds, cruising west and south of the Hawaiian Islands, continuing to Southeast Asia and the Western Pacific.

Tropical depressions also develop over open water and can achieve hurricane strength. Meteorologists study satellite imagery to pick up on early development and monitor progress. "In the Philippines," Wittman said, "we have 'hurricane alley' with the Inter-Tropical Convergence Zone feeding these storms just slightly north of the equator. Some of these storms can drift as far north as Hong Kong, Japan and Eastern China during the peak of the northern summer in July and August over open water."

The Indian Ocean cyclone nursery is unique in that the storms are born near the equator and are funneled almost directly north to India and Pakistan by the Arabian Peninsula and Sea to the west of India and the Bay of Bengal and Myanmar to the east of the subcontinent. "The activity is very different from the other regions," Wittman said.

Pocket Guide to Hurricane Formation Conditions

Here's a concise list of meteorological conditions necessary for the formation of tropical cyclonic storms provided by Brad Crosier of FlightSafety International. Look for these in weather (aka, met) reports:

▶ Warm sea surface temperatures (or SSTs, >26C/79F). Cooler sea surface temperatures inhibit convective development.

▶ Latitude: More than 5 deg. from the equator. Closer to the equator, there is insufficient Coriolis force to impart rotation to the system.

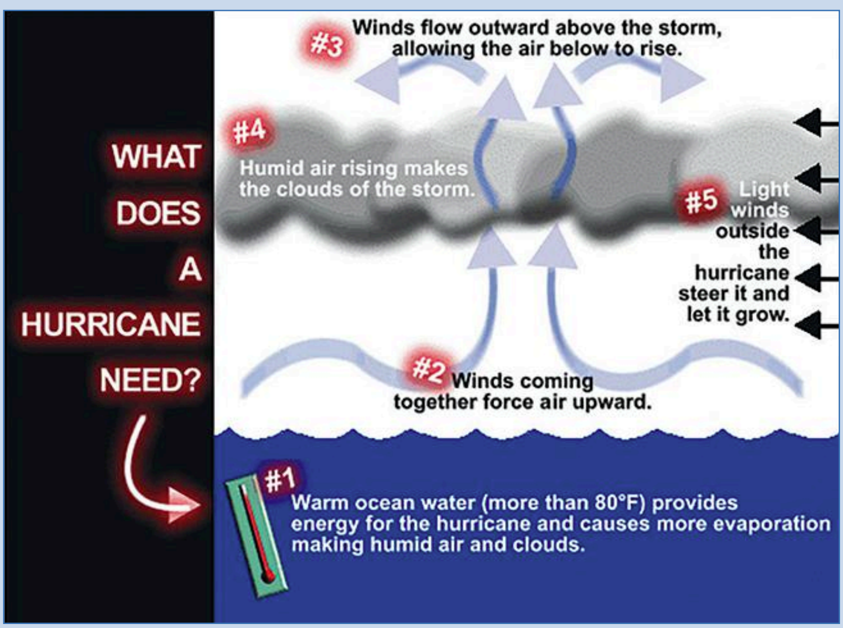
▶ High relative humidity in the low and middle levels of the atmosphere. Latent heat from condensation of water vapor is the fuel that drives these storms. Additionally, dry air inhibits convection by two means:

(1) Evaporation of liquid water removes energy from the local atmosphere, cooling the lifted parcel of air and decreasing its buoyancy.

(2) Dry air in the mid-levels can be due to a "trade-wind inversion," and like any inversion it tends to cap and limit convection.

▶ Low, vertical wind shear. This is one of the more critical components. If there is excessive vertical shear, particularly in the upper levels of the atmosphere, it will impede the vertical ascent of air parcels, in turn choking off convection.

▶ An existing wave or boundary. Often, cyclones form when an existing disturbance moves off the coast of a landmass or along a shear boundary that remains after a frontal boundary has moved far enough south (or north in the Southern Hemisphere) that the air masses are relatively homogeneous. **BCA**



Flight Planning for Hurricane Season

Brad Crosier, lead international procedures instructor at FlightSafety International, advises that pilots heading into regions where cyclonic activity may be rife can supplement their usual flight planning resources with others that specifically address hurricane avoidance. "The National Weather Service's Aviation Weather Center is an excellent source of information," he said, "including easy access to SIGMETs for tropical cyclones worldwide."

But while SIGMETs provide information about the current state of tropical systems, they offer little guidance on their future development. Crosier pointed out that more in-depth information can be found at the six tropical cyclone Regional Specialized Meteorological Centers (RSMCs) and six Tropical Cyclone Warning Centers (TCWCs). "These facilities provide advisories and bulletins with meteorological information on tropical cyclones, hurricanes and typhoons around the world," he said. "Data provided includes a system's current location, size and intensity, as well as forecast movement and intensity." In addition, summaries of the official national warnings may be included in the advisories.

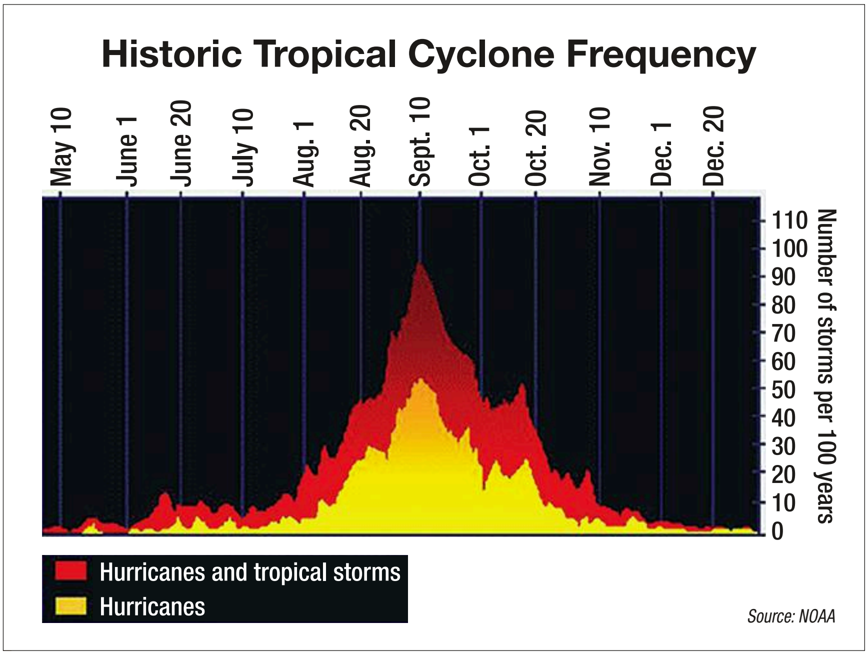
The U.S. Navy and Air Force jointly operate the Joint Typhoon Warning Center (JTWC), which is responsible for issuing tropical cyclone warnings in the North and West Pacific, South Pacific and Indian Ocean for all branches of the U.S. Department of Defense and other government agencies. (In some cases, they cover the same areas as several of the RSMCs and TCWCs.) The JTWC can be a good one-stop resource for information in the covered areas. Information provided includes the same as that of the RSMCs and TCWCs but may also include meteorological discussions that offer insights into forecasts as well as observational data sources.

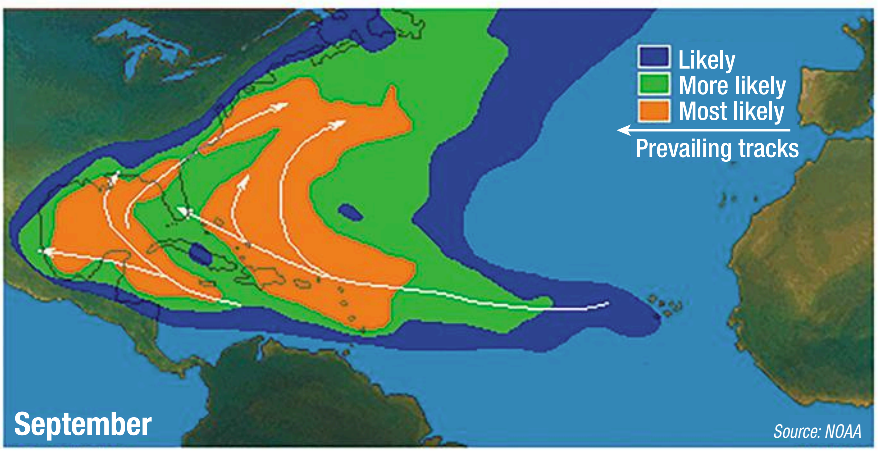
Still another resource providing observational data and forecast products is the Fleet Numerical Meteorology and Oceanography Center (FNMOC), which produces a number of meteorological and oceanographic products. In particular, for tropical cyclone formation and development, it provides worldwide and regional sea surface temperature (SST) graphics, an important metric for forecasting cyclonic development.

Between the National Hurricane Center in Miami and the Central Pacific Hurricane Center in Honolulu (both of which are RSMCs) along with the JTWC, coverage is provided for virtually all areas that are prone to tropical cyclones. Crosier warned that when planning operations in tropical environments, bear in mind that forecasts more than about 72 hr. in advance have a low level of confidence with respect to both track and intensity, making advance planning difficult.

Operational planning can be broken down into two areas: en route and terminal operations. For the former, the same guidelines for thunderstorms apply to cyclonic storms, the most obvious being avoidance by circumnavigation of the areas impacted by tropical weather.

"Happily technology has made it relatively easy to be aware of storms that may impact our route of flight. Crews simply need to plan accordingly to avoid those areas," Crosier said. "What can complicate this is that everyone else is doing the same thing, and the scale to tropical — and even extra-tropical — systems can result in the closure of many routes and large areas of airspace, possibly resulting in congestion or saturation in the surrounding areas." Coordination with flight planning providers and/or the FAA's Operational Information System (**https://www.fly.faa.gov/ois/**) can assist with finding the most workable solution.





The Atlantic region at the peak of the current hurricane paradigm.

Accepted practices for avoiding convective weather may require some adjustment, given the dynamics of tropical systems. "FAA Advisory Circular 00-24 provides a number of 'dos and don'ts' for thunderstorm avoidance," Crosier continued, "one of which is to circle around storms reflecting intense radar echoes by at least 20 nm. However, recent studies of tropical cyclones indicate that conditions favorable for significant turbulence can extend in excess of 500 nm from the storm center and up to the level of the tropopause. Thus, selecting a routing that provides a significant clearance from the system is likely to provide a better ride for passengers."

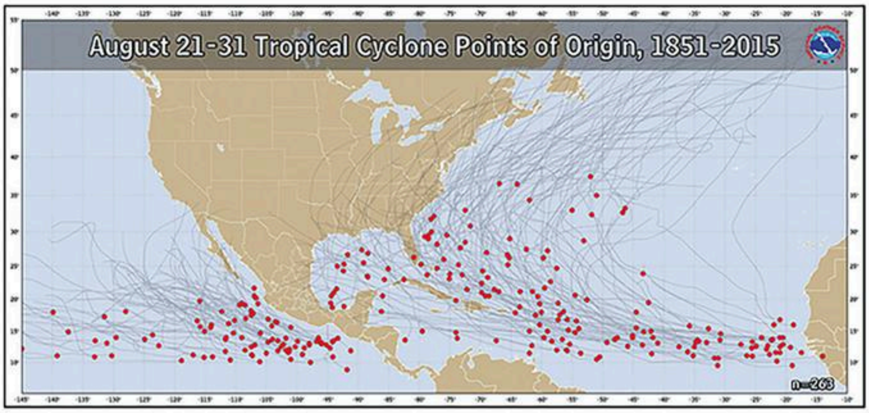
Obviously, planning to operate into a destination directly impacted by a storm is out of the question, but what distance from the event is acceptable for the operation to remain viable? According to Crosier, the answer varies with the intensity of each storm. However, some aspects crews should consider include (but are not limited to):

▶ The destination's location relative to the system? Clearly operating into the convective bands of the system is not an option, but also consider the breadth of the wind field of the storm since tropical storm force winds can extend far beyond the main portion of the storm, in some cases almost 300 sm from the eye.

▶ Along with the proximity of strong winds, local orographic effects should be considered. Crosier illustrated with an example: "The terrain around Hong Kong can generate significant turbulence under normal conditions when the winds exceed 15 kt. The presence of storm force or greater winds may make the airport unsuitable for operations, even if the prevailing conditions would otherwise permit operations."

▶ Watch storm development and progress. Ensure the operation has the flexibility to rapidly adjust to changes in the storm's intensity and path. Consider the weather not only for the immediate time frame of the operation but also for the duration of the time on ground.

▶ Take into account the potential for air traffic service unit closures. Towers, approach and possibly even en route facilities may be shut down and evacuated in anticipation of the storm. "Even if your planned destination is away from the



immediate area of landfall, services may be impacted by closure of other units," Crosier said. "Alternates and diversionary airports should be selected with these limitations in mind."

▶ Consider carrying extra fuel, as changes in the storm's intensity and track may significantly impact en route winds.

Post-Hurricane Considerations

"If operating into an area after a storm has passed," Crosier continued, "crews should consider the extensive damage that even a relatively weak system such as a tropical storm or Category 1 hurricane can wreak." While NOTAMs should reflect the state of the airport, consideration should be given to impacts beyond the scope of what the notices usually cover.

"There will likely be vast amounts of debris throughout the area," Crosier elaborated. Consequently, operators must ensure that runways, taxiways and ramps are cleared to prevent FOD to aircraft and engines. Torrential rainfall can result in flooding, so in addition to issues at the airport, flood damage may limit access to surrounding areas. Damage to buildings may render the airport and other facilities partially or totally unusable, and infrastructure damage may limit or prevent fueling of aircraft. Finally, assume that there probably will be utility and electrical outages — such as those that occurred in Puerto Rico after Maria — that can result in unsafe and/or unsanitary conditions.

Also, Crosier added, "If considering operations into such an environment after the passage of a storm, operators should consult with their in-house and third-party security providers, as appropriate, to determine what mitigations are necessary to ensure the safety and security of the operation."

The chief pilot for a charter/management company that frequently dispatches flights into the Pacific and Caribbean regions related some of his lessons-learned from operating into hurricane-prone areas, especially in the wake of the storms.

"First," he quipped, "don't be there when there is a hurricane." Then he turned serious: "We will get calls like, 'The hurricane's coming, can we charter your airplane to come and get our people out?' The last one to hit Hawaii, we got a call from a news agency, 'Please come and get our people off this island!' The big concern in situations like this is that there will be major evacuations by airlines and, thus, there may not be enough gas for us to get out once we've gotten in."

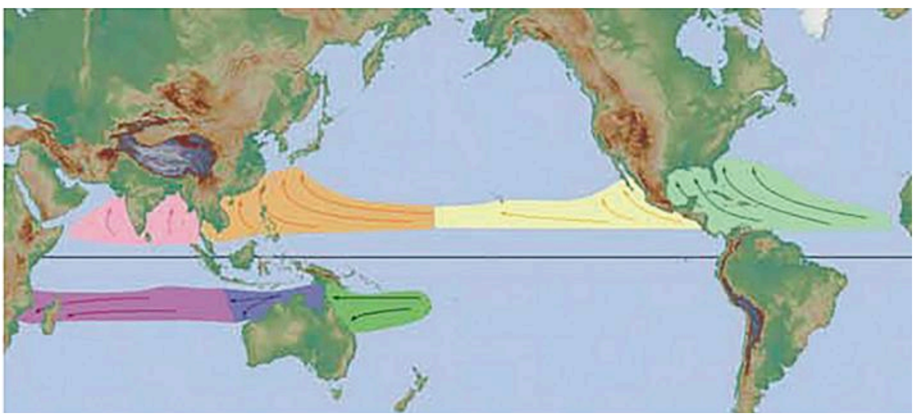
From these experiences, the pilot has composed a checklist to support post-hurricane missions to destinations that have been hit by storms. "It is extremely important to communicate with a reliable source on the status of the airport and the surrounding area on access and egress," he stressed. "After the event, we want to talk to a government entity, not just the FBO — if there is one still standing — to determine the status of the runway and the rest of the airport. We went to St. Martin [in the Leeward Islands of the Caribbean] after a hurricane in 2002 and found that there were ships on the side of the runway dumped there by the storm surge. Nevertheless, we were told the strip was good, so we landed anyway. You also have to know the condition of the infrastructure. On St. Martin, over half of the hotels on the island were closed due to damage from the storm."

Next, what is the fuel situation? "We may have to plan round-trip fuel in and out if there is no fuel on the airport. In Hawaii or other Pacific islands, you probably won't be able to do that because of range issues unless you're running one of the ultra-long-range business jets."

Then, check the infrastructure, the chief advised. "Roads. Communications. Will the cellphones work or will I need a satellite phone? Consider availability of food and provisions. St. Martin was hit by a devastating storm that approached from the west — not the usual [easterly] direction from which they get them. Normally, St. Martin survives hurricanes because it is shielded by a mountain on the east side of the island. This time, it didn't. But there was a guy there who ran a Burger King out of a trailer, and when he saw the storm coming, he towed that trailer into a tunnel in the mountain, and after the storm, he was the primary food source in the area. He contacted the Burger King people, and the next day they sent a C-130 to the island loaded with food.

"If you have to get off the airport, what are the conditions of the roads?" he continued. "Will you need potable water?

NATIONAL WEATHER SERVICE JETSTREAM ONLINE SCHOOL



Tropical cyclone formation regions: Note Atlantic tracks from Africa to Caribbean and U.S.; Pacific tracks from Mexico south of Hawaii to Southeast Asia and north to China and Japan; Indian Ocean tracks north to Indian subcontinent; and southern hemisphere tracks west from Australia to Madagascar to southern Africa.

Here is an argument for carrying desalination kits on the airplane. There may be security issues to deal with a big population competing for limited resources, too. Lastly, depending on the devastation, you may face flat-out restrictions on operating there at all."

Note that for humanitarian flights, the FAA requires compliance with an Op Spec addressing emergency relief service. "You can't just show up and drop off supplies without complying with it," the pilot said. "You have to work with an organization on the ground in charge of receiving and distributing supplies. This is different from the company mission to just go there and pick people up." The pilot's employer has conducted humanitarian operations to locations like Haiti after the 2010 earthquake there. "We were prepared to do this. We've tankered fuel when we've had to, and we operate transport category airplanes."

Prepare for a Hit

In the U.S. federal government's weather monitoring apparatus, the National Oceanic and Atmospheric Administration's (NOAA) Climate Prediction Center in College Park, Maryland, takes the lead in seasonal forecasting. It was scheduled to issue its outlook for the 2019 hurricane season on May 23.

Dennis Feltgen, NOAA communications and public affairs officer at the National Hurricane Center (NHC) in Miami, cautioned readers to "keep in mind the outlook only provides a range of how many named storms, hurricanes and major hurricanes are expected to form over the entire Atlantic basin during the entire six-month hurricane season."

The outlook, however, does not answer the most common question addressed to the NHC: "What are we going to get this year?" Feltgen pointed out that "There is no forecast of where/when storms will form, or if/where they will hit land and what the impacts will be. It is why an outlook can never be used as a guide to preparation. It only takes one storm hitting you to make it a bad year. So, this year should be treated like any other year: Prepare as if you are going to get hit." **BCA**

Cyclonic Storm Flight Planning Resources

List of Tropical Cyclone Regional Specialized Meteorological Centers (RSMCs)

Caribbean Sea, Gulf of Mexico, North Atlantic and eastern North Pacific Oceans:
RSMC Miami-Hurricane Center/NOAA/NWS National Hurricane Center, USA
http://www.nhc.noaa.gov/index.shtml

Western North Pacific Ocean and South China Sea:
RSMC Tokyo-Typhoon Center/Japan Meteorological Agency
http://www.jma.go.jp/en/typh/

Bay of Bengal and the Arabian Sea:
RSMC-tropical cyclones New Delhi/India Meteorological Department
http://www.imd.gov.in

South-West Indian Ocean:
RSMC La Réunion-Tropical Cyclone Centre/Météo-France
http://www.meteofrance.re/cyclone/activite-cyclonique-en-cours

Southest Pacific Ocean:
RSMC Nadi-Tropical Cyclone Centre/Fiji Meteorological Service
http://www.met.gov.fj/index.php?page=warn

Central North Pacific Ocean:
RSMC Honolulu-Hurricane Center/NOAA/NWS, USA
http://www.prh.noaa.gov/hnl/cphc/

List of Tropical Cyclone Warning Centers (TCWCs) with Regional Responsibility

South-East Indian Ocean:
TCWC-Perth/Bureau of Meteorology (Western Australia region), Australia
http://www.bom.gov.au/cyclone/?ref=ftr

Arafura Sea and the Gulf of Carpenteria:
TCWC-Darwin/Bureau of Meteorology, Australia
http://www.bom.gov.au/cyclone/?ref=ftr

Coral Sea:
TCWC-Brisbane/Bureau of Meteorology, Australia
http://www.bom.gov.au/cyclone/?ref=ftr

Solomon Sea and Gulf of Papua:
TCWC-Port Moresby/National Weather Service, Papua New Guinea
Website under construction
http://www.pngmet.gov.pg/

Tasman Sea:
TCWC-Wellington/Meteorological Service of New Zealand, Ltd.
https://www.metservice.com/warnings/tropical-cyclone-activity

Jakarta/Indonesia:
TCWC-Meteorological and Geophysical Agency, Indonesia
http://meteo.bmkg.go.id

U.S. Department of Defense Resources

North-West Pacific Ocean, South Pacific Ocean, and Indian Ocean:
Joint Typhoon Warning Center (JTWC)
https://www.metoc.navy.mil/jtwc/jtwc.html

General Forecast Products:
Fleet Numerical Model Output Center (FNMOC)
https://www.usno.navy.mil/FNMOC

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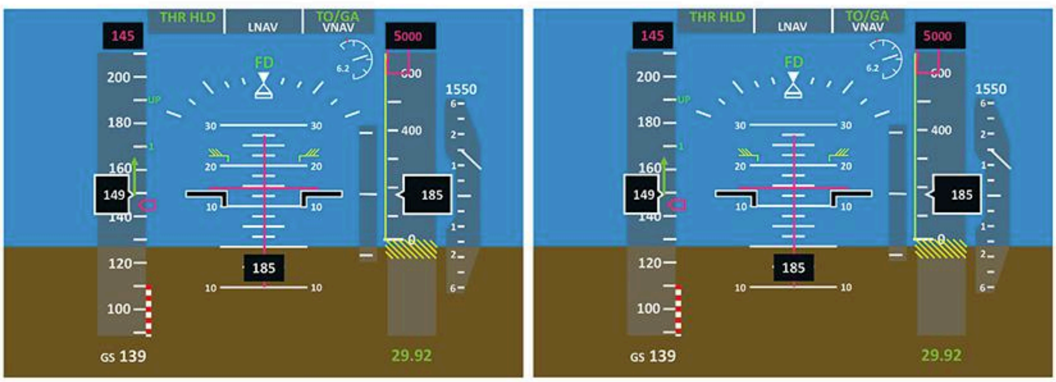
Lessons From the MCAS Accidents

Deficiencies in **training, airmanship and experience** are all factors

BY **FRED GEORGE** fred.george@informa.com

LEFT AND RIGHT PFDS – NORMAL AIR DATA AND AOA



Pundits, politicians and the general press continue to jab fingers into Boeing and the FAA over design and certification shortcomings associated with the Boeing 737 MAX. The aircraft's maneuvering characteristics augmentation system (MCAS) is implicated in the Lion Air Flight 610 and Ethiopian Airlines Flight 302 accidents that, combined, killed 346 people, as though government airworthiness regulators and the Chicago-based jetliner manufacturer were solely to blame for the tragedies.

In his April 2019 news release, Boeing CEO Dennis Muilenburg acknowledged that a malfunctioning MCAS was involved. But he also noted, "The history of our industry shows most accidents are caused by a chain of events. This again is the case here, and we know we can break one of those chain links in these two accidents. As pilots have told us, erroneous activation of the MCAS function can add to what is already a high workload environment."

While MCAS is unique to the MAX, all in aviation can derive important safety lessons for their own operations — regardless of aircraft make or type — from the tragedies.

The two accidents most assuredly involved multiple factors, including B737 MAX flight control computer software design shortcomings, but in addition there was a lack of information provided to airlines about how and why MCAS works, along with crew training deficiencies, startle factor, distraction and disorientation, along with a failure of cockpit resource management and basic airmanship, among others.

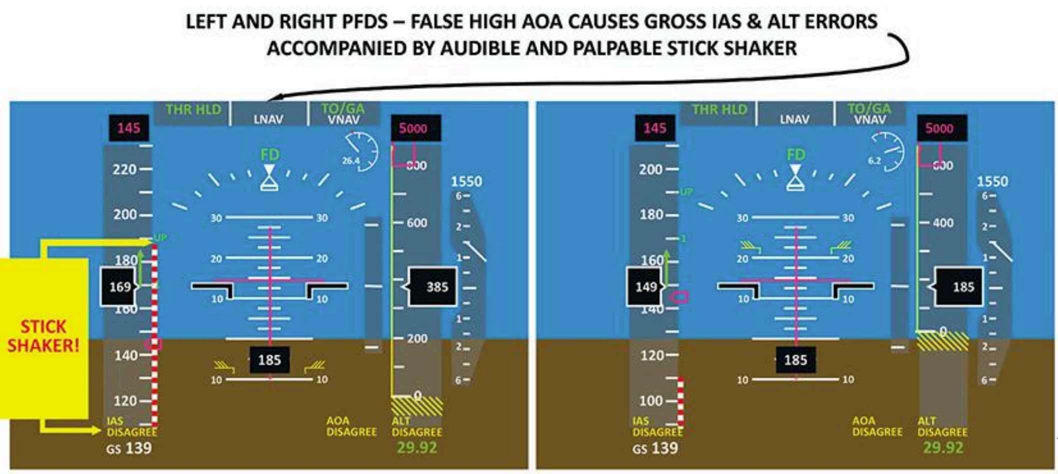
MCAS is a new flight control computer law that was added to the MAX because the latest 737's new LEAP 1B turbofans are considerably larger than their predecessors, mounted higher and farther ahead of the wing for ground clearance and produce considerable vortex lift at high angles of attack (AOA). The extra lift shifts forward the center of pressure, thus reducing the aircraft's longitudinal stability as it approaches aerodynamic stall. This is not problematic, except when slats and flaps are retracted, and at extremely light operating weights and at full aft CG. In this extreme corner of the flight envelope, the margin between the center of pressure and CG gets too thin at high AOA, so the MAX cannot meet certification requirements for positive pitch stability. Increasing G, or load factor, just aggravates the instability at high AOA.

MCAS is a stability augmentation function, embedded in the flight control computer software, that commands up to 2.5 deg. of nose-down stabilizer trim at high AOA, depending upon the starting position of the horizontal stabilizer and aircraft Mach number, to increase nose-down pitching moment sufficiently to augment pitch stability enough to meet airworthiness standards. Despite numerous news reports to the contrary, MCAS is not an "anti-stall" or "stall prevention" system. It's there to make the MAX behave like a Boeing approaching the stall, at full stall and during stall recovery.

Notably, flight tests have shown that MCAS is not needed to meet the certification standards at normal operating weights with typical minimum fuel reserves and passengers aboard. There is a fat spread between center of pressure and CG, so the forward shift in the former caused by nacelle vortex lift doesn't significantly degrade pitch stability.

One pilot, who has flown and evaluated both the Boeing 737NG and MAX models, recounted his experience flying a full aerodynamic stall with MCAS inoperative in the latter's engineering cab simulator: "We reduced thrust at 5,000 ft. and slowed the aircraft at about 1 kt. per second. We were at a mid-range

CG with gear, slats and flats up. We trimmed until we reached 30% above stall speed and then just continued to ease back on the control wheel. Pitch feel was natural, progressively increasing as airspeed decayed. Somewhere between the audible low airspeed warning and stick shaker, I felt the slightest lightening on control pressure in my fingertips. Quite candidly, if I hadn't been watching for it, I don't think I would have noticed any difference between the MAX and the NG. I kept pulling back through stick shaker, then buffet, then elevator feel shift [a function that doubles the artificial control feel forces near stall] and finally until the yoke was buried in my lap. The nose just flopped down gently at the stall and I initiated recovery as I would in most other airplanes I've flown.”



FRED GEORGE/BCA

Boeing added two more vortilons to each wing leading edge, for a total of six per side, and also lengthened and raised the inboard, leading edge stall strips to assure the MAX's stall behavior would be as docile as that of the NG in most parts of the flight envelope. However, the pilot commented that he'd previously not flown any slower than stall warning stick shaker during MAX or NG sim sessions.

Multiple Factors in Accident Chains

As originally implemented, MCAS had at least five potentially serious flaws.

First, it appears Boeing didn't tell operators, pilot unions or flight crews about the MCAS function being added to the MAX, let alone teach all stakeholders about normal and abnormal operating modes. So, apparently, the first time MCAS activated, it would come as a surprise to pilots. The rationale? Boeing officials seemed to believe that MCAS would be triggered so rarely that there was virtually no need to burden operators with its technical minutia.

Second, the original version of MCAS used a single α vane sensor. AOA probes and vane sensors have proven so reliable that their failure was deemed to be an ultra-rare event. But if a single AOA sensor did malfunction — evidently the case in the Lion Air and Ethiopian crashes — MCAS could be erroneously triggered.

Third, Boeing 737 pilots long have been taught that pushing or pulling the yoke against the stick forces activates the control column force trim cutout switches that interrupt electrical power to the trim system. This temporarily freezes uncommanded stab trim, thereby affording time for the crew to turn off both manual and autopilot cutoff switches on the center console, halting stab trim runaway.

But that's not the case with MCAS. Once it's triggered and it starts commanding nose-down stab trim, pulling back on the yoke won't deactivate the electric stab trim system. The rationale? If pilots could disable MCAS with yoke pressure, it would have defeated the design intent of MCAS commanding nose-down trim to increase longitudinal stability.

Fourth, pilots weren't told that if they made pitch trim inputs, using the thumb switches on the control wheels while MCAS was operating, after a 5-sec. delay, it would trigger another nose-down trim command if the high AOA condition persisted. Repeated MCAS nose-down trim commands could drive the elevator to full travel, causing the horizontal stab to overpower the elevator's pitch control authority. B737 pilots say the stab at full travel always “wins” over elevators. Pilots usually lose the pitch control battle with the stab and the aircraft goes out of control.

Fifth, an MCAS horizontal stab trim runaway most likely would be preceded by an impressively distracting and disorienting IAS disagree/ALT disagree/stall warning stick shaker/runaway stall margin red “zipper” on the airspeed scale. The air data computers use AOA inputs to correct pitot and static position source errors for variations in relative wind angle. If an α sensor erroneously goes to full up travel on takeoff rotation, as it did in the Lion Air and Ethiopian crashes, it can cause significant airspeed and altitude indication variations between the left- and right-side PFDs. One pilot, who flew MCAS failure scenarios in Boeing's 737 MAX engineering simulator, explains the resulting confusion and potential for loss of situational awareness.

“We began a normal takeoff, but at rotation, the left AOA pegged at the top of the scale. This was like nothing we've seen before during initial or recurrent sim training. The [stall warning] stick shaker fires continuously, using loud sound and control wheel vibration to focus your attention on the critically high AOA indication. But I didn't appreciate the effect that erroneous AOA also has on creating such large-scale indicated airspeed and altitude errors on the PFD. It was both distracting and disorienting because I'd not seen it before in sim training. I initially got tunnel vision and blinded as to what might next happen.”

Large errors in AOA can cause 20- to 40-kt. errors in indicated airspeed and 200- to 400-ft. errors in indicated altitude, according to the pilot we interviewed. This is accompanied by IAS disagree (indicated airspeed disparity between left and right PFDs) and ALT disagree (indicated altitude disparity between left and right PFDs) warning annunciators that illuminate on both PFDs. Boeing also is upgrading the MAX with optional AOA dial indicator displays and standard AOA disagree warning annunciators on the PFDs.

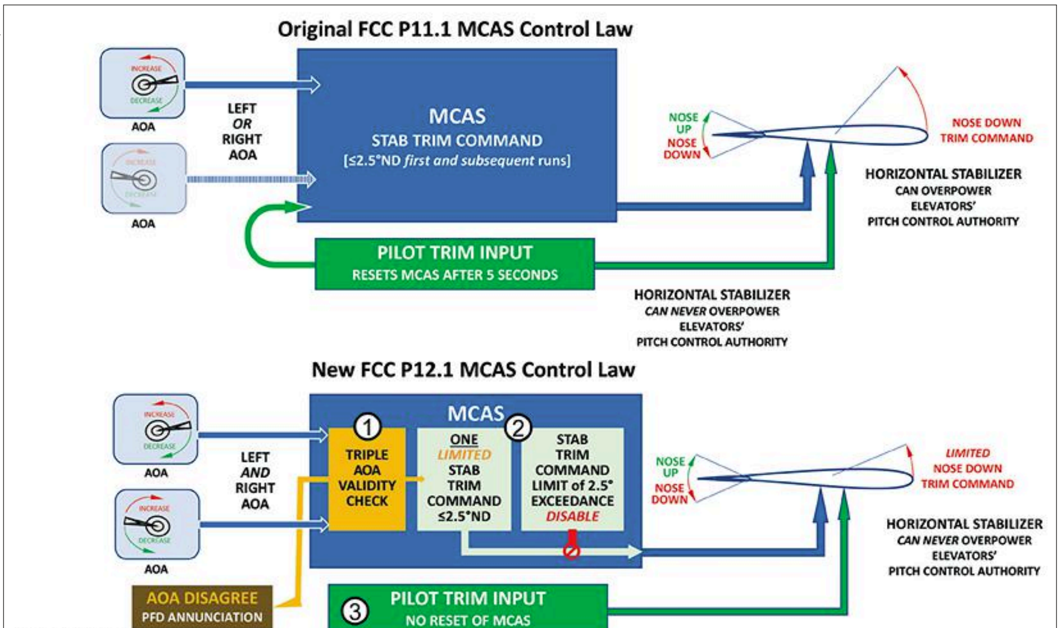
“We followed the checklist for ‘airspeed unreliable,’ assuring that autopilot, autothrottles and flight directors were turned off. We pulled back power to 80% N1 [fan speed], set 10-deg. nose-up pitch attitude and climbed to 1,000 ft. AGL. We then lowered the nose, started accelerating and began retracting slats and flaps at 210 KIAS."

When the slats and flaps were fully retracted, MCAS kicked in because of the erroneous high AOA reading.

"It's a good thing we knew what to expect. Otherwise tunnel vision from the "airspeed unreliable" event could have blinded us to the subsequent MCAS nose-down trim input. When I noticed the frisbees [manual trim wheels] racing, I grabbed the left wheel. It was easy to stop the trim with hand pressure, but I knew in advance what was happening. We followed the checklist for runaway stabilizer, checking again for autopilot off and autothrottle off. We turned off both trim cutout switches and cranked the frisbees to relieve control pressures. We used manual trim for the remainder of the flight to landing touchdown and rollout. That was quite an eye-opener, as I had never been exposed to that during sim training, let alone actually experienced it."

The pilot said it's critical to follow the checklist memory items, pull back thrust to 75% after retracting slats and flaps and peg nose attitude at 4-deg. nose up. Let speed build up beyond 220 to 250 kt. and controllability becomes increasingly difficult, if not impossible, because air loads create so much friction in the elevator jackscrew that the stab cannot be moved using the manual trim wheels.

FRED GEORGE/BCA



MCAS Changes
1. Both AOA Sensors used: MCAS inhibited if sensors vary by ≥5.5°; sudden low-to-high spike in AOA; AOA rate change unreasonable
2. Elevator pitch authority exceeds MCAS stab pitch authority; MCAS disabled if command limit is reached.
3. MCAS will activate only once for each elevated AOA input. No 5-second reset after pilot trim inputs.

Train-to-Cost Versus Train-to-Proficiency

In the wake of the Indonesian and North African B737 MAX crashes, some airline pilots feel betrayed by others in the aviation industry. They say they've never been taught about how gross AOA sensing errors can cause substantial deviations in air data indications between the left and right PFDs, let alone runaway stall warning tapes and constant stickers. They've never been exposed to non-normal systems scenarios during initial or recurrent simulator training sessions, such as the ones already described.

B737 pilots, flying for three U.S. air carriers, told us they've never had to fly the simulator from the point of a runaway stab emergency all the way back to landing at a divert field using the "frisbee" manual trim wheels. In contrast, one retired airline captain who flew for the former Air Berlin, told us that, years ago, flying the sim to touchdown with manual trim was a regular part of his recurrent training. Such rigorous sim training no longer is routine in the airline industry.

"We're just checking boxes for the FAA," says one Seattle-based B737 airline pilot. This aviator, in his mid-30s, has logged more than 17,000 hr. total flight time in the 737, CRJs, tow planes, sailplanes, sky dive aircraft and his own Cessna 185, plus a DC-3 and a P-40 Warhawk, among dozens of other models. But he's the exception, rather than the norm among professional pilots in his age group. He expects a higher level of training to assure airline pilots are proficient.

But finding a sufficient number of new pilots to fill slots in a rapidly growing industry is tough. And allocating enough time and resources for comprehensive training of new hires is challenging.

"Airlines worldwide face a pilot shortage created by the tandem forces of pilot retirements and escalating air traffic. Thus far, the focus has been on the quantitative challenge. New academies and career programs are targeted at increasing the output of pilots but are up against issues such as instructor capacity and financing," wrote Thierry Dubois, Aviation Week & Space Technology's Lyon, France, bureau chief for that sister publication, this past March. "The pilot shortage is both quantitative and qualitative."

"A looming pilot shortage is coupled with variation in the level of training worldwide," Jean-Michel Bigarre, head of global flight training for Airbus, told Dubois.

There isn't much consistency in pilot training or proficiency around the world. "[We] see strange things in poor countries where air transport is growing very fast — suspiciously quick pilot qualification and fraudulent flight hour accounting," Bigarre added.

But as the U.S. pilot said after flying the MAX engineering cab simulator, the emergencies he experienced in runaway AOA scenarios, including the need to fly the aircraft all the way to touchdown using manual trim, were like nothing he'd experienced during NG or MAX sim training sessions. His comments were echoed by other airline pilots with whom we spoke. That doesn't speak well of First World training standards. So, can we expect flight training to be better in poorer countries than it is in the west?

Boeing's new flight control computer P12.1 software load provides triple-redundant AOA validity checks to prevent false triggering of MCAS. It also limits the system's nose-down stab trim authority. And if the MCAS nose-down stab trim command ever exceeds 2.5 deg., the system is disabled. Those changes should assure there will be no more MCAS runaways.

However, Boeing's upgrade addresses only one problem affecting one airplane model. It doesn't look at those controllability issues as being more symptomatic of numerous larger problems, including training, airmanship and preparation for the unexpected. Chief among these is the current train-to-cost, rather than train-to-proficiency, pilot instruction model.

"Human error may explain the 'what,' but not the 'why.' We wouldn't do this if it were computer error. We'd find why the computer made the error. We'd fix it," says Capt. Shem Malmquist, a former Air Line Pilots Association aircraft technical and engineering chairman for his company and now visiting professor at the Florida Institute of Technology. "If we want to eliminate accidents, we need to train pilots to do the one thing that computers cannot. That is to innovate, to come up with novel solutions that are outside of anything that designers could imagine on the ground. We expect pilots to manage any unexpected events they might encounter in a flight."

Malmquist also authored Angle of Attack, a book that examines the Air France Flight 447 accident, among others, as it relates to the abilities of pilots to handle the unexpected.

"But how do they gain these skills? And are we providing new pilots with that opportunity?" he asks. "As training becomes more regimented, pilots are exposed less and less to unusual events and more and more to well-defined scenarios. Pilots are getting very good at handling expected problems, but they are losing their ability to handle the unexpected."

The "why" of human error involves pilot experience, the quality of knowledge-based training and the frequency and depth of learning during simulator sessions. Critics point to the scant 200 hr. of flight time logged by the copilot of Ethiopian Flight 302.

"There's no way they can claim they had a qualified crew on that flight," says Mike Boyd, an Evergreen, Colorado-based aviation industry analyst in a Washington Post report. Many current and former U.S. airline pilots, including Capt. Chesley "Sully" Sullenberger, are strong advocates of retaining the 1,500-hr. minimum flight time rule for airline pilot new hires.

But U.S. and other military pilots typically fly no more than 250-275 hr. before earning their wings. And then they're fully qualified to fly Mach 2 fighters and land them aboard aircraft carriers or pilot attack helicopters into combat, attesting to the quality of military undergraduate pilot training.

Military pilots are taught innovation and creativity when dealing with airborne emergencies, including evaluating aircraft performance capabilities after battle damage. Simulator sessions often involve compound emergencies, ones that start with seemingly minor malfunctions that progress into major emergencies. Air Facts Journal's Arnold Reiner partially attributes the services' high level of proficiency to sifting out potentially weak performers during rigorous pilot candidate screening and comprehensive physical exams that candidates undergo as a condition of being accepted for flight training.

Years ago, Robinson Helicopter Co. instituted a flight instructor training program that emphasizes lessons learned from R22 light helicopter accidents. The goal was to eliminate maintenance and pilot errors that cause such mishaps. It succeeded in slashing the fatal accident rate of both certified flight instructors and students. The training program became a model for the rotary-wing community. Southwest, among other U.S. airlines, also wraps lessons learned from accidents into its risk resource management training programs.

Yet, too many online, classroom and simulator training sessions still emphasize conventional emergencies. For instance, turbofan pilots learn to how handle engine failure or fire before and after the V_1 takeoff decision speed. They do not address "black swan" events, such as catastrophic engine failure or gross AOA sensing errors. But such events do occur, as evidenced by the uncontained, high-energy engine rotor burst that occurred aboard Qantas Flight 32, an Airbus A380 that departed Singapore for Sydney in November 2010.

Capt. Richard de Crespigny and crew had to struggle with controllability issues, erroneous or missing ECAM alerts, partial or total failure of several systems and massive fuel leaks that could have left the crippled jet engulfed in flames after landing rollout. De Crespigny, a 35-year pilot at the time of the incident, told us that he gleaned critical knowledge about the aircraft and its systems by studying the A380 flight crew operations manual and several other technical documents for 2 hr. every day. While determining what was wrong with the aircraft, he never lost his focus on first flying it and then sorting out the malfunctions.

Similarly, an AOA sensor that suddenly springs to full upscale on takeoff rotation may seem as though it's just as unlikely as an explosive engine failure. But it seems that very malfunction did indeed occur aboard Lion Air Flight 610 and Ethiopian Flight 302. And it startled the flight crews, perhaps leading to a loss of situational awareness, including failure to recognize the subsequent runaway stab trim.

The three B737 pilots, flying for U.S. air carriers, with whom we spoke for this report told us they've never seen anything like that during recurrent simulator training sessions. They haven't been taught that AOA inputs are used by the air data computers to correct for pitot and static position source errors to provide calibrated airspeed and altitude readouts on the PFDs. Thus, they'd never been taught in the classroom about the distraction and disorientation that can be caused by catastrophic AOA sensor failure on takeoff, let alone experienced it during sim training.

They've been taught some of the nuances of the B737 speed trim and Mach trim functions, but never MCAS stab trim. And none of the three said they had been required to use manual trim to fly the simulator from the point of an electric pitch trim malfunction all the way to landing.

A preliminary analysis of the MCAS-related crashes in Indonesia and North Africa thus reveals a complex chain of events to which Boeing's Muilenburg alluded. The responsibilities of civil aviation regulatory officials go far beyond just assuring that airplanes are safe to fly when delivered by the manufacturers. There needs to be much closer monitoring of maintenance, line service disciplines and crew training.

What caused the apparent AOA sensor failures aboard the two doomed jetliners may never be determined. However, a thorough investigation into ground handling protocols, along with a review of all maintenance procedures, quality control checks and records, is a must. Regulators need to determine how such sensors might have been damaged on the ground or misrepaired during shop visits to prevent future sensor malfunctions.

It's time for international agreement by governments, manufacturers, airlines and pilots to raise the bar on all these levels to restore public confidence in the safety and security of air travel. And using Boeing or the FAA as the sole scapegoats won't cut it. BCA

2019 Avionics Roundup

While business aircraft utilization **continues to climb** — slowly — **avionics sales remain strong.** A sampling of some of the new products and services follows.

BY **MAL GORMLEY** mal.gormley@gmail.com

Embraer Legacy 650 cockpit

Jet Support Services Inc. (JSSI), a provider of maintenance support and financial services to the aviation industry, released its JSSI Business Aviation Index for the fourth quarter of 2018 in March. The index tracks utilization of approximately 2,000 business aircraft worldwide and reports average flight hours flown on a monthly basis by region, industry and cabin type. According to it, global business aviation flight activity recorded a year-to-date increase of 4.9% in 2018 and a year-over-year increase of 4.7%. Regional increases were reported in nearly every segment of the world, with the highest year-to-date increases reported in Africa at 17.4%, Europe at 8.8% and South America at 8.1%.

Neil W. Book, president and CEO of JSSI, said of the findings, "This positive trend in aircraft utilization demonstrates a high level of confidence in current economic conditions. The continued growth this year, with back-to-back quarters of flight hour averages not seen since 2008 and a year-over-year increase of 5.7%, is a testament to today's demand for private travel."

Meanwhile, the Aircraft Electronics Association (AEA) says worldwide sales of business and general aviation avionics rose 15.5% in the first nine months of 2018 compared to the previous year. Avionics sales worldwide totaled $2 billion during the first three quarters of 2018, up from $1.73 billion for the same time in 2017. According to the association, both retrofit and forward-fit markets experienced double-digit sales increases when compared to the first nine months of 2017.

"With robust growth in sales during the first nine months of the year, [our] industry is on pace to produce the largest dollar amount of year-end avionics sales since the reporting process began back in 2012," AEA President Paula Derks said. "We have now seen seven straight quarters of positive year-over-year growth dating back to the end of 2016, and it's an encouraging sign for the industry that sales are strong in both the forward-fit and retrofit markets."

Sales include all business and general aviation aircraft electronics sales, including all components and accessories in the cockpit, cabin, software upgrades, portables, certified and noncertified aircraft electronics, all hardware, batteries and chargeable product upgrades from participating manufacturers, the AEA said.

Sales to the retrofit market — avionics equipment installed after original production — totaled $1.15 billion during the first nine months of 2018, up 14.7% from a year earlier. Sales to the forward-fit market — avionics equipment installed by airframe manufacturers during original aircraft production — totaled $854.9 million, up 16.6% from the same period in 2017. Of total sales, 77.7% occurred in North America, while 22.3% took place in international markets.

Despite the good news on utilization and avionics sales overall, sales of new business aircraft remain relatively flat.

Trending

First, let's take a look at some of the largest developments in the avionics industry.

With its acquisition of Rockwell Collins last November, Farmington, Connecticut-based United Technologies Corp. (UTC) plans to spin off its non-aerospace business units, Carrier heating and air conditioning, and Otis elevators, and potentially become a $50 billion aerospace parts, engines and services provider.

The decision to divest its Carrier and Otis subsidiaries was announced the same day UTC closed on its record-making $30 billion acquisition of Collins, which it merged with UTC Aerospace Systems but renamed with the Collins brand. UTC's breakup heralds an end to an era of industrial conglomerates participating in aerospace and defense, as General Electric and others have also sold off non-aero units.

Carrier and Otis will be gone over the next 18-24 months. The remaining UTC will focus on acquisition and development of its two surviving brands: Collins Aerospace and Pratt & Whitney. The post-spinoff UTC will count nine major business lines, six under Collins Aerospace. Each will have $3 billion to $5 billion in annual revenue.

Meanwhile, in early November 2018, Haifa, Israel-based Elbit Systems Ltd. completed its acquisition of the assets and operations of Universal Avionics Systems Corp., headquartered in Tucson, Arizona, for approximately $120 million.

Universal Avionics' equipment for the retrofit and forward-fit market for fixed- and rotary-wing aircraft, including flight management systems (FMSes), displays, communication systems and related avionics, are complementary to Elbit Systems' commercial avionics systems. Since its entry in the commercial aviation market in the early 2000s, Elbit has introduced several innovative avionics systems, including the first enhanced vision system (EVS) for business jets. The new Universal Avionics will retain its name and leadership and will continue to operate from its current offices.

The coming year will see the introduction of a new generation of internet protocol-based broadband satellite communications services to the flight deck, delivered by smaller, lighter avionics shipsets. The bigger space-based data pipes and smaller and lighter avionics will soon support operational applications for cockpits. Virginia-based Iridium expects to start its Certus service for aviation users by midyear, delivering global broadband connectivity to aircraft flight decks supporting electronic flight bags (EFBs), graphical weather and other applications.

An internet protocol-based service operating in the L band, Certus employs the new-generation, Iridium Next satellite constellation. The final 10 satellites of the 75-satelitte LEO (low Earth orbit) constellation (66 operational and nine spares) were launched in January by California-based SpaceX, headed by Elon Musk.

In addition to supporting Certus service, Iridium Next satellites carry automatic dependent surveillance-broadcast (ADS-B) receivers for the Aireon space-based surveillance network.

Iridium has designated Thales, L3 Communications, Collins and Gogo as service providers and Iridium value-added manufacturers, which are licensed to build and sell Certus hardware. It also has named Collins Information Management Services, Satcom Direct, Honeywell Aerospace, Skytrac, Avitek and Navicom Aviation as service providers.

Meanwhile, British satcom competitor Inmarsat's SB-S, which uses geographic spot-beam technology over Inmarsat's I-4 series geostationary satellites, will receive terminals from avionics manufacturers Cobham, Honeywell and Thales. Communications network providers SITA OnAir and Collins recently signed distribution agreements with Inmarsat to make SB-S available to airline and business aviation operators.

Both Inmarsat's SwiftBroadband and Iridium's fleet operate in the L-band frequency range of 1-2 GHz. Though it has had a narrower pipe for voice and data, Iridium's lower-orbiting satellites provide full global coverage to include the high polar regions, which Inmarsat's geosynchronous-Earth-orbit system cannot. With the advent of the Iridium Next constellation, it will compete with Inmarsat on bandwidth. In late March, a private equity-led consortium agreed to buy Inmarsat Plc for about $3.4 billion in cash. The U.S.-U.K.-Canadian consortium is betting in part on Inmarsat's ability to sell faster and more reliable inflight Wi-Fi to air carriers.

Following the disappearance of Malaysia Airlines Flight 370 in March 2014, the International Civil Aviation Organization (ICAO) promulgated a requirement that aircraft be capable of reporting their position every 15 min. by November 2018, leading to the development of a more stringent Global Aeronautical Distress and Safety System (GADSS) by 2021. Aircraft fitted with Inmarsat's Classic Aero system can already meet the 15-min. tracking standard. SB-S, which features a built-in GPS tracking function capable of constantly transmitting aircraft position, altitude, speed and heading, also meets GADSS requirements for once-per-minute autonomous distress tracking, Inmarsat says.

In June 2014, the FAA revised its master minimum equipment list (MMEL) requirements to allow an approved satcom voice system to serve as an alternative for one of the two high-frequency voice radios required on long-range aircraft. Iridium says its single-channel Safety Voice service now flies on nearly 700 aircraft, mostly airliners. One of the design drivers of Certus was to advance such aviation safety applications with a higher-bandwidth voice and data system. One such application could be a "push-to-talk" function with dedicated channels that would look and feel like a tunable radio.

Iridium Next satellites also will host payloads from third-party and partner companies, including ADS-B receivers offered by Aireon, a joint venture of Iridium, Nav Canada and the air navigation service providers of Ireland, Italy and Denmark.

In other developments, the Dassault Falcon 900LX, Falcon 2000LXS and Falcon 2000S have been certified by the European Aviation Safety Agency (EASA) and the FAA for an enhanced flight vision system (EFVS) capability that greatly improves access to airports in bad weather, providing operational credit for poor visibility approaches down to 100 ft.

The new EFVS capability, provided through Dassault Aviation's revolutionary FalconEye Combined Vision System (CVS) and its unique combination of six fused sensors, was previously certified on the Falcon 8X ultra-long-range trijet following the completion of joint EASA/FAA trials last year. The system will also be available on the new Falcon 6X ultra-widebody twinjet, which is due to enter service in 2022.

FalconEye is the first head-up display (HUD) to show separate synthetic, database-driven terrain mapping and enhanced thermal and low-light camera images at the same time. It also allows pilots to adjust the split between a synthetic vision system (SVS) and an EVS imaging area to suit visibility conditions.

Original Equipment Manufacturers

Astronics/Max-Viz

East Aurora, New York-based Astronics Corp. has obtained an amended Supplemental Type Certificate (STC) for its Max-Viz 2300 EVS. Offered by the company's wholly owned subsidiary Astronics Max-Viz and obtained in cooperation with AVIO dg in Calgary Canada, the STC covers multiple Textron and Leonardo Helicopter models, including the latter's AW109 and AW119 aircraft.

With the approval, images produced by the Max-Viz 2300 can now be presented on multi-function displays (MFDs), primary flight displays (PFDs) or on standalone displays depending on aircraft configurations. The amendment upgrades the wiring package to include Vivisun switches for more-effective mission utilization with night vision goggles (NVGs) in search and rescue, emergency medical services, aerial firefighting and military applications.

A recent ruling from the FAA permitting properly equipped aircraft to fly certain instrument approaches to landing, in lieu of relying on natural vision, is expected to drive additional acceptance of EVS technology. Of the over 3,250 installed Astronics Max-Viz enhanced vision systems, approximately 60% are on fixed-wing general aviation aircraft and 40% are operating on helicopters.

Avio dg will serve as the point of contact for obtaining new installations of the Max-Viz 2300 with this STC and can be reached at http://www.avio-dg.com.

Avidyne

Following the initial STC of Avidyne's IFD550/540 in the Cessna CitationJet 525/A models, the manufacturer is aiming for wider-reaching retrofits in the Citation CJ1+, CJ2+ and CJ3.

Astronics new STC covers multiple Textron and Leonardo Helicopter models, including the latter's AW109 and AW119 aircraft.

Avidyne is actively involved in multiple FMS upgrade programs for Cessna's Citation series of aircraft, using its IFD550/545 FMS navigators to provide localizer performance with vertical guidance (LPV) approach capability, electronic approach charts, wireless connectivity and ADS-B compliance at competitive prices. Initial CJ certification was obtained in NASCAR legend Bill Elliott's 2001 Cessna CJ1.

Citation CJ1+, CJ2+ and CJ3 owners who upgrade to the Avidyne IFD series FMS systems will add hybrid-touch FMS capability; autopilot-coupled LPV approach capability; 3-D synthetic vision views of nearby terrain, obstacles and traffic; integrated wireless connectivity to the IFD100 and many third-party apps including ForeFlight; plus an option for dual Avidyne SkyTrax 322 remote-mount or SkyTrax 340 panel-mount Mode S transponders for ADS-B Out compliance.

Meanwhile, Avidyne's TAS600 series traffic advisory systems (TASes) with ADS-B In have been TSOed, STCed and renamed. The systems combine the safety benefits of active-surveillance traffic detection and alerting with the increased precision and accuracy of ADS-B In. With the addition of ADS-B In, the TAS600 series is being rebranded as the SkyTrax 600 series, extending Avidyne's line of SkyTrax ADS-B products.

The SkyTrax 600 series includes the SkyTrax 600 ($9,999), the SkyTrax 605 ($11,099), the SkyTrax 615 ($14,999) and the SkyTrax 620 ($20,999). Each of these active-surveillance TAS/ADS-B systems correlates all the traffic information — derived from the active interrogation of nearby transponder-equipped aircraft, along with the direct reception of 1090 MHz position reports from participating ADS-B aircraft, plus the data received from ground-based rebroadcast (ADS-R and TIS-B) targets — to present pilots with the most accurate depiction of potentially conflicting aircraft.

New SkyTrax systems and SkyTrax upgrades for existing TAS600/9900BX TAS units are available now. SkyTrax upgrade time and cost will vary based upon the hardware vintage and configuration of the existing TAS system.

Collins

Flight tracking data provider FlightAware has added space-based surveillance coverage to its ground network of ADS-B receivers and announced Collins ARINCDirect as its first partner for the enhanced offering to business aviation.

FlightAware has incorporated satellite-routed ADS-B position data collected over oceans and remote areas by Aireon, whose system is based on ADS-B receiver payloads carried on Iridium Next satellites; it is expected to begin operating sometime this year.

Through an agreement with McLean, Virginia-based Aireon, FlightAware will combine space-based surveillance with its 19,000 terrestrial ADS-B receivers and other sources of data, including airlines and air navigation service providers (ANSPs) including the FAA. In addition to ARINCDirect, flight operation management system provider Avianis, of Austin, Texas, also will use space-based ADS-B, FlightAware said.

With space and terrestrial tracking available, FlightAware says it can provide operators with flight updates once per minute in the air and once per second on the ground.

EASA has certified the Collins Pro Line Fusion avionics upgrade for Pro Line II-equipped King Air B200 and B300 series turboprops. Featuring three, 14.1-in. widescreen liquid crystal displays (LCDs) with advanced graphics, the Pro Line Fusion suite supports compliance with Europe's June 2020 ADS-B mandate and satellite-aided localizer performance with vertical guidance approaches, radius-to-fix legs and other operations. The FAA approved the upgrade in 2016.

Meanwhile, Silicon Valley aviation tech firm Stellar Labs and Collins have launched a next-generation flight operations management product. The companies are jointly developing a suite of integrated, cloud-based applications as a successor to Rockwell Collins' ARINCDirect Flight Operations System (FOS). The new capability provides users with new architecture, web interface and features. The first set of cloud-based modules provides powerful capabilities for quoting, trip planning and reporting. Its reporting and analytics tool helps sales and revenue managers understand quoted and scheduled flight volume, conversion rates, revenue and profit margin with preconfigured reports.

And Collins Pro Line Fusion avionics are featured on Embraer's new Praetor 500 and Praetor 600 business jets. The Collins system offers an industry-first synthetic-vision guidance system on a head-up guidance system. Embraer's new midsize and super-midsize business jets also include predictive wind shear and vertical weather display capability. So, Pro Line Fusion is now featured on four Embraer aircraft, including the already certified and flying Legacy 500 midsize jet and the Legacy 450 mid-light jet.

In addition to these new options, Pro Line Fusion for the Praetor 500 and 600 features a pilot-selectable display format on four 15-in. diagonal LCDs that allows the flight crew to view plenty of information on multiple presentations. It also includes a paperless-capable flight deck with fully integrated, geo-referenced electronic charts, enhanced maps and electronic checklists; traffic collision avoidance system (TCAS) with optional ADS-B capabilities; dual advanced FMSes with wide area augmentation system/LPV (WAAS/LPV) and required navigation performance (RNP) capabilities; plus RNP AR 0.3 (optional); MultiScan weather radar providing full color, automatic and clutter-free storm cell tracking; as well as data link and optional future air navigation systems (FANS 1/A) on-demand text messaging.

Last year, Collins became aware of a minor TSO non-compliance issue with its TDR-94/94D transponders and developed a software fix to address that. Modification work was suspended at that time. However, it released a Service Bulletin for the fix by year-end and Duncan Aviation resumed modifications of the units at its Lincoln, Nebraska, facility. Modification of the transponders can be performed only by Collins or by Duncan's avionics component shop. The TDR-94/94D meet the FAA mandate requiring aircraft to comply with the DO-260B standard for ADS-B Out by Jan. 1, 2020.

"We'd like to reassure our customers that the recent software issue has no flight deck effect and in no way affects flight safety," said Mark Cote, vice president of component services at Duncan. "The fix will be an optional Service Bulletin that Duncan Aviation can perform during a scheduled maintenance event as a quick-turn in our avionics component shop. There is no reason to put down an aircraft for this modification."

PIPER

Garmin's G1000 NXi iavionics suite is certified on the Piper M350 and M500 (above).

Esterline CMC Electronics

Esterline Avionics Systems, CMD Flight Solutions and DAC International have obtained STC approval of their ADS-B Out solution for FAR Part 25 aircraft. The CMD STCs pair Esterline CMC Electronics' CMA-3024 GPS and satellite-based augmentation system (GPS/SBAS) and global navigation system sensor unit (GNSSU) receiver with the Collins TDR-94/94D or Honeywell RCZ-8XX Primus II com/transponder to meet the latest DO-260B ADS-B Out standards mandated worldwide.

These approved model list (AML) STCs, provided by CMD Flight Solutions, cover a wide list of aircraft including Bombardier's CRJ, Challenger and Dash-8; Hawker 400/400XP; Learjet 24, 35, 45 and 60; Gulfstream GII, GIII, GIV and GV; Cessna Citation II, V, VI and VII; and many more.

Due to its bolt-on installation, it requires no special avionics mounting. The CMA-3024 aviation sensor provides ADS-B-compliant SBAS/GPS primary means navigation for business, regional and commercial air transport aircraft and helicopters. It is fully compatible and operational with all SBAS signals worldwide. With SBAS coverage, differential corrections are incorporated to further improve RNP capability, providing RNP 0.1 with navigation system availability. Full install kits, including the CMA-3024 and STC package, are provided by DAC International.

Meanwhile, Honeywell has chosen Esterline's CMA-6800 CRT to LCD conversion for its ED-800 replacement program. Based on an active-matrix LCD, the CMA-6800 is a form, fit and functional replacement for Honeywell's ED-800 cathode ray tube (CRT) displays. Approved for installation on more than 10 aircraft types and by multiple certification agencies including Transport Canada, the FAA and EASA, the CMA-6800 has been deployed on approximately 70 aircraft.

FreeFlight Systems

Dallas-based FreeFlight Systems' 1203C SBAS/GNSS sensor is now approved for installation with the latest Collins TDR-94/94D transponder variant. Collins has received FAA STC approval for ADS-B Out installations across a wide range of

Part 25 aircraft including models from Bombardier, Gulfstream, Sabreliner and Textron. Installation is also approved for Part 23 Class 3 and 4 aircraft via the AML certification Collins received in 2018. This product pairing provides legacy aircraft registered in the U.S. a way to meet requirements for the upcoming ADS-B equipage mandate. Additional foreign validations are planned to support mandate compliance in other regions.

Select part numbers of the TDR-94/94D can be upgraded via a Service Bulletin or exchange to the latest ADS-B Out compliant status.

Several hundred 1203Cs are in service today across airline transport, military and business aviation platforms. The 1203C can also serve as the approved position source for select manufacturers of terrain awareness warning system (TAWS), FMS, RNP and other NextGen applications.

Meanwhile, FreeFlight's Avail Performance Package is now available for installation. It recently received FAA STC and AML certifications. The latter allows for the installation of the performance package into over 25 makes and models of twin-turboprop aircraft from M7 Aerospace, Piper Aircraft and Textron Aviation.

Included in the Avail package is dual 1090 Mode S/ES transponders, the RANGR-RX/G 978 ADS-B receiver with an internal WAAS/GPS, integrated Wi-Fi and a single control head. These remote-mounted solutions will provide twin turboprop aircraft with a modular, all-in-one ADS-B In and Out capability.

The FDL-1090-TX is one of the smallest Mode S/ES transponders available today and can be mounted anywhere within the pressure vessel. The control head's user interface features positive control knobs and push buttons for squawk codes designation, fault annunciation, and IDENT and VFR operations on its sunlight-readable, backlit LED display. It fits in a standard 2.25-in. instrument mounting.

The TSO-certified RANGR-RX/G serves as the compliant position source required for ADS-B and also provides pilots with critical ADS-B flight information services-broadcast (FIS-B) and traffic information services-broadcast (TIS-B) data, both modernizing the aircraft cockpit and drastically improving situational awareness. The RANGR-RX/G offers users an installed solution that provides ADS-B In information to a multitude of preferred MFDs, mobile EFBs and tablet devices for viewing traffic and weather while in flight.

Garmin International

The Olathe, Kansas-based avionics maker has added two more TSOed ADS-B transponder models to its lineup. The GTX 335D offers ADS-B Out, while the GTX 345D provides ADS-B Out, as well as ADS-B In traffic and weather for display on compatible avionics and mobile devies. Remote-mount versions are also available. The GTX 335D/GTX 345D are intended for qualifying aircraft that may prefer or require a diversity solution, while also meeting or exceeding global ADS-B airspace requirements.

Garmin GTX 345D

The GTX 335D/GTX 345D utilize two antennas mounted on the top and bottom of the aircraft, as opposed to having a single antenna that is mounted on the belly. Garmin says diversity antennas help reduce antenna "shading" caused when the aircraft turns or maneuvers. They also improve line-of-sight visibility and allow the transponder to more robustly send and receive ADS-B transmissions from other participating aircraft, further improving visibility.

Select G1000-, G1000 NXi-, and G3000-equipped aircraft can now incorporate a diversity transponder-based ADS-B solution using the GTX 335D/GTX 345D. A remote-mounted version of the GTX 335D or GTX 345D takes the place of the aircraft's transponder and interfaces with the aircraft's existing WAAS position source to meet ADS-B Out requirements. The GTX 345D is capable of displaying various ADS-B In benefits, including subscription-free FIS-B weather and ADS-B traffic on the PFD and MFD. The new units interface with a variety of other Garmin avionics, flight displays and mobile devices, including the GTN 650/750 and GNS 430W/530W navigators, the G500 TXi/G600 TXi/G700 TXi and G500/G600 flight displays, as well as the aera 796/795 and aera 660 portables. These transponders are also compatible with the Garmin Pilot, FltPlan Go and ForeFlight Mobile applications, as well as other third-party avionics. Additional Garmin display compatibility with new FIS-B weather products is expected later this year.

Garmin expected to have an updated AML STC in the late second quarter of this year applicable to hundreds of aircraft makes and models. The GTX 335D and GTX 345D are available for a list price of $6,495 and $7,995, respectively.

Meanwhile, Garmin has received FAA TSOs involving several aircraft models for the GFC 500 and GFC 600 autopilots. The GFC 500 is intended for single-engine piston aircraft, while the GFC 600 is intended for high-performance piston single/twin-engine and turbine aircraft that have a wide range of speed and performance characteristics.

New aircraft models approved for the GFC 500 include the Mooney M20M, M20R and M20S. New aircraft models approved for the GFC 600 autopilot include the Cessna 414A and Beechcraft Baron models: 58P, 58PA, 58TC and 58TCA (1983 model year or earlier only).

The GFC 500 autopilot integrates with the G5 electronic flight instrument or a combination of both the G5 and the G500 TXi or G500 flight displays. The GFC 600 is designed as a standalone autopilot and also boasts integration potential when paired with the G500 TXi/G600 TXi or G500/G600 glass flight displays, Garmin navigators, as well as a variety of third-party flight displays, instruments and navigation sources.

Notably, as a standard feature on both the GFC 500 and GFC 600 autopilots, pilots receive Garmin electronic stability and protection (ESP), which works to assist the pilot in maintaining the aircraft in a stable flight condition. ESP functions independently of the autopilot and works in the background to help pilots avoid inadvertent flight attitudes or bank angles and provides airspeed protection while the pilot is hand-flying the aircraft.

Genesys Aerosystems

Over the past year, Genesys, a Mineral Wells, Texas-based autopilot manufacturer, has certified over 100 different aircraft models for its new S-TEC 3100 Part 23 digital autopilot. With it, the company uses the same servo design as in previous systems, thus simplifying upgrades.

Based upon the Level A certified S-TEC 5000, the S-TEC 3100 also features digital envelope protection and straight-and-level capabilities. Since the S-TEC 3100 can use existing servos from previous S-TEC autopilots, Genesys is offering upgrades starting at $9,995, while

S-TEC 3100

complete systems start at $19,995 for a two-axis and $24,995 for a three-axis system. All new systems include autotrim at no additional charge.

In addition to its fixed-wing line of autopilots, Genesys recently announced an IFR version of its HeliSAS. The new IFR system, targeted toward Part 29 aircraft, is based upon the company's VFR HeliSAS; however, the new system adds more robust hardware and redundancy for the harsher environment and heavier controls of larger helicopters. HeliSAS IFR is designed for a two-axis (pitch and roll) autopilot configuration for dual-pilot IFR operations and three-axis (pitch, roll and yaw) autopilot configuration for single-pilot IFR operations. The two-axis HeliSAS is priced at $186,475 uninstalled and the three-axis version for single-pilot operations is priced at $211,375 uninstalled.

Honeywell Aerospace

The Good Design Awards program is one of the oldest and most prestigious of its kind for design excellence and innovation. The 2018 transportation category award was given to BendixKing's AeroVue Touch flight display. It was designed by Honeywell's User Experience team for BendixKing in Albuquerque, New Mexico.

BendixKing's AeroVue

Among the AeroVue Touch's design features are its 10.1-in. display providing near 4K resolution and displaying terrain information, airspace boundaries and weather data. Pilots can customize the screen to show a full-screen PFD with synthetic vision, or a split-screen mode that shows the PFD, MFD and vertical situation display simultaneously to the pilot. This enables all flight-critical information to be displayed to the pilot on one compact screen, making AeroVue Touch viable for both conventional general aviation cockpits and tandem-seat cockpits such as in aerobatic and military training aircraft with limited panel space.

AeroVue displays feature hand anchoring so that the pilot can always accurately press menu buttons on the display even when flying in turbulence. The touch display also requires only a maximum of four touches to access any function within the software, which reduces the time required for a pilot to learn how to use AeroVue Touch as well as ongoing pilot workload.

And in an effort to reduce the need for multiple flight operations tools, Honeywell has launched a new software-based flight planning engine. The new GoDirect technology provides pilots and operators in business and general aviation with new options when planning flights worldwide. GoDirect can deliver faster, more accurate flight plans along with a highly integrated view of cabin connectivity, flight planning and tracking, all from a single sign-on.

With a single click, GoDirect presents pilots with a comprehensive list of routes at multiple cruise modes and various approaches and departures. In addition, the pilot can select the route based on time, fuel used and forecasted weather around the globe.

Using GoDirect, pilots can choose more cruise speeds than before with the aid of Honeywell's cruise performance algorithms. Route performance data are provided with each route option, allowing pilots and operators to compare multiple cruise modes with every route. Pilots and operators have more control over how much fuel is required and exactly how much time it will take from departure to destination. Users can now move easily between previously separate portals and monitor cabin connectivity, flight planning and tracking all from one place. All GoDirect customers have access to GoDirect Flight Bag Pro, an EFB application from Honeywell.

Meanwhile, Honeywell's BendixKing unit has rolled out an upgrade for Citation operators with CNI 5000 integrated radio systems to be ADS-B Out compliant. The retrofit is a slide-in replacement for existing KT 70 transponders. CitationJet models 525 and 525A and the Bravo 550 will be mandate-compliant with the new KT 74 transponders broadcasting on 1090 MHz. This solution can be additionally expanded to receive ADS-B In using a universal access transceiver (UAT), providing weather and traffic information.

And BendixKing's new Avionics-as-a-Service plan allows aircraft operators and owners to upgrade their avionics via a monthly subscription instead of an outright purchase. An industry-first, it will be available soon for many BendixKing products including AeroVue, AeroVue Touch, xVue Touch, KSN 770 navigator, AeroWave satellite communications system and the MST 70B transponder with ADS-B Out.

Similar to a cellular plan that includes a new mobile phone, the subscription will include virtually everything: avionics equipment, installation at an authorized BendixKing dealer, equipment repairs, software updates, databases and navigation charts, as well as technical support. Instead of paying a flyaway cost of $20,000 or more to purchase and install a single flight display, Avionics-as-a-Service would allow the owner to pay a fee of about $400 per month.

IS&S

Innovative Solutions & Support hopes to certify its ThrustSense retrofit autothrottle system this year on the Pratt & Whitney Canada PT6-powered Beechcraft King Air B200, providing pilots of the twin-engine turboprops with turbofan-like engine power control.

IS&S ThrustSense retrofit auththrottle on the Pilatus PC-12.

The Malvern, Pennsylvania, avionics maker obtained the STC from the FAA for ThrustSense on the PT6-powered Pilatus PC-12 single-engine turboprop last year. It plans to add hot-start protection and in-trail spacing capability to the STC during the same timeframe as the King Air certification.

The ThrustSense computer calculates and controls appropriate power levels, adjusting the throttles automatically to achieve and hold the selected airspeed within a torque/temperature-limit mode. The system offers full authority digital engine control (FADEC)-like protection, IS&S says, supporting minimum-speed mitigation, required time of arrival speed, takeoff and go-around mode, and turbulence penetration speed, among other functions.

The retrofit involves installing the IS&S integrated standby unit (ISU) computer with autothrottle in existing panel space and adding an actuator directly in line with the aircraft's power control lever and cable. Installations are independent of avionics and typically require less than four days with minimum modifications to the existing flight deck.

ThrustSense is available as a standalone installation with the IS&S ISU or with one of the company's two 4-D NextGen flight deck suites. In-trail spacing will be available on the PC-12 4-D NextGen flight deck equipped with ThrustSense. The functionality allows the pilot to automatically follow an airplane along its track based on ADS-B position reports, at a constant speed and distance as requested by air traffic control.

IS&S also offers the autothrottle for the TBM 940, and a retrofit version for the PC-12 NG.

L3 Commercial Aviation

As the FAA's ADS-B Out mandate looms, ACSS, L3's joint venture with Thales, is reportedly seeing a surge in orders of its NXT Mode S family of transponders. The company recently achieved a significant milestone, delivering the 10,000th production unit of the transponder.

The NXT first entered production in 2014.

Universal Avionics

So, in addition to its aforementioned acquisition by Elbit Systems, Universal Avionics is continuing its research partnership with the FAA to help the agency develop enhanced flight vision systems/enhanced helicopter vision systems (EFVS/EHVS) regulations for helicopters. The FAA is evaluating the use of Heli-ClearVision as a representative EHVS to improve helicopter safety and provide operational benefit during day, night and low visibility conditions.

Heli-ClearVision includes a SkyLens head-wearable display or SkyVis helmet-mounted display capable of displaying PFD flight symbology, conformal information, SVS, EVS with an EVS-4000 multispectral camera and combined vision system (CVS).

Testing hardware was fully integrated into the FAA's Sikorsky S-76 helicopter at the FAA William J. Hughes Technical Center at Atlantic City, New Jersey, International Airport (KACY). Once integration was completed, training and familiarization flights were conducted with FAA test pilots, followed quickly by the commencement of the FAA's planned R&D data collection flight tests. The next phase of testing includes additional day, night and twilight flights with SkyLens and SkyVis. Later this year, experimental trials are also scheduled and will include the SkyVis NVG.

The flight test program will help quantify the unique sensor and display characteristics, visual cues and operational concepts needed to assist the FAA with policy and rulemaking efforts to allow for the use of EHVS technologies on helicopters operating to and from helipads, heliports and landing zones.

Meanwhile, Universal has received FAA TSO authorization for the company's new touchscreen EFIS control display unit (ECDU) for its InSight display system. The ECDU is now available in touchscreen or non-touchscreen versions. Both ECDU models combine multiple InSight system controls, including the flight displays, FMS, radios, traffic and terrain, into a centralized control device.

The ECDU eliminates the need for external panels that take up valuable cockpit space by integrating with the PFD/MFD and standalone radios. The Touch ECDU combines the functionality of the traditional ECDU with a more intuitive interface. Operators can now use the Touch ECDU, cursor control panel (CCP) or both for point-and-click system control.

Universal's new EFIS control display unit (ECDU) for its InSight display system. The ECDU is now available in touchscreen or non-touchscreen versions.

And in March, Universal authorized dealer Heli-One received STC approval from Transport Canada and the Malaysia Department of Civil Aviation for its Sikorsky S-76 helicopter flight deck upgrade. Completed for a customer in Asia, the STC covers three Universal EFI-890H advanced flight displays and a Universal UNS-1Lw FMS with Vision-1 SVS.

The new, advanced flight displays replace legacy analog EFIS systems, increasing operational capability, reducing issues with aging instruments and reliability, and eliminating the costs of replacing and maintaining older displays. The upgrade is a cost-friendly option for operators who desire the modern S-76D-like avionics "look and feel" for other S-76 variants including the S-76A, C, C+ or C++ models.

The multiple screen installation allows for special-mission equipment integration, such as Vision-1 SVS with 3-D terrain awareness and external camera inputs. Combined with the upgraded FMS, the mission-specific navigation and control panel upgrade provides customers with added long-term value to their S-76B aircraft.

Obviously, then, there's no shortage of tools to keep expanding the utility of any business aircraft. Stay tuned for more. **BCA**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Airplane Outlook for 2019

BY **FRED GEORGE** fred.george@informa.com

Turbine aircraft sales historically have tracked with economic trends. This no longer is true. At the European Business Aviation Convention and Exhibition (EBACE) last month, Rolland Vincent, president of the Plano, Texas, consulting firm sharing his name and creator of Jetnet iQ, noted that the U.S. gross domestic product grew by 3.1% in the fourth quarter of 2018 compared to the fourth quarter of 2017, continuing its slow, rocky climb that started in 2010. Europe's overall GDP also grew in the fourth quarter of 2018, the fifth year of recovery following the shallow correction in 2012 and 2013.

However, flat is the new normal in turbine business aircraft sales. While general aviation aircraft deliveries increased by 5.1% in 2018, according to the General Aviation Manufacturers Association (GAMA), there has been a gradual, bumpy decline in turbofan aircraft production since 2009. The Big Five business jet makers, Bombardier, Dassault, Embraer, Gulfstream and Textron, are eating through their fat order backlogs, declining from $46 billion in 2014 to less than $31 billion in 2018. Production capacity discipline, though, has enabled the Big Five to stabilize their book-to-bill ratios near 1:1 so that they don't risk accumulating unsold white tails.

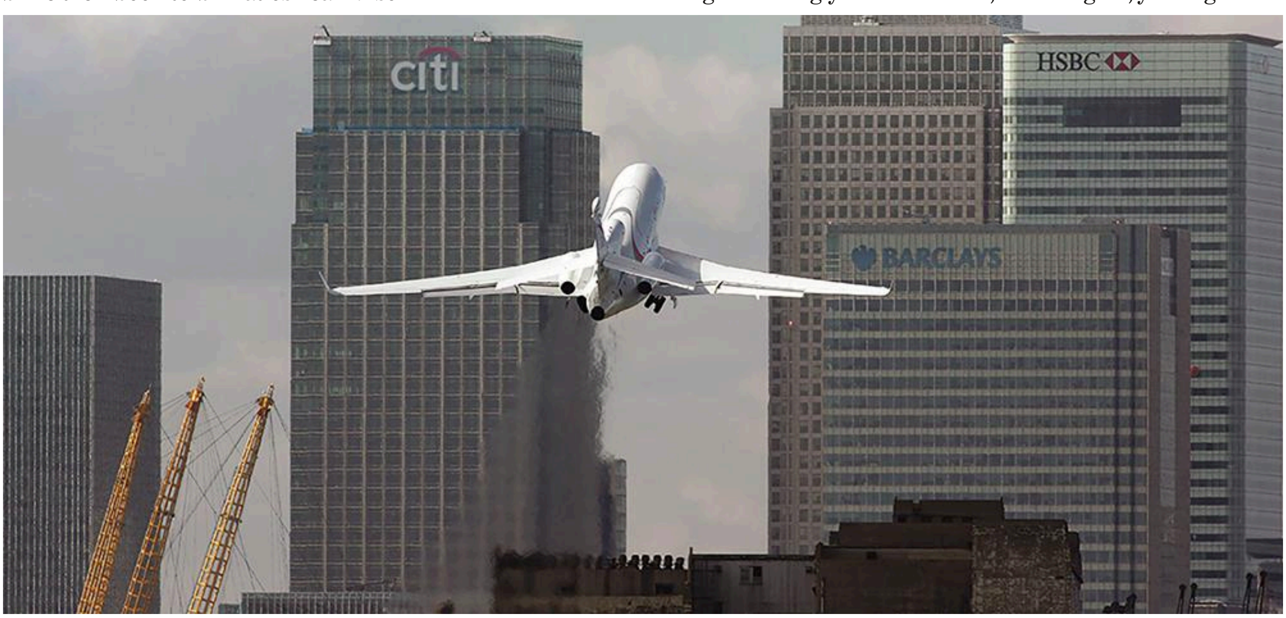
Headwinds are on the horizon. Vincent cautions that world economies are slowing and there are subtle indications of the risk of a future recession, including turbulence in the stock market, sagging crude oil prices, rising interest rates and bitterly partisan politics causing virtual paralysis in Washington. The economic boost provided by the Tax Cuts and Jobs Act of 2017 is wearing off, U.S. versus China trade disputes continue and both Britons and Europeans are fretting over Brexit.

Vincent notes that business aircraft operators are ambivalent about the chances of an economic slowdown in 2019. Six of 10 European operators, more than 49% of North American operators and a third in Latin America and the Caribbean expect a downturn. Almost two-thirds of the rest of those surveyed in the world expect a decline. It follows that 87% of North American and 83% of European operators, plus seven in 10 in Latin America and the Caribbean, feel comfortable with flying aircraft that were manufactured prior to 2008. They're simply holding onto their older aircraft, in large part because of depressed values in the resale market.

That market is becoming increasingly bifurcated, complicating operators' decisions to trade up. Vincent points out that three-quarters of the used aircraft sold in 2018 were 1998 and newer models. Demand for older models is stagnating, causing a glut of aircraft built before 1998. Prices for these matrons of the fleet are falling, so operators are loathe to upgrade them for the airspace requirements of the 21st century. Many older aircraft are severely under-utilized or even parked most of the time, awaiting eventual dismantling.

Aircraft manufacturers aren't waiting for economic resurgence to invest in significant upgrades to their existing products or to develop clean-screen models with more capabilities. This year's *Handbook* bears witness to the results of their efforts.

It starts with the single-turbofan Cirrus SF50 VisionJet G2, an aircraft we flew late last year. Less than two years into production of its first pressurized, turbine airplane, the Duluth, Minnesota, airframer upgraded the aircraft with improved avionics, lighter weight and more powerful batteries, and a Williams FJ33 turbofan with more high-altitude cruise thrust. Along with higher pressurization, this allows the aircraft to cruise 3,000 ft. higher, yielding better



fuel efficiency and more range. The interior also has been upgraded with better soundproofing and quick-change executive seating for four occupants. The VisionJet's appeal to Cirrus SR20/22 owners looking to move up to their first turbine aircraft is stronger than ever.

Take a close look at what Michimasa Fujino's team has done with the HondaJet Elite. The innovative light jet looks nearly identical to the original model, but it has substantial improvements. The aircraft not only gets higher operating weights and more fuel capacity, resulting in both more range and better loading flexibility, it also has engine inlet acoustical modifications that reduce interior sound levels, already class leading in the light jet category. Several subtle drag reduction modifications, plus engine tuning, improve climb and max range performance. Most importantly, a new round of runway performance testing enabled Honda Aircraft to shave nearly 500 ft. off sea-level ISA takeoff field length and pare nearly 1,000 ft. of required runway at *BCA*'s 5,000-ft. elevation, ISA+20C airport. It now can use many of the same landing facilities as competitive light jets.

Demand for the Pilatus PC-24 midsize jet is picking up, encouraging chairman Oscar Schwenk to hike the price by more than $1 million compared to 2018. At just over $10 million with *BCA* equipment, it's still a bargain, considering that its cross-section is bigger than that of the Cessna Citation XLS+, it has a flat floor, a capacious aft cargo door and certification for unimproved runway operations. The aircraft's unmatched capabilities give it potential for as long and successful a production run as the single-engine turboprop Pilatus PC-12.

In contrast, the future for Bombardier's Learjet 70/75 is decidedly gloomy. Average production in 2018 was down to just one aircraft per month, as Embraer continues to soar past with its popular Phenom 300. The Brazilian jet is less expensive to buy and operate, while providing most of the capabilities and comfort of the Learjets. The Model 70 and 75 will vanish from future issues of the *Handbook,* as Bombardier phases out of the light jet segment.

Michael Amalfitano, CEO and president of Embraer Executive Jets, is using a very sharp pencil for setting prices in 2019, with the intent of boosting market share in many segments. While many competitors have hiked asking prices, Amalfitano has held over 2018 prices on the Phenom 100 EV and 300, and the Legacy 450 and 500, along with lopping off $1 million from the asking price of the new Praetor 500 and reducing the Praetor 600's price by $1.5 million. He's also slashed $3.8 million off the price of the slow-selling Lineage 1000E.

In contrast, Ron Draper, Textron Aviation's CEO, is bullish on demand for the firm's Beechcraft and Cessna products. The venerable Bonanza G36, for instance, gets a $44,000 price increase, 5% over 2018. It now lists for $914,000. Most Citation models also are getting sizable price boosts of $200,000 to $400,000, or more. The Citation Latitude now is $500,000 more expensive than arch-rival Praetor 500. And the Citation Longitude continues to top all super-midsize jets in price. Textron claims the Longitude is a best-in-class model. We're anxiously awaiting the opportunity for an evaluation flight that can prove it.

Cirrus, Daher, Piper, Pilatus and many others are lifting prices, confident in rising demand for their products. Epic Aircraft in Bend, Oregon, is holding the price on its Epic 100 single-engine turboprop that seems no closer to certification than it was last year. Late in 2018, engineers elected to redesign the engine air inlet, with the goal of improving ram recovery and high-altitude cruise performance. The change has added months to the certification schedule, so the company is not forecasting when the aircraft will enter service.

Alain Bellemare, Bombardier's president and CEO, continues to slim the company's aviation holdings, including last year's divestiture of the CSeries regional jets to Airbus; the sale of its Downsview, Ontario, production facility, CL415 water bomber and pilot training; the recent sale of the remainder of the de Havilland Dash 8 turboprop line to Viking; and the upcoming sale of its Belfast and Morocco facilities. Its future aviation portfolio primarily will consist of super-midsize, large and ultra-long-range business jets. This year, the *Handbook* welcomes aboard the Bombardier Global 7500, the biggest, heaviest, longest-range and most expensive purpose-built business aircraft yet produced. Montreal's new flagship is igniting a three-way fight for the title of Ultimate Business Jet, soon to be joined by Gulfstream with its upcoming G700 and next year with the expected announcement of Dassault's Falcon 9X.

Bombardier's Global 5000 and 6000 large-cabin jets are carried over unchanged from 2018, place holders until the stronger performing Global 5500 and 6500, powered by new Rolls-Royce BR700-710D5-21 Pearl turbofans, succeed them in next year's *Handbook*. Spoiler alert: Expect the 5500 and 6500 to be strongly, if not surprisingly, cost competitive when they make their debut in the 2020 *Handbook*.

The popularity of airliner derivative business jets continues to wane. Comlux is a notable exception, as chairman and CEO Richard Gaona, formerly head of Airbus Corporate Jets, expands his charter fleet with three new ACJ320neos that have 15% better fuel efficiency, a new standard forward airstair, lighter weight interiors and higher operating weights that yield considerably better tanks-full payloads. Interest in the Boeing BBJ MAX may be rekindled after improvements to its much criticized MCAS software have been approved and the company becomes considerably more transparent when communicating with the outside world.

Notably, the MCAS debacle has long-term fallout for all other aircraft manufacturers. Just last year, the U.S. Congress passed P.L. 115-254, the long-term FAA reauthorization bill. Now signed into law, the bill incorporated expansion of the FAA's Organizational Designation Authorization (ODA) program that delegates many certification tasks to aircraft manufacturers, with the intent of accelerating dozens of approval processes. Boeing's ODA, for example, enabled it to approve the original MCAS software package that was vulnerable to single angle-of-attack sensor failure. Congress is sure to take a close look at the ODA process with an eye toward stricter interpretation of FAR Part 25 certification rules and more robust safety standards. If the FAA is compelled to reassume many certification tasks now delegated to ODAs, it has potential for creating logjams in several certification programs currently in progress or still in the planning stages.

Vincent, though, still is upping his forecast for total deliveries during the coming decade. Last year, he projected 7,730 deliveries between 2018 and 2027. Now, he's looking at 7,863 units between 2019 and 2028. For the first time, Jetnet iQ is including deliveries of supersonic business jets starting in 2026.

For now, though, the business aircraft industry is in for a rougher ride, should world economies cool off, consumer and business confidence become unsettled and aircraft utilization rates remain near rock-bottom historical levels. Even so, Vincent expects business jet unit deliveries to be marginally higher in 2019 and sales revenues to climb. **BCA**

How to Use the Airplane Charts

EMBRAER EXECUTIVE JETS

For an aircraft to be listed in the *Purchase Planning Handbook,* a production conforming article must have flown by May 1 of this year. The dimensions, weights and performance characteristics of each model listed are representative of the current production aircraft being built or for which a type certificate application has been filed. The basic operating weights we publish should be representative of actual production turboprop and turbofan aircraft because we ask manufacturers to supply us with the average weights of the last 10 commercial aircraft that have been delivered. However, spot checks of some manufacturers' BOW numbers reveal anomalies. We reserve the right to make adjustments to weights, dimensions and performance data. These data adjustments will be noted in the Remarks section for specific models as "*BCA* Estimated Data."

The takeoff field length distances are based on maximum takeoff weight for maximum range missions.

Please note that "all data preliminary" in the Remarks section indicates that actual aircraft weight, dimension and performance numbers may vary considerably after the model is certified and delivery of completed aircraft begins. All data for these aircraft is highlighted with a tint.

Manufa cturer, Model and Type Designation

In some cases, the airplane manufacturer's name is abbreviated. The model name and the type designation also are included in this group.

BCA Equipped Price

▶Price *estimates* are first quarter, current year dollars for the next available delivery. Some aircraft have long lead times, thus the actual price will be higher than our published price because of block point changes and inflation adjustments. Note well, manufacturers may change prices without notification.

▶**Piston-powered airplanes** — Computed retail price with at least the level of equipment specified in the "*BCA* Required Equipment List."

▶**Turbine-powered airplanes** — Computed retail price with at least the level of equipment specified in the "*BCA* Required Equipment List," if available. Some manufacturers decline to provide us with actual prices of delivered aircraft, so we may estimate them. The aircraft serial numbers aren't necessarily consecutive because of variations in completion time and because some aircraft may be configured for non-commercial, special missions.

Characteristics

▶**Seating:** Crew + Typical Executive Seating/High-Density Seating/Max Certification Seating — For example, 2+8/13/19 indicates that the aircraft requires two pilots, there are eight seats in the typical executive configuration, 13 seats with optional high-density seating and up to 19 passenger seats based upon FAA and/or EASA certification limits. A four-place, single-engine aircraft is shown as 1+3/3, indicating that one pilot is required and there are three other seats available for passengers. We require two pilots for all turbofan airplanes, except for single-pilot certified aircraft such as the Cirrus Vision SF-50, Eclipse 550, Cessna Citation CJ series, HondaJet and Syberjet SJ30-2, which have, or will have, a large percentage of single-pilot operators. Four crewmembers are specified for ultra-long-range aircraft — three pilots and one flight attendant. However, Dassault only provides data with three crewmembers aboard for its ultra-long-range aircraft, thus the notations for the Falcon 8X.

Each occupant of a turbine-powered airplane is assumed to weigh 200 lb., thereby allowing for stowed luggage and carry-on items. In the case of piston-engine airplanes, we assume each occupant weighs 170 lb. There is no luggage allowance for piston-engine airplanes.

▶ **Wing Loading** — MTOW divided by total wing area.

▶ **Power Loading** — MTOW divided by total rated takeoff horsepower or total rated takeoff thrust.

▶ **FAR Part 36 Certified Noise Levels** — Flyover noise in A-weighted decibels (dBA) for small and turboprop aircraft. For turbofan-powered aircraft, we provide Part 36 EPNdB (effective perceived noise levels) for Lateral, Flyover and Approach.

Dimensions

▶ **External Length, Height and Span** dimensions are provided for use in determining hangar and/or tie-down space requirements.

Internal Length, Height and Width are based on a completed interior, including insulation, upholstery, carpet, carpet padding and fixtures. Note well: These dimensions are not intended to be based upon green aircraft dimensions. They must reflect the actual net dimensions with all soft goods installed. Some manufacturers provide optimistic measurements. Thus, prospective buyers are advised to measure aircraft themselves.

As shown in the Cabin Interior Dimensions illustration, for small airplanes other than "cabin-class" models, the length is measured from the forward bulkhead ahead of the rudder pedals to the back of the rear-most passenger seat in its normal, upright position. The upright position of the aft seat backs allows room for luggage in the cabin.

AIRBUS CORPORATE JETS

For so-called cabin-class and larger aircraft, we show two or three dimensions, depending on aircraft class. **The first** is the overall length of the passenger cabin, measured from the aft side of the forward cockpit/cabin divider to the aft-most bulkhead of the cabin. The aft-most point is defined by the rear side of a baggage compartment that is accessible to passengers in flight or the aft pressure bulkhead. The overall length is reduced by the length of any permanent mounted system or structure that is installed in the fuselage ahead of the aft bulkhead. For example, some aircraft have full fuselage cross-section fuel tanks mounted ahead of the aft pressure bulkhead.

The second length number is the net length of the cabin that routinely is occupied by passengers. It's measured from the aft side of the forward cockpit/cabin divider to an aft point defined by the rear of the cabin floor capable of supporting passenger seats, the rear wall of an aft galley or lavatory, an auxiliary pressure bulkhead or the front wall of the pressurized baggage compartment. Some aircraft have the same net and overall interior length because the manufacturer offers at least one interior configuration with the aft-most passenger seat located next to the front wall of the aft luggage compartment.

The third length dimension is the main seating area of the cabin, including all passenger seats in the standard aircraft configuration that are certified for full-time occupancy. Some manufacturers may fit their aircraft with forward, side-facing divans, ahead of areas with individual fore-aft facing chairs. The main seating length dimension may include such forward cabin side-facing divans at the discretion of the manufacturer. The length of the lavatory, even though it may have a seat certified for full-time occupancy, may not be included in the main seating length dimension.

Interior height is measured at the center of the cabin cross-section. If the aircraft has a dropped aisle, the maximum depth below the adjacent cabin floor is shown. Some aircraft have dropped aisles of varying depths, resulting in less available interior net height in certain sections of the cabin.

Two width dimensions are shown for multiengine turbine airplanes — one at the widest part of the cabin and the other at floor level. The dimensions, however, are not completely indicative of the usable space in a specific aircraft because of individual variances in interior furnishings.

Power

Number of engines, if greater than one, and the abbreviated name of the manufacturer: GE — General Electric; GE/Honda — General Electric and Honda; Hon — Honeywell; CFMI — CFM International; IAE — International Aero Engines; Lyc — Textron Lycoming; P&WC — Pratt & Whitney Canada; RR — Rolls-Royce; Snecma; TCM — Teledyne Continental; and Wms — Williams International.

▶ **Output** — Takeoff rated horsepower for propeller-driven aircraft or pounds thrust for turbofan aircraft. If an engine is flat rated, enabling it to produce takeoff rated output at a higher than ISA (standard day) ambient temperature, the flat rating limit is shown as ISA+XXC. Highly flat-rated engines, i.e. engines that can produce takeoff rated thrust at a much higher than standard ambient temperature, typically provide substantially improved high density altitude, climb and high-altitude cruise performance.

▶ **Inspection Interval** is the longest scheduled hourly major maintenance interval for the engine, either "t" for TBO or "c" for compressor zone inspection. In some cases, we show a second number if the engine manufacturer has obtained an extended maintenance interval, provided that the engines are enrolled in the manufacturer's service program. OC is shown only for engines that have "on condition" repair or replace parts maintenance.

BOMBARDIER

Weights (lb.)

Weight categories are listed as appropriate to each class of aircraft.
▶ **Max Ramp** — Maximum ramp weight for taxi.
▶ **Max Takeoff** — Maximum takeoff weight as determined by structural limits.
▶ **Max Landing** — Maximum landing weight as determined by structural limits.
▶ **Zero Fuel** — Maximum zero fuel weight, shown by "c," indicating the certified MZFW, or "b," a *BCA*-computed weight based on MTOW minus the weight of fuel required to fly 1.5 hr. at high-speed cruise.
▶ **Max ramp, max takeoff and max landing** weights may be the same for light aircraft that may only have a certified max takeoff weight.
▶ **EOW/BOW** — Empty Operating Weight is shown for piston-powered airplanes. EOW is based on the factory standard weight, plus items specified in the "*BCA* Required Equipment List," less fuel, loose equipment and cabin stores.

Basic Operating Weight is shown for turbine-powered airplanes. BOW is based on the average EOW weight of the last 10 commercial deliveries, plus 200 lb. for each required crewmember. Three flight crewmembers and one cabin crewmember are required for ultra-long-range aircraft, unless otherwise noted.

While there is no requirement to add in the weight of cabin stores, some manufacturers choose to include galley stores and passenger supplies as part of the BOW build-up. Life vests, life rafts and appropriate deep-water survival equipment are included in the weight buildup of the 80,000+ lb., ultra-long-range aircraft.
▶ **Max Payload** — Zero Fuel weight minus EOW or BOW, as appropriate. For piston-engine airplanes, Max Payload frequently is a computed value because it is based on the *BCA* ("b") computed maximum ZFW.
▶ **Max Fuel** — Usable fuel weight based on 6.0 lb. per U.S. gallon for avgas or 6.7 lb. per U.S. gallon for jet fuel. Fuel quantity is based upon the largest capacity tanks that are available as standard equipment.
▶ **Available Payload With Max Fuel** — Max Ramp weight minus the tanks-full weight, not to exceed Zero Fuel weight minus EOW or BOW.
▶ **Available Fuel With Max Payload** — Max Ramp weight minus Zero Fuel weight, not to exceed maximum fuel capacity.

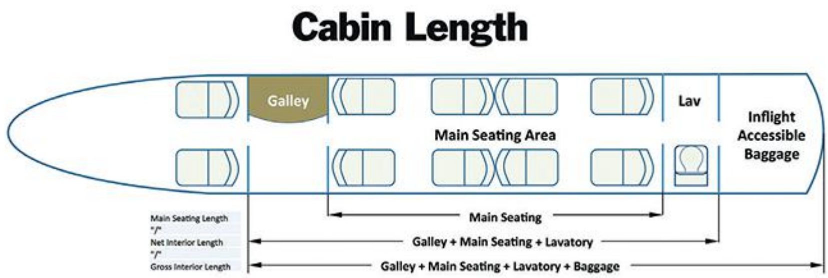
BOEING BUSINESS JETS

Limits

BCA lists V speeds and other limits as appropriate to the class of airplane. These are the abbreviations used on the charts:
▶ **VNE** — Never exceed speed (redline for piston-engine airplanes).
▶ **VNO** — Normal operating speed (top of the green arc for piston-engine airplanes).
▶ **VMO** — Maximum operating speed (redline for turbine-powered airplanes).
▶ **MMO** — Maximum operating Mach number (redline for turbofan-powered airplanes and a few turboprop airplanes).
▶ **FL/VMO** — Transition altitude at which VMO equals MMO (large turboprop and turbofan aircraft).
▶ **VW** — Maneuvering speed (except for certain large turboprop and all turbofan aircraft).
▶ **VDEC** — Accelerate/stop decision speed (multiengine piston and light multiengine turboprop airplanes).
▶ **VMCA** — Minimum control airspeed, airborne (multiengine piston and light multiengine turboprop airplanes).
▶ **VSO** — Maximum stalling speed, landing configuration (single-engine airplanes).
▶ **VX** — Best angle-of-climb speed (single-engine airplanes).
▶ **VXSE** — Best angle-of-climb speed, one-engine inoperative (multiengine piston and multiengine turboprop airplanes under 12,500 lb.).
▶ **VY** — Best rate-of-climb speed (single-engine airplanes).
▶ **VYSE** — Best rate-of-climb speed, one-engine inoperative (multiengine piston and multiengine turboprop airplanes under 12,500 lb.).
▶ **V2** — Takeoff safety speed (large turboprops and turbofan airplanes).
▶ **VREF** — Reference landing approach speed (large turboprops and turbofan airplanes, four passengers, NBAA IFR reserves; eight passengers for ultra-long-range aircraft).
▶ **PSI** — Cabin pressure differential (all pressurized airplanes).

Airport Performance

Airplane Flight Manual takeoff runway performance is shown for sea level, standard day and for 5,000-ft. elevation/25C day density altitude. All-engine takeoff distance (TO) is shown for single-engine and multiengine piston, and turboprop airplanes with an MTOW of less than 2,500 lb. Takeoff distances and speeds assume MTOW, unless otherwise noted.



▶ **Accelerate/Stop distance (A/S)** is shown for small multiengine piston and small turboprop airplanes.

▶ **Takeoff Field Length (TOFL),** the greater of the one-engine inoperative (OEI) takeoff distance or the accelerate/stop distance, is shown for FAR Part 23 Commuter Category and FAR Part 25 airplanes. If the accelerate/stop and accelerate/stop distances are equal, the TOFL is the balanced field length.

▶ **Landing distance (LD)** is shown for FAR Part 23 Commuter Category and FAR Part 25 Transport Category airplanes. The landing weight is BOW plus four passengers and NBAA IFR fuel reserves. We assume that 80,000+ lb. ultra-long-range aircraft will have eight passengers on board.

▶ **V2 and VREF** speeds are useful for reference when comparing the TOFL and LD numbers because they provide an indication of potential minimum-length runway performance when low RCR or runway gradient is a factor.

BCA lists two additional warm day airport performance numbers for large turboprop- and turbofan-powered airplanes. First, we publish the Mission Weight, which is the maximum allowable takeoff weight when departing a 5,000-ft. elevation/ISA+20C airport with at least four passengers aboard.

Mission Weight, when departing from a 5,000-ft./ISA+20C airport, may be less than the MTOW at sea level on a standard day because of FAR Part 25 second-segment, one-engine-inoperative, climb performance requirements. If maximum allowable mission weight at takeoff is restricted under said conditions, it's flagged with a "p." Aircraft with highly flat-rated engines are less likely to have a performance limited mission weight when departing under said warm day conditions.

Second, we publish the NBAA IFR range for said warm-day conditions, assuming a transition into standard-day, ISA flight conditions after takeoff. For purposes of computing NBAA IFR range, the aircraft is flown at the long-range cruise speed shown in the "Cruise" block or at the same speed as shown in the "Range" block. Notably, some aircraft may actually have slightly better range performance when departing from said warm day airports because they have a 5,000-ft. head start on the climb to cruise altitude.

Climb

The all-engine time to climb provides an indication of overall climb performance, especially if the aircraft has an all-engine service ceiling well above our sample time-to-climb altitudes. We provide the all-engine time to climb to one of three specific altitudes, based on type of aircraft departing at MTOW from a sea-level, standard-day airport: (1) FL 100 (10,000 ft.) for normally aspirated single-engine and multiengine piston aircraft, plus pressurized single-engine piston aircraft and unpressurized turboprop aircraft; (2) FL 250 for pressurized single-engine and multiengine turboprop aircraft; or (3) FL 370 for turbofan-powered aircraft. These data are published as time-to-climb in minutes/climb altitude. For example, if a non-pressurized twin-engine piston aircraft can depart from a sea-level airport at MTOW and climb to 10,000 ft. in 8 min., the time to climb is expressed as 8/FL 100.

We also publish the initial all-engine climb feet per nautical mile gradient, plus initial engine-out climb rate and gradient, for single-engine and multiengine pistons and turboprops with MTOWs of 12,500 lb. or less.

The one-engine-inoperative (OEI) climb rate for multiengine aircraft at MTOW is derived from the Airplane Flight Manual. OEI climb rate and gradient are based on landing gear retracted and wing flaps in the takeoff configuration used to compute the published takeoff distance. The climb gradient for such airplanes is obtained by dividing the product of the climb rate (fpm) in the Airplane Flight Manual times 60 by the VY or VYSE climb speed, as appropriate.

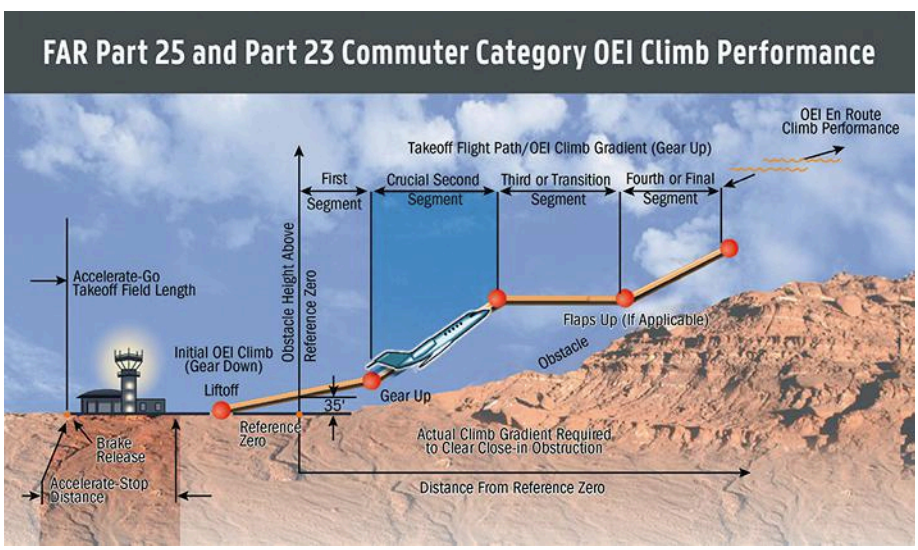
The OEI climb gradients we show for FAR Part 23 Commuter Category and FAR Part 25 Transport Category aircraft are the second-segment net climb performance numbers published in the AFMs. Please note: The AFM net second-segment climb performance numbers are adjusted downward by 0.8% to compensate for variations in pilot technique and ambient conditions.

The OEI climb gradient is computed at the same flap configuration used to calculate the takeoff field length.

Ceilings (ft.)

▶ **Maximum Certificated Altitude** — Maximum allowable operating altitude determined by airworthiness authorities.

▶ **All-Engine Service Ceiling** — For turbofan



aircraft: maximum altitude at which at least a 300-fpm rate of climb can be attained, assuming the aircraft departed a sea-level, standard-day airport at MTOW and climbed directly to altitude. For piston and turboprop aircraft: 100 fpm rate of climb.

▶ **Sea-Level Cabin (SLC) Altitude** — Maximum cruise altitude at which a 14.7-psia, sea-level cabin altitude can be maintained in a pressurized airplane.

Cruise

Cruise performance is computed using EOW with four occupants or BOW with four passengers and one-half fuel load. Ultra-long-range aircraft carry eight passengers for purposes of computing cruise performance.

Assume 170 lb. for each occupant of a piston-engine airplane and 200 lb. for each occupant of a turbine-powered aircraft.

▶ **Long Range** — True airspeed (TAS), fuel flow in pounds/hour, flight level (FL) cruise altitude and specific range for long-range cruise specified by the manufacturer.

▶ **Recommended (Piston-Engine Airplanes)** – TAS, fuel flow in pounds/hour, FL cruise altitude and specific range for normal cruise performance specified by the manufacturer.

▶ **High Speed** — TAS, fuel flow in pounds/hour, FL cruise altitude and specific range for short-range, high-speed performance specified by the aircraft manufacturer.

Speed, fuel flow, specific range and altitude in each category are based on one mid-weight cruise point and these data reflect standard-day conditions. They are not an average for the overall mission and they are not representative of the above standard-day temperatures at cruise altitudes commonly encountered in everyday operations.

BCA imposes a 12,000-ft. maximum cabin altitude requirement on CAR3/FAR Part 23 normally aspirated aircraft. Non-pressurized turbocharged piston-engine airplanes are limited to FL 250, providing they are fitted with supplemental oxygen systems having sufficient capacity for all occupants for the entire duration of the mission. Pressurized CAR3/FAR Part 23 aircraft are limited to a maximum cabin altitude of 10,000 ft. For FAR Part 23 Commuter Category and FAR Part 25 aircraft, the maximum cabin altitude for computing cruise performance is 8,000 ft.

To conserve space, we use flight levels (FL) for all cruise altitudes, which is appropriate considering that we assume standard-day ambient temperature and pressure conditions. Cruise performance is subject to *BCA*'s verification.

Range

BCA shows various paper missions for each aircraft that illustrate range versus payload trade-offs, runway and cruise performance, plus fuel efficiency. Similar to the cruise profile calculations, *BCA* limits the maximum altitude to 12,000 ft. for normally aspirated, non-pressurized CAR3/FAR Part 23 aircraft, 25,000 ft. for turbocharged non-pressurized airplanes with supplemental oxygen, 10,000-ft. cabin altitude for pressurized CAR 3/FAR Part 23 airplanes and 8,000-ft. cabin altitude for FAR Part 23 Commuter Category or FAR Part 25 aircraft.

DASSAULT FALCON JET

▶ **Seats-Full Range (Single-Engine Piston Airplanes)** — Based on typical executive configuration with all seats filled with 170-lb. occupants, with maximum available fuel less 45-min. IFR fuel reserves. We use the lower of seats full or maximum payload.

▶ **Tanks-Full Range (Single-Engine Piston Airplanes)** — Based on one 170-lb. pilot, full fuel less 45-min. IFR fuel reserves.

▶ **Max Fuel With Available Payload (Single-Engine Turboprops)** — Based on BOW, plus full fuel and the maximum available payload up to maximum ramp weight. Range is based on arriving at destination with NBAA IFR fuel reserves, but only a 100-mi. alternate is required.

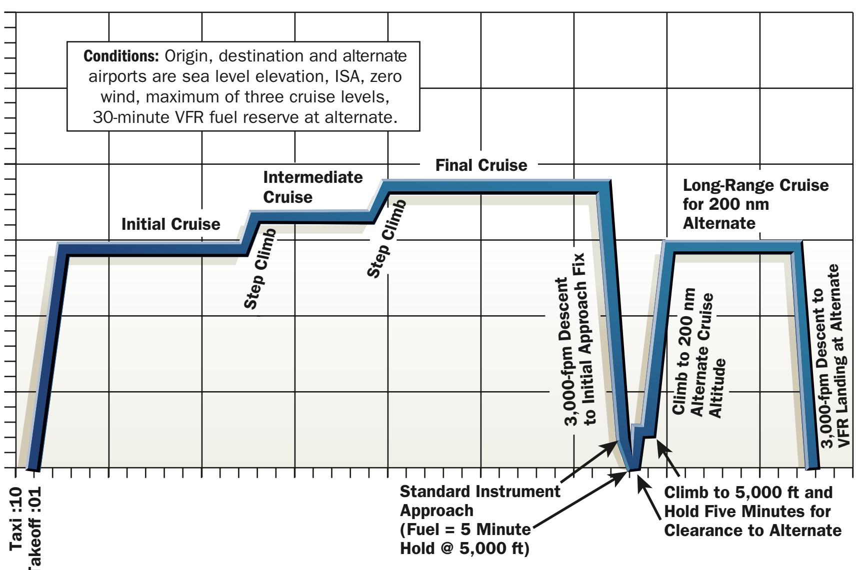
▶ **Ferry (Multiengine Piston Airplanes and Single-Engine Turboprops)** — Based on one 170-lb. pilot, maximum fuel less 45-min. IFR fuel reserves.

Please note: None of the missions for piston-engine aircraft includes fuel for diverting to an alternate. However, single-engine turboprops are required to have NBAA IFR fuel reserves, but only a 100-mi. alternate is required.

NBAA IFR range format cruise profiles, having a 200-mi. alternate, are used for turbine-powered aircraft with MTOWs equal to, or greater than, 22,000 lb. Turbine aircraft having MTOWs less than 22,000 lb. only need a 100-mi. NBAA alternate. The difference in alternate requirements should be kept in mind when comparing range performance of various classes of aircraft.

▶ **Available Fuel With Max Payload (Multiengine Turbine Airplanes)** — Based on aircraft loaded to maximum zero fuel weight with maximum available fuel up

NBAA IFR RANGE PROFILE



GULFSTREAM AEROSPACE

to maximum ramp weight, less NBAA IFR fuel reserves at destination.

▶ **Available Payload With Max Fuel (Multiengine Turbine Airplanes)** — Based on BOW plus full fuel and maximum available payload up to maximum ramp weight. Range based on NBAA IFR reserves at destination.

▶ **Full/Max Fuel With Four Passengers (Multiengine Turbine Airplanes)** — Based on BOW plus four 200-lb. passengers and the lesser of full fuel or maximum available fuel up to maximum ramp weight. Ultra-long-range aircraft must have eight passengers on board.

▶ **Ferry (Multiengine Turbine Airplanes)** — Based on BOW, required crew and full fuel, arriving at destination with NBAA IFR fuel reserves.

We allow 2,000-ft. increment step climbs above the initial cruise altitude to improve specific range performance, even though current air traffic rules in North America provide for 4,000-ft. altitude semicircular directional traffic separation above FL 290. The altitude shown in the range section is the highest cruise altitude for the trip — not the initial cruise or mid-mission altitude.

The range profiles are in nautical miles, and the average speed is computed by dividing that distance by the total flight time or weight-off-wheels time en route. The Fuel Used or Trip Fuel includes the fuel consumed for start, taxi, takeoff, cruise, descent and landing approach but not after-landing taxi or reserves.

The Specific Range is obtained by dividing the distance flown by the total fuel burn. The Altitude is the highest cruise altitude achieved on the specific mission profile shown.

Missions

Various paper missions are computed to illustrate the runway requirements, speeds, fuel burns and specific range, plus cruise altitudes. The mission ranges are chosen to be representative for the airplane category. All fixed-distance missions are flown with four passengers on board, except for ultra-long-range airplanes, which have eight passengers on board. The pilot is counted as a passenger on board piston-engine airplanes. If an airplane cannot complete a specific fixed distance mission with the appropriate payload, *BCA* shows a reduction of payload in the remarks section or marks the fields NP (Not Possible) at our option.

Runway performance is obtained

BCA Required Equipment List

	Single-Engine Pistons	Single-Engine Pistons, Turbocharged	Single-Engine Pistons, Pressurized	Multiengine Pistons	Multiengine Pistons, Turbocharged	Single-Engine Turboprops	Turboprops ≤12,500 lb.	Turboprops >12,500 lb.	Jets <20,000 lb.	Jets ≥20,000 lb.
POWERPLANT SYSTEMS										
Batt temp indicator (nicad only, for each battery)						●	●	●	●	●
Engine synchronization									◉	◉
Fire detection, each engine						●	●	●	●	●
Fire extinguishing, each engine						●	●	●	●	●
Propeller, reversible pitch						●	●	●		
Propellers, synchronization							●	●		
Thrust reversers									◉	◉
AVIONICS										
ADF receiver (non U.S. deliveries)						●	●	●	●	●
Altitude alerter						●	●	●	●	●
Altitude encoder	●	●	●	●	●	●	●	◉	◉	◉
Audio control panel	●	●	●	●	●	●	●	◉	◉	◉
Automatic flight guidance, 2-axis, alt hold	●	●	●	●						
Automatic flight guidance, 3-axis, alt hold					●	●	●	●	●	◉
Digital air data computer							●	◉	◉	◉
DME or approved GPS distance indication	●	●	●	●	●	●	●	●	●	◉
EFIS/large-format flat-panel displays	●	●	●	●	●	●	●	●	●	●
ELT	●	●	●	●	●	●	●	●	●	●
FMS (TSO C115) or GPS (TSO C129/145/146)	●	●	●	●	●	●	●	●	●	◉
Marker beacon receiver	●	●	●	●	●	●	●	●	◉	◉
Radio altimeter						●	●	●	●	◉
RVSM certification						●	●	◉	◉	◉
Satcom, Iridium, or Inmarsat									●	●
TAS or TCAS I						●	●	●		
TAWS						●	●	●	●	●
TCAS I/II									●	●
Transponder, Mode S 1090ES	●	●	●	●	●	●	●	◉	◉	◉
VHF comm transceiver, 25-KHz spacing	●	●	●	●	●	●	●	●		
VHF comm tranceiver, 8.33-kHz spacing									◉	◉
VOR/ILS	◉	◉	◉	◉	◉	◉	◉	◉	◉	◉
Weather data link										
Weather radar						●	●	●	●	●
GENERAL										
Air conditioning, vapor cycle (not required with APU)				●		●	●	●	●	●
Anti-skid brakes (not required MTOW <10,000 lb.)								●	●	●
APU (required for air-start engines, ACM air conditioning)										●
Cabin/cockpit bulkhead divider								●	●	●
Corrosion-proofing	●	●	●	●	●	●	●	●	●	●
Exterior paint, tinted windows	●	●	●	●	●	●	●	●	●	●
Fire extinguisher, cabin						●	●	●	●	●
Fire extinguisher, cockpit	●	●	●	●	●	●	●	●	●	●
Fuel tanks, long-range	●	●	●	●	●					
Ground power jack	●	●	●	●	●	●	●	●	●	●
Headrests, air vents at all seats	●	●	●	●	●	●	●	●	●	●
Lavatory								●	●	●
Lights, external — nav/beacon/strobe/landing/taxi	●	●	●	●	●	●	●	●	●	●
Lights, internally illuminated instrument/cockpit flood	●	●	●	●	●	●	●	●	●	●
Oxygen, supplemental — all seats		●			●	●	●	●	●	●
Refreshment center							●	●	●	●
Seats, crew, articulating	●	●	●	●	●	●	●	●	●	●
Seats, passenger, reclining	●	●	●	●	●	●	●	●	●	●
Shoulder harness, all seats/crew with inertial reel	●	●	●	●	●	●	●	●	●	●
Tables, cabin work						●	●	●	●	●
ICE AND RAIN PROTECTION										
Alternate static pressure source (not required with dual DADC)	●	●	●	●	●	●	●			
Flight Into Known Icing (FIKI) approval			●	●	●	●	●	●	●	●
Ice protection plates							●	●		
Pitot heat	●	●	●	●	●	●	●	◉	◉	◉
Windshield rain removal, mechanical/pneumatic/hygroscopic							●	●	●	●
INSTRUMENTATION										
Angle-of-attack stall margin indicator									●	●
EGT	●	●	●	●	●					
IVSI (or equivalent DADC function)	●	●	●	●	●	●	●	●	●	●
OAT	●	●	●	●	●	●	●	●	●	●
Primary flight instruments	●	●	●	●	●	●	◉	◉	◉	◉

● Required
◉ Dual Required

from the Approved Airplane Flight Manual. Takeoff distance is listed for single-engine airplanes; accelerate/stop distance is listed for piston twins and light turboprops; and takeoff field length, which often corresponds to balanced field length, is used for FAR Part 23 Commuter Category and FAR Part 25 large Transport Category airplanes.

Flight Time (takeoff to touchdown, or weight-off-wheels, time) is shown for turbine airplanes. Some piston-engine manufacturers also include taxi time, resulting in a chock-to-chock, Block Time measurement. Fuel Used, though, is the actual block fuel burn for each type of aircraft, but it does not include fuel reserves. The cruise altitude shown is that which is specified by the manufacturer for fixed-distance missions.

▶ **200 nm** — (Piston-engine airplanes).
▶ **500 nm** — (Piston-engine airplanes).
▶ **300 nm** — (Turbine-engine airplanes, except ultra-long-range).
▶ **600 nm** — (Turbine-engine airplanes, except ultra-long-range).
▶ **1,000 nm** — (All turbine-engine airplanes).
▶ **3,000 nm** — (Ultra-long-range turbine-engine airplanes).
▶ **6,000 nm** — (Ultra-long-range turbine-engine airplanes).

Remarks

In this section, *BCA* generally includes the base price, if it is available or applicable; the certification basis and year; and any notes about estimations, limitations or qualifications regarding specifications, performance or price. All prices are in 2017 dollars, FOB at a U.S. delivery point, unless otherwise noted. The certification basis includes the regulation under which the airplane was originally type certified, the year in which it was originally certified and, if applicable, subsequent years during which the airplane was re-certified. "*BCA* Estimated Data" indicates that we made adjustments to data provided by manufacturers.

General

The following abbreviations are used throughout the tables: **"NA"** means not available; "—" indicates the information is not applicable; and **"NP"** signifies that specific performance is not possible. **BCA**

SINGLE-ENGINE PISTONS NORMALLY ASPIRATED

Manufacturer			Cirrus Design	Piper Aircraft	Textron Aviation	Cirrus Design
Model			SR20	Arrow PA-28R-201	Cessna Skylane CE-182T	SR22
BCA Equipped Price			$454,900	$502,000	$515,000	$629,000
Characteristics		Seating	1+3/4	1+3/3	1+3/3	1+3/4
		Wing Loading	21.7	16.2	17.8	23.5
		Power Loading	14.65	13.75	13.48	11.61
		Noise (dBA)	83.4	77.7	77.7	83.7
External Dimensions (ft.)		Length	26.0	24.7	29.0	26.0
		Height	8.9	7.9	9.3	8.9
		Span	38.3	35.4	36.0	38.3
Internal Dimensions (ft.)		Length	8.0	7.7	7.2	8.0
		Height	4.1	3.7	4.0	4.1
		Width	4.1	3.5	3.5	4.1
Power		Engine	Lyc IO-390-C3B6	Lyc IO-360-C1C6	Lyc IO-540-AB1A5	Cont IO-550-N
		Output (hp)	215	200	230	310
		Inspection Interval	2,000t	2,000t	2,000t	2,000t
Weights (lb.)		Max Ramp	3,160	2,758	3,110	3,610
		Max Takeoff	3,150	2,750	3,100	3,600
		Max Landing	3,150	2,750	2,950	3,600
		Zero Fuel	3,043b	2,636b	2,986b	3,400c
		EOW	2,120	1,798	2,000	2,260
		Max Payload	923	838	986	1,140
		Useful Load	1,040	960	1,110	1,350
		Max Baggage	130	200	200	130
		Max Fuel	336	432	522	552
		Available Payload w/Max Fuel	704	528	588	798
		Available Fuel w/Max Payload	117	122	124	210
Limits		V_{NE}	201	183	175	205
		V_{NO}	164	146	140	176
		V_A	133	118	110	140
Airport Performance		TO (SL elev./ISA temp.)	2,530	1,600	1,514	1,756
		TO (5,000-ft. elev.@25C)	4,305	3,250	2,708	3,016
		V_{SO}	62	55	49	64
		V_X	81	78	65	88
		V_Y	88	90	80	108
Climb		Time to Climb (min.)/Altitude	20/FL 100	16/FL 100	15/FL 100	11/FL 100
		Initial Gradient (ft./nm)	540	560	694	775
Ceiling (ft.)		Service	17,500	16,200	18,100	17,500
Cruise	Long Range	TAS	135	124	125	160
		Fuel Flow	53	51	61	68
		Altitude	FL 080	FL 100	FL 100	FL 080
		Specific Range	2.547	2.431	2.049	2.353
	Recommended	TAS	145	130	135	171
		Fuel Flow	61	68	69	92
		Altitude	FL 080	FL 090	FL 100	FL 080
		Specific Range	2.377	1.912	1.957	1.859
	High Speed	TAS	152	137	144	180
		Fuel Flow	71	76	76	107
		Altitude	FL 080	FL 060	FL 060	FL 080
		Specific Range	2.141	1.803	1.895	1.682
Ranges	Seats Full	Nautical Miles	672	537	723	1,118
		Average Speed	135	121	130	162
		Fuel Used	275	256	379	492
		Specific Range/Altitude	2.444/FL 080	2.098/FL 070	1.908/FL 120	2.272/FL 080
	Tanks Full	Nautical Miles	672	926	912	1,118
		Average Speed	135	121	131	162
		Fuel Used	275	408	471	492
		Specific Range/Altitude	2.444/FL 080	2.270/FL 070	1.936/FL 120	2.272/FL 080
Missions (4 occupants)	200 nm	Runway	1,685	1,600	1,249	1,303
		Block Time	1+26	1+29	1+37	1+09
		Fuel Used	112	125	123	127
		Specific Range/Altitude	1.786/FL 080	1.600/FL 070	1.626/FL 120	1.575/FL 080
	500 nm	Runway	1,685	1,600	1,402	1,519
		Block Time	3+30	3+50	3+52	2+49
		Fuel Used	245	278	269	305
		Specific Range/Altitude	2.041/FL 080	1.799/FL 090	1.859/FL 120	1.639/FL 080
		Suggested Base Price	$454,900	$490,298	$515,000	$629,000
Remarks		Certification Basis	FAR 23, 2000 Includes Garmin Perspective+ avionics.	CAR 3, 1976/2001 Garmin G500 TXi standard.	FAR 23, 1996/2001 A23-6 Garmin G1000 NXi with GFC 700 autopilot.	FAR 23, 2000 Includes Garmin Perspective+ avionics.

SINGLE-ENGINE PISTONS NORMALLY ASPIRATED

			Mooney	Textron Aviation	GippsAero
Manufacturer			Mooney	Textron Aviation	GippsAero
Model			Ovation Ultra M20U	Beechcraft Bonanza G36 G36	Airvan GA-8
BCA Equipped Price			$728,900	$914,000	$939,632
Characteristics		Seating	1+3/4	1+4/5	1+6/7
		Wing Loading	19.3	20.2	20.7
		Power Loading	10.86	12.17	13.33
		Noise (dBA)	NA	76.7	84.9
External Dimensions (ft.)		Length	26.7	27.5	29.3
		Height	8.3	8.6	12.8
		Span	36.5	33.5	40.7
Internal Dimensions (ft.)		Length	8.3	12.6	11.6
		Height	3.7	4.2	3.7
		Width	3.6	3.5	4.2
Power		Engine	Cont IO-550-G-AP	Cont IO-550-B	Lyc IO-540-K1A5
		Output (hp)	310	300	300
		Inspection Interval	2,200t	1,900t	2,000t
Weights (lb.)		Max Ramp	3,374	3,663	4,014
		Max Takeoff	3,368	3,650	4,000
		Max Landing	3,200	3,650	4,000
		Zero Fuel	3,197b	3,510b	3,849b
		EOW	2,244	2,590	2,241
		Max Payload	953	920	1,608
		Useful Load	1,130	1,073	1,773
		Max Baggage	120	670	180
		Max Fuel	600	444	540
		Available Payload w/Max Fuel	530	629	1,233
		Available Fuel w/Max Payload	177	153	166
Limits		V_{NE}	195	203	185
		V_{NO}	174	165	143
		V_A	127	139	121
Airport Performance		TO (SL elev./ISA temp.)	1,600	1,913	1,860
		TO (5,000-ft. elev.@25C)	3,400	3,450	3,670
		V_{SO}	59	59	57
		V_X	75	84	70
		V_Y	105	100	86
Climb		Time to Climb (min.)/Altitude	10/FL 100	14/FL 100	15/FL 100
		Initial Gradient (ft./nm)	NA	730	787
Ceiling (ft.)		Service	NA	18,500	20,000
Cruise	Long Range	TAS	163	160	127
		Fuel Flow	50	71	78
		Altitude	FL 120	FL 080	FL 120
		Specific Range	3.260	2.254	1.628
	Recommended	TAS	186	167	135
		Fuel Flow	84	86	88
		Altitude	FL 121	FL 080	FL 080
		Specific Range	2.214	1.942	1.534
	High Speed	TAS	196	174	142
		Fuel Flow	114	93	101
		Altitude	FL 080	FL 080	FL 060
		Specific Range	1.719	1.865	1.406
Ranges	Seats Full	Nautical Miles	1,075	217	487
		Average Speed	161	153	124
		Fuel Used	438	115	339
		Specific Range/Altitude	2.454/FL 121	1.887/FL 040	1.437/FL 120
	Tanks Full	Nautical Miles	1,465	860	690
		Average Speed	173	159	125
		Fuel Used	558	403	464
		Specific Range/Altitude	2.625/FL 121	2.134/FL 080	1.487/FL 120
Missions (4 occupants)	200 nm	Runway	1,230	1,665	1,860
		Block Time	1+13	1+11	1+38
		Fuel Used	115	130	157
		Specific Range/Altitude	1.739/FL 050	1.538/FL 060	1.274/FL 120
	500 nm	Runway	1,290	1,858	1,860
		Block Time	2+58	2+54	3+55
		Fuel Used	221	304	339
		Specific Range/Altitude	2.262/FL 100	1.645/FL 060	1.475/FL 120
		Suggested Base Price	$689,000	$914,000	$798,256
Remarks		Certification Basis	CAR 3/FAR 23, 1955/94; STC SA02483CH Includes Garmin G1000; composite fuselage shell with left and right doors.	CAR 3, 1956/69/83/2005 A/C system standard; Garmin G1000 NXi.	FAR 23 A 54 Includes Garmin G500. All data preliminary.

SINGLE-ENGINE PISTONS TURBOCHARGED

Manufacturer			Textron Aviation	Cirrus Design	Mooney	GippsAero
Model			Cessna Turbo Stationair HD CE-T206H	SR22T	Acclaim Ultra M020V	GA8 Airvan TC GA8-TC320
BCA Equipped Price			$714,000	$729,000	$807,900	$977,856
Characteristics		Seating	1+5/5	1+3/4	1+3/3	1+6/7
		Wing Loading	21.8	23.5	19.2	20.7
		Power Loading	12.22	11.43	12.03	13.13
		Noise (dBA)	82.6	80.3	78.0	85.4
External Dimensions (ft.)		Length	28.3	26.0	26.9	28.3
		Height	9.3	8.9	8.3	9.3
		Span	36.0	38.3	36.4	36.0
Internal Dimensions (ft.)		Length	9.3	8.0	8.1	11.6
		Height	4.1	4.1	3.7	3.7
		Width	3.7	4.1	3.6	4.2
Power		Engine	Lyc TIO-540-AJ1A	Cont TSIO-550-K	Cont TSIO-550-G	Lyc TIO-540-AH1A
		Output (hp)	310	315	280	320
		Inspection Interval	2,000t	2,000t	2,200t	1,800t
Weights (lb.)		Max Ramp	3,806	3,610	3,374	4,214
		Max Takeoff	3,789	3,600	3,368	4,200
		Max Landing	3,600	3,600	3,200	4,000
		Zero Fuel	3,615b	3,400c	3,173b	4,053b
		EOW	2,365	2,342	2,378	2,349
		Max Payload	1,250	1,058	795	1,704
		Useful Load	1,441	1,268	996	1,865
		Max Baggage	180	130	120	180
		Max Fuel	522	552	612	540
		Available Payload w/Max Fuel	919	716	384	1,325
		Available Fuel w/Max Payload	191	210	201	161
Limits		V_{NE}	182	205	195	185
		V_{NO}	149	176	174	143
		V_{A}	125	140	127	121
Airport Performance		TO (SL elev./ISA Temp.)	1,970	1,517	1,900	1,840
		TO (5,000-ft. elev.@25C)	2,845	2,268	3,300	2,788
		V_{SO}	59	64	60	61
		V_{X}	70	88	80	71
		V_{Y}	88	103	105	81
Climb		Time to Climb (min.)/Altitude	12/FL 100	7/FL 100	7/FL 100	13/FL 100
		Initial Gradient (ft./nm)	724	782	770	825
Ceilings (ft.)		Certificated	26,000	25,000	25,000	20,000
		Service	26,000	25,000	25,000	20,000
Cruise	Long Range	TAS	137	171	215	125
		Fuel Flow	85	76	99	68
		Altitude	FL 240	FL 250	FL 250	FL 200
		Specific Range	1.612	2.250	2.172	1.838
	Recommended	TAS	155	201	227	130
		Fuel Flow	99	98	128	78
		Altitude	FL 240	FL 250	FL 180	FL 200
		Specific Range	1.574	2.051	1.773	1.667
	High Speed	TAS	164	213	242	135
		Fuel Flow	116	110	130	98
		Altitude	FL 200	FL 250	FL 250	FL 200
		Specific Range	1.410	1.936	1.862	1.378
Ranges	Seats Full	Nautical Miles	465	1,021	500	233
		Average Speed	137	171	178	125
		Fuel Used	358	486	259	220
		Specific Range/Altitude	1.299/FL 200	2.101/FL 250	1.931/FL 160	1.059/FL 200
	Tanks Full	Nautical Miles	608	1,021	1,122	618
		Average Speed	138	171	200	125
		Fuel Used	430	486	539	459
		Specific Range/Altitude	1.414/FL 240	2.101/FL 250	2.082/FL 250	1.346/FL 200
Missions (4 occupants)	200 nm	Runway	1,420	1,405	1,300	1,743
		Block Time	1+23	1+08	1+05	1+35
		Fuel Used	163	197	139	125
		Specific Range/Altitude	1.227/FL 150	1.015/FL 100	1.439/FL 120	1.600/FL 120
	500 nm	Runway	1,626	1,699	1,380	1,743
		Block Time	3+22	2+28	2+54	3+30
		Fuel Used	386	360	259	373
		Specific Range/Altitude	1.295/FL 240	1.389/FL 180	1.931/FL 250	1.340/FL 200
		Suggested Base Price	$714,000	$729,000	$769,000	$837,133
Remarks		Certification Basis	FAR 23, 1998 Utility version w/2,212-lb. EOW, $707,650; Garmin G1000 NXi with GFC 700 autopilot; new interior.	FAR 23, 2010 Includes Garmin Perspective+ avionics.	CAR 3, 1955/89/2006 Incudes Garmin G1000; new composite fuselage shell with left and right doors.	FAR 23, 1998 Garmin G500; KC 225. All data preliminary.

SINGLE-ENGINE PISTONS PRESSURIZED

Manufacturer			Piper Aircraft
Model			M350 PA-46-350P
BCA Equipped Price			$1,478,000
Characteristics		Seating	1+4/5
		Wing Loading	24.8
		Power Loading	12.40
		Noise (dBA)	81.0
External Dimensions (ft.)		Length	28.9
		Height	11.3
		Span	43.0
Internal Dimensions (ft.)		Length	12.4
		Height	3.9
		Width	4.2
Power		Engine	Lyc TIO-540-AE2A
		Output (hp)	350
		Inspection Interval	2,000t
Weights (lb.)		Max Ramp	4,358
		Max Takeoff	4,340
		Max Landing	4,123
		Zero Fuel	4,123c
		EOW	3,146
		Max Payload	977
		Useful Load	1,212
		Max Baggage	200
		Max Fuel	720
		Available Payload w/Max Fuel	492
		Available Fuel w/Max Payload	235
Limits		V_{NE}	198
		V_{NO}	168
		V_A	133
		PSI	5.5
Airport Performance		TO (SL elev./ISA temp.)	2,090
		TO (5,000-ft. elev.@25C)	2,977
		V_{SO}	58
		V_X	81
		V_Y	110
Climb		Time to Climb (min.)/Altitude	8/FL 100
		Initial Gradient (ft./nm)	703
Ceilings (ft.)		Certificated	25,000
		Service	25,000
		Sea-Level Cabin	12,300
Cruise	Long Range	TAS	156
		Fuel Flow	66
		Altitude	FL 250
		Specific Range	2.364
	Recommended	TAS	203
		Fuel Flow	108
		Altitude	FL 250
		Specific Range	1.880
	High Speed	TAS	213
		Fuel Flow	120
		Altitude	FL 250
		Specific Range	1.775
Ranges	Seats Full	Nautical Miles	535
		Average Speed	138
		Fuel Used	312
		Specific Range/Altitude	1.715/FL 120
	Tanks Full	Nautical Miles	1,343
		Average Speed	159
		Fuel Used	670
		Specific Range/Altitude	2.004/FL 250
Missions (4 occupants)	200 nm	Runway	2,090
		Block Time	1+06
		Fuel Used	167
		Specific Range/Altitude	1.198/FL 200
	500 nm	Runway	2,090
		Block Time	2+31
		Fuel Used	350
		Specific Range/Altitude	1.429/FL 250
		Suggested Base Price	$1,195,000
Remarks		Certification Basis	FAR 23, 1983/88 Garmin G1000 NXi; FIKI optional.

MULTIENGINE PISTONS NORMALLY ASPIRATED

Manufacturer			Vulcanair SpA	Vulcanair SpA	Textron Aviation
Model			P.68C P 68C	Victor P 68R	Beech Baron G58 G58
BCA Equipped Price			$1,001,600	$1,179,058*	$1,486,000
Characteristics		Seating	1+5/6	1+5/6	1+4/5
		Wing Loading	22.9	22.7	27.6
		Power Loading	11.49	11.37	9.17
		Noise (dBA)	74.7	78.8	77.6
External Dimensions (ft.)		Length	31.3	31.3	29.8
		Height	11.2	11.2	9.8
		Span	39.4	39.4	37.8
Internal Dimensions (ft.)		Length	10.6	10.6	12.6
		Height	3.9	3.9	4.2
		Width	3.8	3.8	3.5
Power		Engines	2 Lyc IO-360-A1B6	2 Lyc IO-360-A1B6	2 Cont IO-550-C
		Output (hp each)	200	200	300
		Inspection Interval	2,000t	2,000t	1,900t
Weights (lb.)		Max Ramp	4,630	4,548	5,524
		Max Takeoff	4,594	4,548	5,500
		Max Landing	4,365	4,321	5,400
		Zero Fuel	4,167c	4,374b	5,210b
		EOW	3,153	3,197	3,965
		Max Payload	1,014	1,177	1,245
		Useful Load	1,477	1,351	1,559
		Max Fuel	1,063	1,063	1,164
		Available Payload w/Max Fuel	415	289	395
		Available Fuel w/Max Payload	463	174	314
Limits		V_{NE}	194	197	223
		V_{NO}	154	157	195
		V_A	132	127	156
Airport Performance		TO (SL elev./ISA Temp.)	1,312	1,260	2,345
		TO (5,000-ft. elev.@25C)	4,000	4,000	4,144
		A/S (SL elev./ISA)	2,150	1,410	3,009
		A/S (5,000-ft. elev.@25C)	2,950	2,370	4,335
		V_{MCA}	60	60	84
		V_{DEC}	70	70	85
		V_{XSE}	82	82	100
		V_{YSE}	88	88	101
Climb		Time to Climb (min.)/Altitude	12/FL 100	12/FL 100	10/FL 100
		Initial Engine-Out Rate (fpm)	217	217	390
		Initial All-Engine Gradient (ft./nm)	1,100	920	988
		Initial Engine-Out Gradient (ft./nm)	147	147	232
Ceilings (ft.)		Certificated	—	—	—
		All-Engine Service	18,000	20,000	20,688
		Engine-Out Service	5,000	5,650	7,284
Cruise	Long Range	TAS	144	144	185
		Fuel Flow	94	94	144
		Altitude	FL 080	FL 080	FL 080
		Specific Range	1.532	1.532	1.285
	Recommended	TAS	155	155	192
		Fuel Flow	108	108	174
		Altitude	FL 080	FL 080	FL 080
		Specific Range	1.435	1.435	1.103
	High Speed	TAS	162	162	200
		Fuel Flow	116	116	193
		Altitude	FL 080	FL 080	FL 080
		Specific Range	1.397	1.397	1.035
Ranges	Max Payload	Nautical Miles	300	300	250
		Average Speed	140	140	174
		Trip Fuel	315	315	231
		Specific Range/Altitude	0.952/FL 080	0.952/FL 080	1.082/FL 040
	Ferry	Nautical Miles	1,000	1,000	1,480
		Average Speed	145	145	180
		Trip Fuel	975	975	1,081
		Specific Range/Altitude	1.026/FL 080	1.026/FL 080	1.369/FL 120
Missions (4 occupants)	200 nm	Runway	1,450	1,450	2,861
		Block Time	1+28	1+28	1+02
		Fuel Used	140	140	226
		Specific Range/Altitude	1.429/FL 80	1.429/FL 080	0.885/FL 060
	500 nm	Runway	1,500	1,500	2,940
		Block Time	3+25	3+25	2+31
		Fuel Used	375	375	531
		Specific Range/Altitude	1.333/FL 080	1.333/FL 080	0.942/FL 060
		Suggested Base Price	$1,001,600	$1,160,490	$1,486,000
Remarks		Certification Basis	FAR 23, 1976/80 Garmin G1000 NXi with GFC autopilot.	EASA 23, 2009 Garmin G1000 NXi. *BCA estimate.	CAR 3, 1957/69/83/2005 A/C system standard; Garmin G1000 NXi; max payload mission flown with six occupants.

MULTIENGINE PISTONS TURBOCHARGED

			Vulcanair SpA	Piper Aircraft
Manufacturer			Vulcanair SpA	Piper Aircraft
Model			P 68C-TC	Seneca V PA-34-220T
BCA Equipped Price			$1,063,200	$1,242,000
Character-istics		Seating	1+5/5	1+4/5
		Wing Loading	20.7	22.8
		Power Loading	10.94	10.80
		Noise (dBA)	74.7	75.6
External Dimensions (ft.)		Length	31.3	28.6
		Height	11.2	9.9
		Span	39.4	38.9
Internal Dimensions (ft.)		Length	10.6	10.4
		Height	3.9	3.6
		Width	3.8	4.1
Power		Engines	2 Lyc TIO-360-C1A6D	2 Cont TSIO-360-RB
		Output (hp each)	210	220
		Inspection Interval	2,000t	1,800t
Weights (lb.)		Max Ramp	4,630	4,773
		Max Takeoff	4,594	4,750
		Max Landing	4,365	4,513
		Zero Fuel	4,140b	4,479c
		EOW	3,197	3,491
		Max Payload	943	988
		Useful Load	1,433	1,282
		Max Fuel	1,062	732
		Available Payload w/Max Fuel	371	550
		Available Fuel w/Max Payload	490	294
Limits		V_{NE}	194	204
		V_{NO}	154	164
		V_A	132	139
Airport Perfor-mance		TO (SL elev./ISA temp.)	1,260	1,707
		TO (5,000-ft. elev.@25C)	2,200	2,435
		A/S (SL elev./ISA)	1,800	2,510
		A/S (5,000-ft. elev.@25C)	2,400	3,117
		V_{MCA}	66	66
		V_{DEC}	NA	73
		V_{XSE}	78	83
		V_{YSE}	88	88
Climb		Time to Climb (min.)/Altitude	10/FL 100	7/FL 100
		Initial Engine-Out Rate (fpm)	240	253
		Initial All-Engine Gradient (ft./nm)	1,400	996
		Initial Engine-Out Gradient (ft./nm)	NA	173
Ceilings (ft.)		Certificated	20,000	25,000
		All-Engine Service	20,000	25,000
		Engine-Out Service	10,000	16,500
Cruise	Long Range	TAS	144	167
		Fuel Flow	104	108
		Altitude	FL 080	FL 230
		Specific Range	1.385	1.546
	Recommended	TAS	155	196
		Fuel Flow	125	144
		Altitude	FL 080	FL 250
		Specific Range	1.240	1.361
	High Speed	TAS	162	200
		Fuel Flow	150	156
		Altitude	FL 080	FL 230
		Specific Range	1.080	1.282
Range	Ferry	Nautical Miles	1,100	866
		Average Speed	145	160
		Trip Fuel	960	648
		Specific Range/Altitude	1.146/FL 080	1.336/FL 180
Missions (4 occupants)	200 nm	Runway	NA	1,520
		Block Time	1+28	1+10
		Fuel Used	260	213
		Specific Range/Altitude	0.769/FL 080	0.939/FL 120
	500 nm	Runway	NA	1,610
		Block Time	3+25	2+41
		Fuel Used	485	476
		Specific Range/Altitude	1.031/FL 080	1.050/FL 200
		Suggested Base Price	$1,063,200	$1,030,000
Remarks		Certification Basis	FAR 23, 1982 Garmin G1000 NXi. *BCA* estimated data.	FAR 23, 1971/80/97 Garmin G1000 NXi standard.

SINGLE-ENGINE TURBOPROPS

			Mahindra Aerospace	Piper Aircraft	Textron Aviation	Quest Aircraft	Textron Aviation
Manufacturer			Mahindra Aerospace	Piper Aircraft	Textron Aviation	Quest Aircraft	Textron Aviation
Model			Airvan 10 GA-10	M500 PA-46-500TP	Cessna Caravan CE-208	Kodiak Kodiak 100	Cessna Grand Caravan EX CE-208B
BCA Equipped Price			$1,700,000*	$2,209,000	$2,320,000	$2,454,800	$2,685,000
Characteristics		Seating	1+9/9	1+4/5	1+9/13*	1+6/9	1+9/13*
		Wing Loading	28.6	27.8	28.6	30.2	31.5
		Power Loading	10.56	10.18	11.85	9.67	10.16
		Noise (dBA)	79.0	76.8	79.0	84.4	84.1
External Dimensions (ft.)		Length	33.5	29.6	37.6	33.8	41.6
		Height	12.7	11.3	14.9	15.3	158.1
		Span	40.6	43.0	52.1	45.0	52.1
Internal Dimensions (ft.)		Length	16.1	12.3	12.7	15.8	16.7
		Height	3.8	3.9	4.5	4.8	4.5
		Width	4.2	4.1	5.3	4.5	5.3
Power		Engine	RR M250 B-17F/2	P&WC PT6A-42A	P&WC PT6A-114A	P&WC PT6A-34	P&WC PT6A-140
		Output (shp)/Flat Rating	450/ISA+31C	500/ISA+55C	675/ISA+31C	750/ISA+7C	867/ISA+24C
		Inspection Interval	3,500t	3,600t	3,600t	4,000t	4,000t
Weights (lb.)		Max Ramp	4,775	5,134	8,035	7,305	8,842
		Max Takeoff	4,750	5,092	8,000	7,255	8,807
		Max Landing	4,750	4,850	7,800	7,255	8,500
		Zero Fuel	4,182b	4,850c	7,432b	6,490c	8,152b
		BOW	2,475	3,634	4,930	4,417	5,510
		Max Payload	1,707	1,216	2,502	2,073	2,642
		Useful Load	2,300	1,500	3,105	2,888	3,332
		Max Fuel	1,025	1,160	2,224	2,144	2,246
		Available Payload w/Max Fuel	1,275	340	881	744	1,086
		Available Fuel w/Max Payload	594	284	604	815	691
Limits		V_{MO}	175	188	175	180	175
		V_A	150	127	150	143	148
		PSI	—	5.6	—	—	—
Airport Performance		TO (SL elev./ISA temp.)	1,600	2,438	2,055	1,468	2,160
		TO (5,000-ft. elev.@25C)	2,973	3,691	2,973	2,396	3,661
		V_{SO}	61	69	61	60	61
		V_X	90	95	90	73	86
		V_Y	107	125	107	101	108
Climb		Time to Climb (min.)/Altitude	9/FL 100	19/FL 250	9/FL 100	9/FL 100	9/FL 100
		Initial Gradient (ft./nm)	771	753	771	915	816
Ceilings (ft.)		Certificated	20,000	30,000	25,000	25,000	25,000
		Service	25,000	30,000	25,000	25,000	25,000
		Sea-Level Cabin	—	12,600	—	—	—
Cruise	Long Range	TAS	157	179	157	164	156
		Fuel Flow	281	135	281	251	328
		Altitude	FL 100	FL 280	FL 100	220	FL 100
		Specific Range	0.559	1.326	0.559	0.653	0.476
	High Speed	TAS	186	258	186	175	185
		Fuel Flow	379	242	379	335	437
		Altitude	FL 100	FL 280	FL 100	FL 120	FL 100
		Specific Range	0.491	1.066	0.491	0.522	0.423
NBAA IFR Ranges (100-nm alternate)	Full Fuel (w/available payload)	Nautical Miles	965	834	965	1,005	807
		Average Speed	156	171	156	175	156
		Trip Fuel	1,795	748	1,799	2,130	1,761
		Specific Range/Altitude	0.538/FL 100	1.115/FL 280	0.536/FL 100	0.472/120	0.458/FL 100
	Ferry	Nautical Miles	970	834	970	1,236	816
		Average Speed	156	171	156	164	156
		Trip Fuel	1,800	748	1,800	2,130	1,772
		Specific Range/Altitude	0.539/FL 100	1.115/FL 280	0.539/FL 100	0.580/FL 200	0.460/FL 100
Missions (4 passengers)	300 nm	Runway	1,468	1,550	1,468	1,468	1,428
		Flight Time	1 + 40	1+22	1+40	1+47	1+41
		Fuel Used	648	379	648	587	750
		Specific Range/Altitude	0.463/FL 100	0.792/FL 280	0.463/FL 100	0.511/FL 120	0.400/FL 100
	600 nm	Runway	1,675	1,625	1,675	1,468	1,792
		Flight Time	3+17	2+32	3+17	3+30	3+19
		Fuel Used	1,260	660	1,260	1,140	1,462
		Specific Range/Altitude	0.476/FL 100	0.909/FL 280	0.476/FL 100	0.526/FL 120	0.410/FL 100
	1,000 nm	Runway	NP	1,700	NP	1,467	NP
		Flight Time	NP	4+18	NP	5+47	NP
		Fuel Used	NP	985	NP	1,878	NP
		Specific Range/Altitude	NP	1.015/FL 280	NP	0.532/FL 120	NP
		Suggested Base Price	NA	$2,081,000	NA	$2,150,000	NA
Remarks		Certification Basis	FAR 23, 1984/98 Garmin G1000 with GFC 700 autopilot. *BCA estimated price.	FAR 23 A 52 Garmin G1000 NXi with SVS. *1,000 nm, three passengers.	FAR 23, 1984/98 Garmin G1000 NXi with GFC 700 autopilot. *Export only.	FAR 23, 2007 Normal category. Includes Garmin G1000 and GFC 700 autopilot with coupled GA; Summit interior option.	FAR 23, 1986/2012 Includes cargo pod; Garmin G1000 NXi with GFC 700 autopilot. *Export only.

SINGLE-ENGINE TURBOPROPS

Manufacturer			Piper Aircraft	*Epic Aircraft*	Daher	Daher	Pilatus
Model			**M600** **PA-46-600TP**	***Epic*** ***E1000***	**TBM 910** **TBM 700 N**	**TBM 930** **TBM 700 N**	**PC-12 NG** **PC-12/47E**
BCA Equipped Price			$3,189,000	*$3,250,000*	$4,069,964	$4,346,150	$4,988,000
Characteristics		Seating	1+4/5	*1+5/6*	1+5/6	1+5/6	1+8/10
		Wing Loading	28.7	*39.4*	38.2	38.2	37.6
		Power Loading	10.00	*6.67*	8.70	8.70	8.71
		Noise (dBA)	76.8	*76.0*	76.2	76.2	77.0
External Dimensions (ft.)		Length	29.6	*35.8*	35.2	35.2	47.3
		Height	11.3	*12.5*	14.3	14.3	14.0
		Span	43.2	*43.0*	42.1	42.1	53.3
Internal Dimensions (ft.)		Length	12.3	*10.5*	15.0	15.0	16.9
		Height	3.9	*4.9*	4.1	4.1	4.8
		Width	4.1	*4.6*	4.0	4.0	5.0
Power		Engine	P&WC PT6A-42A	*P&WC* *PT6A-67A*	P&WC PT6A-66D	P&WC PT6A-66D	P&WC PT6A-67P
		Output (shp)/Flat Rating	600/ISA+55C	*1,200/ISA+35C*	850/ISA+49C	850/ISA+49C	1,200/ISA+35C
		Inspection Interval	3,600t	*3,500t*	3,500t	3,500t	3,500t
Weights (lb.)		Max Ramp	6,050	*8,050*	7,430	7,430	10,495
		Max Takeoff	6,000	*8,000*	7,394	7,394	10,450
		Max Landing	5,800	*8,000*	7,024	7,024	9,921
		Zero Fuel	4,850c	*6,250c**	6,032c	6,032c	9,039c
		BOW	3,850	*5,150*	4,829	4,829	6,782
		Max Payload	1,000	*1,100*	1,203	1,203	2,257
		Useful Load	2,200	*2,900*	2,601	2,601	3,713
		Max Fuel	1,742	*1,800*	2,017	2,017	2,704
		Available Payload w/Max Fuel	458	*1,100*	584	584	1,009
		Available Fuel w/Max Payload	1,200	*1,800*	1,398	1,398	1,456
Limits		V_{MO}	250	*280*	266	266	240
		V_A	151	*170*	160	160	163
		PSI	5.6	*6.7*	6.2	6.2	5.8
Airport Performance		TO (SL elev./ISA temp.)	2,635	*1,600*	2,380	2,380	2,600
		TO (5,000-ft. elev.@25C)	3,998	*NA*	3,475	3,475	4,270
		V_{SO}	62	*65*	65	65	67
		V_X	95	*124*	100	100	120
		V_Y	122	*150*	124	124	130
Climb		Time to Climb (min.)/Altitude	21/FL 250	*10/FL 250*	13/FL 250	13/FL 250	20/FL 250
		Initial Gradient (ft./nm)	785	*1,400*	1,000	1,000	860
Ceilings (ft.)		Certificated	30,000	*34,000*	31,000	31,000	30,000
		Service	30,000	*34,000*	31,000	31,000	30,000
		Sea-Level Cabin	12,600	*18,000*	14,390	14,390	13,100
Cruise	Long Range	TAS	184	*NA*	252	252	225
		Fuel Flow	155	*NA*	241	241	268
		Altitude	FL 280	*NA*	FL 310	FL 310	FL 300
		Specific Range	1.187	*NA*	1.046	1.046	0.840
	High Speed	TAS	274	*NA*	330	330	285
		Fuel Flow	324	*NA*	412	412	497
		Altitude	FL 280	*NA*	FL 260	FL 260	FL 200
		Specific Range	0.846	*NA*	0.801	0.801	0.573
NBAA IFR Ranges (100-nm alternate)	Full Fuel (w/available payload)	Nautical Miles	1,406	*NA*	1,514	1,514	1,608
		Average Speed	179	*NA*	252	252	261
		Trip Fuel	1,324	*NA*	1,599	1,599	2,282
		Specific Range/Altitude	1.062/FL 280	*NA/NA*	0.947/FL 310	0.947/FL 310	0.705/FL 300
	Ferry	Nautical Miles	1,406	*NA*	1,594	1,594	1,650
		Average Speed	179	*NA*	252	252	264
		Trip Fuel	1,324	*NA*	1,598	1,598	2,294
		Specific Range/Altitude	1.062/FL 280	*NA/NA*	0.997/FL 310	0.997/FL 310	0.719/FL 300
Missions (4 passengers)	300 nm	Runway	1,593	*NA*	1,765	1,765	1,563
		Flight Time	1+21	*NA*	1+00	1+00	1+10
		Fuel Used	429	*NA*	440	440	549
		Specific Range/Altitude	0.699/FL 280	*NA/NA*	0.682/FL 280	0.682/FL 280	0.546/FL 260
	600 nm	Runway	1,687	*NA*	2,005	2,005	1,753
		Flight Time	2+31	*NA*	1+55	1+55	2+16
		Fuel Used	735	*NA*	830	830	975
		Specific Range/Altitude	0.816/FL 280	*NA/NA*	0.723/FL 280	0.723/FL 280	0.615/FL 270
	1,000 nm	Runway	1,812	*2,380*	2,380	2,380	2,026
		Flight Time	4+06	*3+10*	3+10	3+10	3+46
		Fuel Used	1,142	*1,320*	1,320	1,320	1,520
		Specific Range/Altitude	0.876/FL 280	*0.758/FL 290*	0.758/FL 290	0.758/FL 290	0.658/FL 280
		Suggested Base Price	$2,944,560	*NA*	$3,833,314	$4,133,500	NA
Remarks		Certification Basis	FAR 23 A 62, 2016 Garmin G3000 with SVS and enhanced AFCS.	*FAR 23 pending* *Garmin G1000 NXi.* **BCA estimate.*	FAR 23, 1990/2006/07/14 Pilot door standard; five-blade propeller; Garmin G1000 NXi; elec-heated seats; five-year system warranty.	FAR 23, 1990/2006/07/14 Pilot door standard; five-blade propeller; autothrottle; Garmin G3000; AoA-ESP-USP; five-year system warranty.	FAR 23, 1996/2005/08 Includes typically equipped executive interior and avionics options.

MULTIENGINE TURBOPROPS ≤12,500-LB. MTOW

			Nextant Aerospace	Vulcanair SpA	Textron Aviation
Manufacturer			Nextant Aerospace	Vulcanair SpA	Textron Aviation
Model			G90XT C90	Viator AP68TP-600	Beechcraft King Air C90GTx C90GTi
BCA Equipped Price			$2,750,000	$2,965,000	$4,200,000
Characteristics		Seating	1+7/10	1+7/10	1+7/8
		Wing Loading	35.6	33.0	35.5
		Power Loading	9.55	10.08	9.53
		Noise (dBA)	71.7	71.7	74.8
External Dimensions (ft.)		Length	35.5	37.0	35.5
		Height	14.3	11.9	14.3
		Span	NA	39.4	53.7
Internal Dimensions (ft.)		**Length:** OA/Net	12.4/12.4	11.9/17.2	12.6/12.6
		Height	4.8	4.1	4.8
		Width: Max/Floor	4.5/4.1	3.7/3.7	4.5/4.1
Power		Engines	2 GE Czech H75-100	2 RR 250 B17C	2 P&WC PT6A-135A
		Output (shp each)/Flat Rating	550/ISA+8C	328/ISA+25C	550/ISA+30C
		Inspection Interval	4,000t	3,500t	3,600t
Weights (lb.)		Max Ramp	10,560	6,669	10,545
		Max Takeoff	10,500	6,613	10,485
		Max Landing	9,700	6,283	9,832
		Zero Fuel	9,650c	5,621c	9,378c
		BOW	7,200	3,850	7,265
		Max Payload	2,450	1,771	2,113
		Useful Load	3,360	2,819	3,280
		Max Fuel	2,573	1,487	2,573
		Available Payload w/Max Fuel	787	1,332	707
		Available Fuel w/Max Payload	910	1,048	1,167
Limits		V_{MO}	208	200	226
		V_A	169	141	163
		PSI	5.0	—	5.0
Airport Performance		TO (SL elev./ISA temp.)	2,100	2,034	1,984
		TO (5,000-ft. elev.@25C)	2,800	2,950	3,375
		A/S (SL elev./ISA temp.)	3,800	2,034	3,690
		A/S (5,000-ft. elev.@25C)	5,100	2,953	5,855
		V_{MCA}	92	77	80
		V_{DEC}	97	85	97
		V_{XSE}	101	90	100
		V_{YSE}	111	105	108
Climb		Time to Climb (min.)/Altitude	18/FL 250	7/FL 100	18/FL 250
		Initial Engine-Out Rate (fpm)	460	270	460
		Initial All-Engine Gradient (ft./nm)	1,900	1,500	1,900
		Initial Engine-Out Gradient (ft./nm)	260	180	260
Ceilings (ft.)		Certificated	30,000	25,000	30,000
		All-Engine Service	30,000	25,000	30,000
		Engine-Out Service	22,000	8,050	19,230
		Sea-Level Cabin	11,065	—	11,065
Cruise	Long Range	TAS	213	169	208
		Fuel Flow	292	261	332
		Altitude	FL 280	FL 100	FL 260
		Specific Range	0.729	0.648	0.627
	High Speed	TAS	283	214	270
		Fuel Flow	578	375	612
		Altitude	FL 240	FL 100	FL 200
		Specific Range	0.490	0.571	0.441
NBAA IFR Ranges (100-nm alternate)	Max Payload (w/available fuel)	Nautical Miles	324	543	260
		Average Speed	203	180	229
		Trip Fuel	600	781	620
		Specific Range/Altitude	0.540/FL 220	0.695/FL 100	0.419/FL 270
	Max Fuel (w/available payload)	Nautical Miles	1,300	837	1,026
		Average Speed	207	179	252
		Trip Fuel	1,782	1,220	2,044
		Specific Range/Altitude	0.730/FL 280	0.686/FL 100	0.502/FL 270
	Full Fuel (w/4 passsengers)	Nautical Miles	1,290	837	975
		Average Speed	207	179	252
		Trip Fuel	1,769	1,220	1,949
		Specific Range/Altitude	0.729/FL 280	0.686/FL 100	0.500/FL 270
	Ferry	Nautical Miles	1,369	837	1,045
		Average Speed	203	179	255
		Trip Fuel	1,850	1,220	2,053
		Specific Range/Altitude	0.740/FL 280	0.686/FL 100	0.509/FL 270
Missions (4 passengers)	300 nm	Runway	3,010	1,247	3,004
		Flight Time	1+06	1+35	1+13
		Fuel Used	584	419	748
		Specific Range/Altitude	0.514/FL 220	0.716/FL 100	0.401/FL 210
	600 nm	Runway	3,350	1,558	3,347
		Flight Time	2+12	3+18	2+22
		Fuel Used	1,162	866	1,353
		Specific Range/Altitude	0.516/FL 280	0.693/FL 100	0.443/FL 230
	1,000 nm	Runway	3,500	NP	3,690
		Flight Time	3+39	NP	3+58
		Fuel Used	1,938	NP	1,996
		Specific Range/Altitude	0.516/FL 280	NP	0.501/FL 270
Remarks		Suggested Base Price	NA	$3,237,140	NA
		Certification Basis	STC ST01902CH; STC SA3593NM; STC SA4010NM; STC SA3593NM; STC SA01902CH; STC SA01456WI-D; STC SA02133SE	FAR 23, 1986 Garmin G1000 NX; S-TEC Genesys 2100 autopilot. *BCA*-computed performance data.	CAR 3 1959/2007 Collins Pro Line Fusion standard; STC SA10747SC, weight increase; STC SA02054SE, winglets; STC SA3593NM, swept propellers; STC SA4010NM, dual aft strakes; 1,000-nm mission flown with 755-lb. payload.

MULTIENGINE TURBOPROPS ≤12,500-LB. MTOW

Manufacturer			Viking Air	Textron Aviation	Piaggio Aero Industries
Model			400 Series DHC-6-400	Beechcraft King Air 250 B200GT	Avanti Evo P180
BCA Equipped Price			$6,500,000*	$6,610,000	$7,695,000
Characteristics		Seating	1+11/19	1+8/10	1+7/9
		Wing Loading	29.8	40.3	70.3
		Power Loading	10.08	7.35	7.12
		Noise (dBA)	85.6	81.2	75.0
External Dimensions (ft.)		Length	51.8	43.8	47.3
		Height	19.5	14.8	13.0
		Span	65.0	57.9	46.0
Internal Dimensions (ft.)		**Length:** OA/Net	18.4/24.5	16.7/16.7	17.5/17.5
		Height	4.9	4.8	5.8
		Width: Max/Floor	5.4/4.4	4.5/4.1	6.1/3.5
Power		Engines	2 P&WC PT6A-34	2 P&WC PT6A-52	2 P&WC PT6A-66B
		Output (shp each)/Flat Rating	620/ISA+27C	850/ISA+37C	850/ISA+28C
		Inspection Interval	3,600t	3,600t	3,600t
Weights (lb.)		Max Ramp	12,525	12,590	12,150
		Max Takeoff	12,500	12,500	12,100
		Max Landing	12,300	12,500	11,500
		Zero Fuel	11,655b	11,000c	9,800c
		BOW	8,100	8,830	8,375
		Max Payload	3,555	2,170	1,425
		Useful Load	4,425	3,760	3,775
		Max Fuel	3,549	3,645	2,802
		Available Payload w/Max Fuel	876	115	973
		Available Fuel w/Max Payload	870	1,590	2,350
Limits		V_{MO}	170	260	260
		V_A	136	181	202
		PSI	—	6.5	9.0
Airport Performance		TO (SL elev./ISA temp.)	1,490	2,111	3,262
		TO (5,000-ft. elev.@25C)	NA	3,099	4,700
		A/S (SL elev./ISA temp.)	2,220	3,687	5,750
		A/S (5,000-ft. elev.@25C)	NA	4,859	7,400
		V_{MCA}	66	86	100
		V_{DEC}	NA	94	106
		V_{XSE}	NA	115	132
		V_{YSE}	NA	121	140
Climb		Time to Climb (min.)/Altitude	NA/FL 100	13/FL 250	10/FL 250
		Initial Engine-Out Rate (fpm)	340	682	670
		Initial All-Engine Gradient (ft./nm)	NA	1,170	1,106
		Initial Engine-Out Gradient (ft./nm)	NA	364	287
Ceilings (ft.)		Certificated	25,000	35,000	41,000
		All-Engine Service	26,700	35,000	39,400
		Engine-Out Service	11,600	26,000	23,800
		Sea-Level Cabin	—	15,293	24,000
Cruise	Long Range	TAS	NA	256	318
		Fuel Flow	NA	430	408
		Altitude	FL 100	FL 350	FL 410
		Specific Range	NA	0.595	0.779
	High Speed	TAS	180	310	400
		Fuel Flow	580	750	792
		Altitude	FL 100	FL 260	FL 310
		Specific Range	0.310	0.413	0.505
NBAA IFR Ranges (100-nm alternate)	Max Payload (w/available fuel)	Nautical Miles	NP	321	1,070
		Average Speed	NP	267	315
		Trip Fuel	NP	870	1,715
		Specific Range/Altitude	NP	0.369/FL 330	0.624/FL 390
	Max Fuel (w/available payload)	Nautical Miles	NA	1,403	1,450
		Average Speed	NA	291	311
		Trip Fuel	NA	2,941	2,167
		Specific Range/Altitude	NA/FL 100	0.477/FL 330	0.669/FL 410
	Full Fuel (w/4 passsengers)	Nautical Miles	NA	1,038	1,510
		Average Speed	NA	288	317
		Trip Fuel	NA	2,225	2,167
		Specific Range/Altitude	NA/FL 100	0.467/FL 330	0.697/FL 410
	Ferry	Nautical Miles	NA	1,420	1,530
		Average Speed	NA	293	318
		Trip Fuel	NA	2,942	2,167
		Specific Range/Altitude	NA/FL 100	0.483/FL 330	0.706/FL 410
Missions (4 passengers)	300 nm	Runway	NA	3,504	2,350
		Flight Time	NA	1+03	0+53
		Fuel Used	NA	869	688
		Specific Range/Altitude	NA/FL 100	0.345/FL 250	0.436/FL 310
	600 nm	Runway	NA	3,587	2,550
		Flight Time	NA	2+03	1+44
		Fuel Used	NA	1,494	1,144
		Specific Range/Altitude	NA/FL 100	0.402/FL 290	0.524/FL 350
	1,000 nm	Runway	NA	3,677	2,700
		Flight Time	NA	3+28	3+02
		Fuel Used	NA	2,147	1,603
		Specific Range/Altitude	NA/FL 100	0.466/FL 330	0.624/FL 390
Remarks		Suggested Base Price	NA	NA	$7,395,000
		Certification Basis	EASA/FAR 23 A57, 2010 *BCA estimate.	FAR 23, 1973/80/2008/11 Collins Pro Line Fusion standard; Wi-Fi optional; STC SA02131SE.	EASA 23, 2014; FAR 23, 2015 Includes Collins Pro Line 21; TCAS I; Iridium satcom; RVSM approved; optional 390-lb. capacity internal tank: $275,000.

MULTIENGINE TURBOPROPS >12,500-LB. MTOW

Manufacturer			Textron Aviation	Textron Aviation
Model			Beech King Air 350i B300	Beech King Air 350iER B300ER
BCA Equipped Price			$7,755,000	$8,804,670
Characteristics		Seating	1+9/11	1+9/11
		Wing Loading	48.4	53.2
		Power Loading	7.14	7.86
		Noise (dBA)	72.9	81.5
External Dimensions (ft.)		Length	46.7	46.7
		Height	14.3	14.3
		Span	57.9	57.9
Internal Dimensions (ft.)		**Length:** OA/Net	19.5/19.5	19.5/19.5
		Height	4.8	4.8
		Width: Max/Floor	4.5/4.1	4.5/4.1
Power		Engines	2 P&WC PT6A-60A	2 P&WC PT6A-60A
		Output (shp each)/Flat Rating	1,050/ISA+10C	1,050/ISA+10C
		Inspection Interval	3,600t	3,600t
Weights (lb.)		Max Ramp	15,100	16,600
		Max Takeoff	15,000	16,500
		Max Landing	15,000	15,675
		Zero Fuel	12,500c	13,000c
		BOW	9,955	10,215
		Max Payload	2,545	2,785
		Useful Load	5,145	6,385
		Max Fuel	3,611	5,192
		Available Payload w/Max Fuel	1,534	1,193
		Available Fuel w/Max Payload	2,600	3,600
Limits		MMO	0.58	0.58
		Trans. Alt. FL/VMO	FL 210/263	FL 240/245
		VA	184	182
		PSI	6.5	6.5
Airport Performance		TO (SL elev./ISA temp.)	3,300	4,057
		TOFL (5,000-ft. elev.@25C)	5,376	7,675
		Mission Weight	14,196	16,100
		NBAA IFR Range	1,549	2,257
		V2	109	111
		VREF	100	104
		Landing Distance	2,390	2,728
Climb		Time to Climb (min.)/Altitude	15/FL 250	18/FL 250
		*FAR 25 Initial Engine-Out Rate (fpm)	552	337
		FAR 25 Initial Engine-Out Gradient (ft./nm)	304	182
Ceilings (ft.)		Certificated	35,000	35,000
		All-Engine Service	35,000	35,000
		Engine-Out Service	21,500	17,100
		Sea-Level Cabin	15,293	15,293
Cruise	Long Range	TAS	235	238
		Fuel Flow	362	402
		Altitude	FL 330	FL 330
		Specific Range	0.649	0.592
	High Speed	TAS	312	303
		Fuel Flow	773	764
		Altitude	FL 240	FL 240
		Specific Range	0.404	0.397
NBAA IFR Ranges (100-nm alternate)	Max Payload (w/available fuel)	Nautical Miles	896	1,316
		Average Speed	273	261
		Trip Fuel	1,891	2,880
		Specific Range/Altitude	0.474/FL 350	0.457/FL 350
	Max Fuel (w/available payload)	Nautical Miles	1,485	2,223
		Average Speed	280	269
		Trip Fuel	2,944	4,528
		Specific Range/Altitude	0.504/FL 350	0.491/FL 350
	Full Fuel (w/4 passengers)	Nautical Miles	1,533	2,271
		Average Speed	285	271
		Trip Fuel	2,951	4,533
		Specific Range/Altitude	0.519/FL 350	0.501/FL 350
	Ferry	Nautical Miles	1,560	2,338
		Average Speed	289	276
		Trip Fuel	2,958	4,543
		Specific Range/Altitude	0.527/FL 350	0.515/FL 350
Missions (4 passengers)	300 nm	Runway	2,586	2,795
		Flight Time	1+02	1+05
		Fuel Used	881	919
		Specific Range/Altitude	0.341/FL 250	0.326/FL 250
	600 nm	Runway	2,702	2,927
		Flight Time	2+02	2+07
		Fuel Used	1,470	1,529
		Specific Range/Altitude	0.408/FL 290	0.392/FL 290
	1,000 nm	Runway	2,827	3,048
		Flight Time	3+27	3+35
		Fuel Used	2,102	2,195
		Specific Range/Altitude	0.476/FL 330	0.456/FL 330
		Suggested Base Price	NA	NA
Remarks		Certification Basis	FAR 23, 1989 Commuter category Collins Pro Line Fusion; Wi-Fi std.; RVSM approved; also available as 350HW with 16,500-lb. MTOW, 15,675-lb. MLW.	FAR 23, 1989/2007 Commuter category; Collins Pro Line Fusion; MultiScan radar; iTAWS; Wi-Fi standard; RVSM approved.

JETS <10,000-LB. MTOW

Manufacturer			Cirrus Design
Model			Vision G2 SF-50
BCA Equipped Price			$2,380,000
Characteristics		Seating	1+4/6
		Wing Loading	30.7
		Power Loading	3.25
		Noise (EPNdB): Lateral/Flyover/Approach	79.6/70.9/80.3
External Dimensions (ft.)		Length	30.7
		Height	10.9
		Span	38.7
Internal Dimensions (ft.)		**Length:** OA/Net	11.5/9.8
		Height/Dropped Aisle Depth	4.1/NA
		Width: Max/Floor	5.1/3.1
Baggage		**Internal:** Cu. ft./lb.	24/NA
		External: Cu. ft./lb.	30/NA
Power		Engine(s)	1 Wms Intl FJ33-5A
		Output (lb. each)/Flat Rating	1,846/ISA+10C
		Inspection Interval/Manu. Service Plan Interval	4,000t/—
Weights (lb.)		Max Ramp	6,040
		Max Takeoff	6,000
		Max Landing	5,550
		Zero Fuel	4,900c
		BOW	3,860
		Max Payload	1,040
		Useful Load	2,180
		Max Fuel	2,000
		Available Payload w/Max Fuel	180
		Available Fuel w/Max Payload	1,140
Limits		MMO	0.530
		Trans. Alt. FL/VMO	FL 183/250
		PSI	7.1
Airport Performance		TOFL (SL elev./ISA temp.)	2,036
		TOFL (5,000-ft. elev.@25C)	3,679
		Mission Weight	6,000
		NBAA IFR Range	1,098
		V2	91
		VREF	87
		Landing Distance	1,628
Climb		Time to Climb/Altitude	23/FL 310
		FAR 25 Engine-Out Rate (fpm)	NA
		FAR 25 Engine-Out Gradient (ft./nm)	NA
Ceilings (ft.)		Certificated	31,000
		All-Engine Service	31,000
		Engine-Out Service	—
		Sea-Level Cabin	NA
Cruise	Long Range	TAS	259
		Fuel Flow	300
		Altitude	FL 310
		Specific Range	0.863
	High Speed	TAS	305
		Fuel Flow	384
		Altitude	FL 310
		Specific Range	0.794
NBAA IFR Ranges (100-nm alternate)	Max Payload (w/available fuel)	Nautical Miles	461
		Average Speed	233
		Trip Fuel	745
		Specific Range/Altitude	0.619/FL 310
	Max Fuel (w/available payload)	Nautical Miles	1,171
		Average Speed	233
		Trip Fuel	1,611
		Specific Range/Altitude	0.727/FL 310
	Four Passengers (w/available fuel)	Nautical Miles	622
		Average Speed	233
		Trip Fuel	941
		Specific Range/Altitude	0.661/FL 310
	Ferry	Nautical Miles	1,220
		Average Speed	233
		Trip Fuel	1,760
		Specific Range/Altitude	0.693/FL 310
Missions (4 passengers)	300 nm	Runway	1,867
		Flight Time	1+12
		Fuel Used	548
		Specific Range/Altitude	0.547/FL 310
	600 nm	Runway	2,036
		Flight Time	2+36
		Fuel Used	914
		Specific Range/Altitude	0.656/FL 310
	1,000 nm	Runway	2,437
		Flight Time	4+18
		Fuel Used	1,401
		Specific Range/Altitude	0.714/FL 310
Remarks		Certification Basis	FAR 23, 2016/18 Garmin Perspective Touch+ avionics; RVSM.

JETS <20,000-LB. MTOW

Manufacturer			Embraer	Nextant Aerospace	Textron Aviation	Honda Aircraft Co.	Syberjet
Model			Phenom 100 EV EMB-500	Nextant 400 XTi BE 400A	Cessna Citation M2 CE-525	HondaJet Elite HA-420	SJ30i SJ30-2
BCA **Equipped Price**			$4,495,000	$4,650,000	$5,150,000	$5,280,000	$8,306,452
Characteristics		Seating	1+5/7/7	2+7/9/9	1+7/7/7	1+5/7/7	1+4/6/6
		Wing Loading/Power Loading	53.1/3.09	67.6/2.67	44.6/2.72	60.6/2.61	73.2/3.03
		Noise (EPNdB): Lateral/Flyover/Approach	81.6/70.8/86.1	76.9/91.5/88.8	85.9/73.2/88.5	85.5/73.1/87.4	78.5/86.2/91.8
External Dimensions (ft.)		Length	42.1	48.4	42.6	42.6	46.8
		Height	14.3	13.9	13.9	14.9	14.2
		Span	40.4	43.5	47.3	39.8	42.3
Internal Dimensions (ft.)		**Length:** Main Seating/Net/Gross	9.0/11.0/11.0	15.5/15.5/—	8.8/11.0/11.0	12.1/12.1/NA	12.5/12.5/—
		Height/Dropped Aisle Depth	4.9/0.3	4.8/flat floor	4.8/0.4	4.8/NA	4.4/NA
		Width: Max/Floor	5.1/3.6	4.9/4.0	4.8/3.1	5.0/NA	4.8/2.8
Baggage		**Internal:** Cu. ft./lb.	10/93	27/410	—/—	NA/NA	6/100
		External: Cu. ft./lb.	60/419	26/450	46/725	66/600	53/500
Power		Engines	2 P&WC PW 617F1-E	2 Wms Intl FJ44-3AP	2 Wms Intl FJ44-1AP-21	2 GE Honda HF-120-H1A	2 Wms Intl FJ44-2A
		Output (lb. each)/Flat Rating	1,730/ISA+8C	3,052/ISA+7C	1,965/ISA+7C	2,050/ISA+10C	2,300/ISA+8C
		Inspection Interval/Manu. Service Plan Interval	3,500t/—	5,000t/—	3,500t/5,000	NA/—	3,500t/—
Weights (lb.)		Max Ramp	10,748	16,500	10,800	10,780	14,050
		Max Takeoff	10,703	16,300	10,700	10,700	13,950
		Max Landing	9,998	15,700	9,900	9,960	12,725
		Zero Fuel	9,072c	13,000c	8,500c	8,900c	10,500c
		BOW	7,297	10,950	6,990	7,348	8,917
		Max Payload	1,775	2,050	1,510	1,552	1,583
		Useful Load	3,451	5,550	3,810	3,432	5,133
		Max Fuel	2,804	4,912	3,296	2,944	4,850
		Available Payload w/Max Fuel	647	638	514	488	283
		Available Fuel w/Max Payload	1,676	3,500	2,300	1,880	3,550
Limits		MMO	0.700	0.780	0.710	0.720	0.830
		Trans. Alt. FL/VMO	280/275	FL 290/320	FL 305/263	FL 302/270	FL 295/320
		PSI/Sea-Level Cabin	8.3/21,280	9.1/24,000	8.5/22,027	8.8/23,060	12.0/41,000
Airport Performance		TOFL (SL elev./ISA temp.)	3,190	3,821	3,210	3,491	3,939
		TOFL (5,000-ft. elev.@25C)	5,663	5,088	5,580	5,166	8,784
		Mission Weight	10,703	14,500p	10,700	10,700	13,125
		NBAA IFR Range	1,092	1,197	1,204	1,191	1,915
		V2	99	116	111	115	112
		VREF	95	105	101	106	104
		Landing Distance	2,473	2,960	2,340	2,804	2,657
Climb		Time to Climb/Altitude	19/FL 370	16/FL 370	18/FL 370	15/FL 370	16/FL 370
		FAR 25 Engine-Out Rate (fpm)	597	305	618	672	312
		FAR 25 Engine-Out Gradient (ft./nm)	316	158	334	303	167
Ceilings (ft.)		Certificated	41,000	45,000	41,000	43,000	49,000
		All-Engine Service	41,000	45,000	41,000	43,000	44,000
		Engine-Out Service	24,045	27,500	26,800	26,400	25,800
Cruise	Long Range	TAS/Fuel Flow (lb./hr.)	340/543	406/740	323/516	360/543	436/684
		Altitude/Specific Range	FL 410/0.626	FL 450/0.549	FL 410/0.626	FL 430/0.663	FL 450/0.637
	High Speed	TAS/Fuel Flow (lb./hr.)	406/955	447/968	401/920	419/999	475/1,188
		Altitude/Specific Range	FL 330/0.425	FL 430/0.462	FL 350/0.436	FL 330/0.419	FL 360/0.400
NBAA IFR Ranges (FAR Part 23, 100-nm alternate; FAR Part 25, 200-nm alternate)	Max Payload (w/available fuel)	Nautical Miles	466	1,024	751	641	1,635
		Average Speed	325	367	358	332	402
		Trip Fuel	1,036	2,411	1,600	1,267	2,908
		Specific Range/Altitude	0.450/FL 410	0.425/FL 450	0.469/FL 410	0.506/FL 430	0.562/FL 470
	Max Fuel (w/available payload)	Nautical Miles	1,194	1,895	1,357	1,433	2,598
		Average Speed	333	384	372	344	410
		Trip Fuel	2,196	3,953	2,675	2,414	4,241
		Specific Range/Altitude	0.544/FL 410	0.479/FL 450	0.507/FL 410	0.594/FL 430	0.613/FL 490
	Four Passengers (w/available fuel)	Nautical Miles	1,092	1,801	1,183	1,171	2,205
		Average Speed	333	383	370	342	408
		Trip Fuel	2,038	3,706	2,352	2,044	3,713
		Specific Range/Altitude	0.536/FL 410	0.486/FL 450	0.503/FL 410	0.573/FL 430	0.594/FL 490
	Ferry	Nautical Miles	1,254	1,981	1,400	1,495	2,667
		Average Speed	329	381	378	342	411
		Trip Fuel	2,220	3,986	2,705	2,430	4,246
		Specific Range/Altitude	0.565/FL 410	0.497/FL 450	0.518/FL 410	0.615/FL 430	0.628/FL 490
Missions (4 passengers)	300 nm	Runway	2,909	3,015	2,625	3,372	2,822
		Flight Time	0+53	0+48	0+52	0+53	0+45
		Fuel Used	753	786	804	679	846
		Specific Range/Altitude	0.398/FL 390	0.382/FL 390	0.373/FL 370	0.442/FL 430	0.355/FL 410
	600 nm	Runway	3,121	3,044	2,692	3,413	3,025
		Flight Time	1+45	1+30	1+38	1+40	1+26
		Fuel Used	1,236	1,323	1,362	1,185	1,313
		Specific Range/Altitude	0.485/FL 390	0.454/FL 430	0.441/FL 390	0.506/FL 430	0.457/FL 450
	1,000 nm	Runway	3,179	3,101	3,009	3,473	3,336
		Flight Time	2+54	2+28	2+42	2+43	2+21
		Fuel Used	1,919	2,145	2,018	1,872	1,980
		Specific Range/Altitude	0.521/FL 410	0.466/FL 450	0.496/FL 410	0.534/FL 430	0.505/FL 450
Remarks		Certification Basis	FAR 23, 2008	FAR 25, 1981/85 STC 02371LA; STC 10959SC; STC 03960AT	FAR 23, 2013	FAR 23, 2015/19 Mature TBO 5,000 hr.	FAR 23 Commuter category

JETS <20,000-LB. MTOW

Manufacturer			Textron Aviation	Embraer	Textron Aviation	Pilatus Aircraft
Model			Cessna Citation CJ3+ CE-525B	Phenom 300E EMB-505	Cessna Citation CJ4 CE-525C	PC-24
BCA Equipped Price			$8,705,000	$9,450,000	$9,655,000	$10,070,950
Characteristics		Seating	1+8/9/9	1+7/10/10	1+9/10/10	1+8/9/9
		Wing Loading/Power Loading	47.2/2.46	60.0/2.74	51.8/2.36	54.0/2.68
		Noise (EPNdB): Lateral/Flyover/Approach	88.7/74.0/88.6	88.8/70.6/88.9	92.8/75.6/89.5	90.9/77.5/91.5
External Dimensions (ft.)		Length	51.2	51.2	53.3	55.2
		Height	15.2	16.7	15.3	17.3
		Span	53.3	52.2	50.8	55.8
Internal Dimensions (ft.)		**Length:** Main Seating/Net/Gross	12.3/15.7/15.7	14.8/17.2/17.2	12.9/17.3/17.3	17.0/17.0/23.0
		Height/Dropped Aisle Depth	4.8/0.4	4.9/0.3	4.8/0.4	5.1/flat floor
		Width: Max/Floor	4.8/3.1	5.1/3.6	4.8/3.3	5.6/3.8
Baggage		**Internal:** Cu. ft./lb.	—/—	10/77	7/40	90/1,000
		External: Cu. ft./lb.	65/1,000	74/573	71/1,000	NA/NA
Power		Engines	2 Wms Intl FJ44-3A	2 P&WC PW 535E	2 Wms Intl FJ44-4A	2 Wms Intl FJ44-4A-QPM
		Output (lb. each)/Flat Rating	2,820/ISA+11C	3,360/ISA+15C	3,621/ISA+11C	3,420/ISA+23C
		Inspection Interval/Manu. Service Plan Interval	4,000t/5,000	5,000t/—	5,000t/5,000	5,000t/5,000
Weights (lb.)		Max Ramp	14,070	18,497	17,230	18,400
		Max Takeoff	13,870	18,387	17,110	18,300
		Max Landing	12,750	17,042	16,250	16,900
		Zero Fuel	10,675c	14,220c	13,450c	14,220c
		BOW	8,540	11,657	10,280	11,720
		Max Payload	2,135	2,563	3,170	2,500
		Useful Load	5,530	6,840	6,950	6,680
		Max Fuel	4,710	5,353	5,963	5,965
		Available Payload w/Max Fuel	820	1,487	987	715
		Available Fuel w/Max Payload	3,395	4,277	3,780	4,180
Limits		MMO	0.737	0.780	0.770	0.740
		Trans. Alt. FL/VMO	FL 293/278	FL 263/320	FL 279/305	FL 280/290
		PSI/Sea-Level Cabin	8.9/23,586	9.4/25,560	9.0/24,005	9.1/24,362
Airport Performance		TOFL (SL elev./ISA temp.)	3,180	3,254	3,410	2,930
		TOFL (5,000-ft. elev.@25C)	4,750	5,400	5,180	4,980
		Mission Weight	13,870	18,387	16,788	18,300
		NBAA IFR Range	1,849	2,019	1,948	2,000
		V2	114	113	117	106
		VREF	99	104	99	90
		Landing Distance	2,422	2,220	2,281	2,120
Climb		Time to Climb/Altitude	15/FL 370	15/FL 370	14/FL 370	26/FL 450
		FAR 25 Engine-Out Rate (fpm)	808	872	839	665
		FAR 25 Engine-Out Gradient (ft./nm)	425	437	430	379
Ceilings (ft.)		Certificated	45,000	45,000	45,000	45,000
		All-Engine Service	45,000	45,000	45,000	45,000
		Engine-Out Service	26,250	30,137	28,200	30,000
Cruise	Long Range	TAS/Fuel Flow (lb./hr.)	352/624	383/757	377/812	358/757
		Altitude/Specific Range	FL 450/0.564	FL 450/0.506	FL 450/0.464	FL 450/0.473
	High Speed	TAS/Fuel Flow (lb./hr.)	415/1,197	444/1,312	442/1,470	438/1,717
		Altitude/Specific Range	FL 350/0.347	FL 350/0.338	FL 370/0.301	FL 300/0.255
NBAA IFR Ranges (FAR Part 23, 100-nm alternate; FAR Part 25, 200-nm alternate)	Max Payload (w/available fuel)	Nautical Miles	1,080	1,351	1,425	1,206
		Average Speed	366	397	407	400
		Trip Fuel	2,381	3,362	3,753	3,069
		Specific Range/Altitude	0.454/FL 450	0.402/FL 450	0.380/FL 450	0.393/FL 450
	Max Fuel (w/available payload)	Nautical Miles	1,814	1,883	1,913	2,013
		Average Speed	377	406	413	366
		Trip Fuel	3,846	4,469	4,904	4,920
		Specific Range/Altitude	0.472/FL 450	0.421/FL 450	0.390/FL 450	0.409/FL 450
	Four Passengers (w/available fuel)	Nautical Miles	1,825	1,936	1,927	2,030
		Average Speed	276	411	416	367
		Trip Fuel	3,767	4,510	4,920	4,956
		Specific Range/Altitude	0.484/FL 450	0.429/FL 450	0.392/FL 450	0.410/FL 450
	Ferry	Nautical Miles	1,900	1,985	1,955	2,129
		Average Speed	383	417	420	359
		Trip Fuel	3,872	4,473	4,955	5,046
		Specific Range/Altitude	0.491/FL 450	0.444/FL 450	0.395/FL 450	0.422/FL 450
Missions (4 passengers)	300 nm	Runway	2,608	2,613	2,669	2,280
		Flight Time	0+49	0+47	0+46	0+50
		Fuel Used	969	1,058	1,087	978
		Specific Range/Altitude	0.310/FL 370	0.284/FL 390	0.276/FL 390	0.307/FL 410
	600 nm	Runway	2,609	2,747	2,715	2,320
		Flight Time	1+35	1+29	1+27	1+32
		Fuel Used	1,571	1,735	1,865	1,674
		Specific Range/Altitude	0.382/FL 410	0.346/FL 410	0.322/FL 410	0.358/FL 450
	1,000 nm	Runway	2,720	2,808	2,770	2,360
		Flight Time	2+36	2+26	2+23	2+29
		Fuel Used	2,315	2,471	2,747	2,659
		Specific Range/Altitude	0.432/FL 430	0.405/FL 450	0.364/FL 430	0.376/FL 450
Remarks		Certification Basis	FAR 23 Commuter category, 2004/14 Garmin G3000.	FAR 23 Commuter category, 2009 Performance based upon optional increased weights.	FAR 23 Commuter category, 2010	EASA CS 23, 2017; FAR 23, 2018 Price includes typically equipped executive interior and avionics options.

JETS ≥20,000-LB. MTOW

Manufacturer			Bombardier	Textron Aviation	Bombardier	Embraer	*Embraer*
Model			Learjet 70 Model 45	Cessna Citation XLS+ CE-560XL	Learjet 75 Model 45	Legacy 450 EMB-545	*Praetor 500 EMB-545*
BCA **Equipped Price**			$11,300,000	$13,700,000	$13,800,000	$16,570,000	*$16,995,000*
Characteristics		Seating	2+6/7/7	2+9/12/12	2+8/9/9	2+7/9/9	*2+7/9/9*
		Wing Loading/Power Loading	69.6/2.79	54.6/2.45	69.6/2.79	74.0/2.73	*NA/NA*
		Noise (EPNdB): Lateral/Flyover/Approach	87.4/74.3/93.4	86.8/72.2/92.8	87.4/74.3/93.4	84.2/72.9/89.9	*NA/NA/NA*
External Dimensions (ft.)		Length	56.0	52.5	58.0	64.6	*64.6*
		Height	14.0	17.2	14.0	21.1	*21.1*
		Span	50.9	56.3	50.9	66.4	*70.5*
Internal Dimensions (ft.)		**Length:** Main Seating/Net/Gross	10.6/17.7/17.7	14.3/18.5/18.5	13.4/19.8/19.8	17.4/20.6/24.0	*17.4/20.6/24.0*
		Height/Dropped Aisle Depth	4.9/flat floor	5.7/0.7	4.9/flat floor	6.0/flat floor	*6.0/flat floor*
		Width: Max/Floor	5.1/3.2	5.5/3.9	5.1/3.2	6.8/4.7	*6.8/4.7*
Baggage		**Internal:** Cu. ft./lb.	15/150	10/100	15/150	40/418	*40/418*
		External: Cu. ft./lb.	50/500	80/700	50/500	110/880	*110/880*
Power		Engines	2 Hon TFE731-40BR	2 P&WC PW545C	2 Hon TFE731-40BR	2 Hon HTF7500E	*2 Hon HTF7500E*
		Output (lb. each)/Flat Rating	3,850/ISA+23C	4,119/ISA+10C	3,850/ISA+23C	6,540/ISA+18C	*6,540/ISA+18C*
		Inspection Interval/Manu. Service Plan Interval	6,000t/—	5,000t/—	6,000t/—	OC/—	*OC/—*
Weights (lb.)		Max Ramp	21,750	20,400	21,750	35,891	*NA*
		Max Takeoff	21,500	20,200	21,500	35,759	*NA*
		Max Landing	19,200	18,700	19,200	32,518	*NA*
		Zero Fuel	16,000c	15,100c	16,000c	25,904c	*NA*
		BOW	13,900	12,860	14,050	22,983	*NA*
		Max Payload	2,100	2,240	1,950	2,921	*NA*
		Useful Load	7,850	7,540	7,700	12,908	*NA*
		Max Fuel	6,062	6,740	6,062	12,108	*13,058*
		Available Payload w/Max Fuel	1,788	800	1,638	800	*1,600*
		Available Fuel w/Max Payload	5,750	5,300	5,750	9,987	*NA*
Limits		MMO	0.810	0.750	0.810	0.830	*0.830*
		Trans. Alt. FL/VMO	FL 270/330	FL 265/305	FL 270/330	FL 295/320	*FL 295/320*
		PSI/Sea-Level Cabin	9.4/25,700	9.3/25,230	9.4/25,700	9.7/27,140	*9.7/27,140*
Airport Performance		TOFL (SL elev./ISA temp.)	4,440	3,560	4,440	3,907	*4,263*
		TOFL (5,000-ft. elev.@25C)	5,191	5,430	5,272	5,189	*NA*
		Mission Weight	20,632	20,200	20,782	35,759	*NA*
		NBAA IFR Range	2,045	1,740	2,026	2,919	*NA*
		V2	125	118	125	117	*NA*
		VREF	112	106	113	101	*NA*
		Landing Distance	2,326	2,740	2,338	2,090	*2,090*
Climb		Time to Climb/Altitude	15/FL 370	15/FL 370	15/FL 370	14/FL 370	*14/FL 370*
		FAR 25 Engine-Out Rate (fpm)	430	765	430	634	*NA*
		FAR 25 Engine-Out Gradient (ft./nm)	207	389	207	324	*NA*
Ceilings (ft.)		Certificated	51,000	45,000	51,000	45,000	*45,000*
		All-Engine Service	45,200	45,000	44,700	44,000	*NA*
		Engine-Out Service	28,400	28,600	27,900	24,476	*NA*
Cruise	Long Range	TAS/Fuel Flow (lb./hr.)	437/970	353/865	437/977	438/1,404	*NA/NA*
		Altitude/Specific Range	FL 470/0.451	FL 450/0.408	FL 470/0.447	FL 450/0.312	*NA/NA*
	High Speed	TAS/Fuel Flow (lb./hr.)	452/1,080	431/1,238	451/1,079	462/1,621	*462/NA*
		Altitude/Specific Range	FL 470/0.419	FL 410/0.348	470/0.418	FL 430/0.285	*NA/NA*
NBAA IFR Ranges (FAR Part 23, 100-nm alternate; FAR Part 25, 200-nm alternate)	Max Payload (w/available fuel)	Nautical Miles	1,728	1,284	1,728	2,170	*NA*
		Average Speed	425	387	425	428	*NA*
		Trip Fuel	4,575	4,020	4,575	8,084	*NA*
		Specific Range/Altitude	0.378/FL 470	0.319/FL 450	0.378/FL 470	0.268/FL 450	*NA/NA*
	Max Fuel (w/available payload)	Nautical Miles	1,881	1,853	1,881	2,904	*NA*
		Average Speed	426	397	426	431	*NA*
		Trip Fuel	4,901	5,582	4,901	10,285	*NA*
		Specific Range/Altitude	0.384/FL 470	0.332/FL 450	0.384/FL 470	0.282/FL 450	*NA/NA*
	Four Passengers (w/available fuel)	Nautical Miles	2,045	1,853	2,026	2,904	*3,250*
		Average Speed	426	397	427	431	*NA*
		Trip Fuel	5,064	5,582	5,058	10,285	*NA*
		Specific Range/Altitude	0.404/FL 470	0.332/FL 450	0.401/FL 470	0.282/FL 450	*NA/NA*
	Ferry	Nautical Miles	2,150	1,918	2,129	2,973	*NA*
		Average Speed	427	404	427	430	*NA*
		Trip Fuel	5,099	5,612	5,093	10,313	*NA*
		Specific Range/Altitude	0.422/FL 490	0.342/FL 450	0.418/FL 490	0.288/FL 450	*NA/NA*
Missions (4 passengers)	300 nm	Runway	3,588	2,741	3,598	3,674	*NA*
		Flight Time	0+45	0+46	0+45	0+45	*NA*
		Fuel Used	1,072	1,239	1,075	1,543	*NA*
		Specific Range/Altitude	0.280/FL 470	0.242/FL 390	0.279/FL 470	0.194/FL 450	*NA/NA*
	600 nm	Runway	3,632	2,730	3,642	2,696	*NA*
		Flight Time	1+24	1+28	1+23	1+26	*NA*
		Fuel Used	1,805	2,081	1,810	2,478	*NA*
		Specific Range/Altitude	0.332/FL 470	0.288/FL 410	0.331/FL 470	0.242/FL 450	*NA/NA*
	1,000 nm	Runway	3,691	2,939	3,701	2,873	*NA*
		Flight Time	2+18	2+26	2+18	2+21	*NA*
		Fuel Used	2,787	3,198	2,792	3,710	*NA*
		Specific Range/Altitude	0.359/FL 470	0.313/FL 430	0.358/FL 470	0.270/FL 450	*NA/NA*
Remarks		Certification Basis	FAR 25, EASA CS 25	FAR 25, 2008	FAR 25, EASA CS 25	RBAC/FAR 25, 2015; EASA CS 25 2015	*RBAC/FAR 25 pending; EASA CS 25 pending*

JETS ≥20,000-LB. MTOW

Manufacturer			Textron Aviation	Textron Aviation	Embraer	*Embraer*
Model			Cessna Citation Latitude CE-680A	Cessna Citation Sovereign+ CE-680	Legacy 500 EMB-550	*Praetor 600 EMB-550*
BCA Equipped Price			$17,457,000	$18,790,000	$19,995,000	*$20,995,000*
Character-istics		Seating	2+9/9/9	2+9/12/12	2+8/12/12	*2+8/12/12*
		Wing Loading/Power Loading	56.8/2.61	56.7/2.60	79.4/2.73	*79.4/2.85*
		Noise (EPNdB): Lateral/Flyover/Approach	87.7/73.5/87.7	87.8/71.9/87.9	85.5/73.1/89.9	*85.5/73.1/89.9*
External Dimensions (ft.)		Length	62.3	63.5	68.1	*68.1*
		Height	20.9	20.3	21.2	*21.2*
		Span	72.3	72.3	66.4	*70.5*
Internal Dimensions (ft.)		**Length:** Main Seating/Net/Gross	15.9/21.8/21.8	17.4/25.3/25.3	21.3/24.1/27.5	*21.3/24.1/27.5*
		Height/Dropped Aisle Depth	6.0/flat floor	5.7/0.7	6.0/flat floor	*6.0/flat floor*
		Width: Max/Floor	6.4/4.1	5.5/3.9	6.8/4.7	*6.8/4.7*
Baggage		**Internal:** Cu. ft./lb.	27/245	35/435	45/418	*45/418*
		External: Cu. ft./lb.	100/1,000	100/1,000	110/880	*110/880*
Power		Engines	2 P&WC PW306D1	2 P&WC PW306D	2 Hon HTF7500E	*2 Hon HTF7500E*
		Output (lb. each)/Flat Rating	5,907/ISA+15C	5,907/ISA+16C	7,036/ISA+18C	*7,528/ISA+18C*
		Inspection Interval/Manu. Service Plan Interval	6,000t/—	6,000t/—	OC/—	*OC/—*
Weights (lb.)		Max Ramp	31,050	31,025	38,537	*42,990*
		Max Takeoff	30,800	30,775	38,360	*42,857*
		Max Landing	27,575	27,575	34,524	*37,478*
		Zero Fuel	21,200c	21,000c	26,500	*28,660*
		BOW	18,656	18,235	23,700	*24,658*
		Max Payload	2,544	2,765	2,800	*4,002*
		Useful Load	12,394	12,790	14,837	*18,332*
		Max Fuel	11,394	11,390	13,058	*16,138*
		Available Payload w/Max Fuel	1,000	1,400	1,779	*2,194*
		Available Fuel w/Max Payload	9,850	10,025	12,037	*14,330*
Limits		MMO	0.800	0.800	0.830	*0.830*
		Trans. Alt. FL/VMO	FL 298/305	FL 298/305	FL 295/320	*FL 295/320*
		PSI/Sea-Level Cabin	9.7/26,800	9.3/25,230	9.7/27,140	*9.7/27,140*
Airport Perfor-mance		TOFL (SL elev./ISA temp.)	3,580	3,530	4,084	*4,717*
		TOFL (5,000-ft. elev.@25C)	5,070	4,760	5,523	*6,431*
		Mission Weight	30,675	30,250	38,360	*42,857*
		NBAA IFR Range	2,700	3,093	3,131	*4,040*
		V2	115	117	120	*128*
		VREF	95	96	102	*104*
		Landing Distance	2,085	2,144	2,114	*2,165*
Climb		Time to Climb/Altitude	16/FL 370	13/FL 370	14/FL 370	*13/FL 370*
		FAR 25 Engine-Out Rate (fpm)	652	735	856	*909*
		FAR 25 Engine-Out Gradient (ft./nm)	340	377	387	*387*
Ceilings (ft.)		Certificated	45,000	47,000	45,000	*45,000*
		All-Engine Service	43,000	45,000	44,000	*42,000*
		Engine-Out Service	26,260	29,740	28,189	*28,189*
Cruise	**Long Range**	TAS/Fuel Flow (lb./hr.)	368/1,114	368/1,059	440/1,441	*433/1,449*
		Altitude/Specific Range	FL 430/0.330	FL 450/0.347	FL 450/0.305	*FL 450/0.299*
	High Speed	TAS/Fuel Flow (lb./hr.)	432/1,765	448/1,756	467/1,741	*466/1,826*
		Altitude/Specific Range	FL 390/0.245	FL 390/0.255	430/0.268	*430/0.255*
NBAA IFR Ranges (FAR Part 23, 100-nm alternate; FAR Part 25, 200-nm alternate)	**Max Payload** (w/available fuel)	Nautical Miles	2,135	2,484	2,603	*3,277*
		Average Speed	394	396	438	*426*
		Trip Fuel	7,901	8,170	9,908	*12,600*
		Specific Range/Altitude	0.270/FL 450	0.304/FL 470	0.263/450	*0.260/450*
	Max Fuel (w/available payload)	Nautical Miles	2,645	2,996	2,998	*3,878*
		Average Speed	401	400	440	*425*
		Trip Fuel	9,586	9,658	11,151	*14,357*
		Specific Range/Altitude	0.276/FL 450	0.310/FL 470	0.269/450	*0.270/450*
	Four Passengers (w/available fuel)	Nautical Miles	2,678	3,069	3,125	*4,018*
		Average Speed	401	402	433	*423*
		Trip Fuel	9,594	9,679	11,222	*14,404*
		Specific Range/Altitude	0.279/FL 450	0.317/FL 470	0.278/FL 450	*0.279/FL 450*
	Ferry	Nautical Miles	2,731	3,138	3,153	*4,102*
		Average Speed	405	405	440	*421*
		Trip Fuel	9,628	9,708	11,250	*14,436*
		Specific Range/Altitude	0.284/FL 450	0.323/FL 470	0.280/FL 450	*0.284/FL 450*
Missions (4 passengers)	**300 nm**	Runway	2,760	2,591	2,822	*2,745*
		Flight Time	0+46	0+45	0+45	*0+46*
		Fuel Used	1,610	1,506	1,545	*1,558*
		Specific Range/Altitude	0.186/FL 390	0.199/FL 390	0.194/FL 450	*0.193/FL 450*
	600 nm	Runway	2,845	2,600	2,817	*2,746*
		Flight Time	1+29	1+26	1+26	*1+26*
		Fuel Used	2,573	2,404	2,478	*2,580*
		Specific Range/Altitude	0.233/FL 430	0.250/FL 430	0.242/FL 450	*0.233/FL 450*
	1,000 nm	Runway	2,951	2,650	2,963	*2,810*
		Flight Time	2+25	2+21	2+21	*2+18*
		Fuel Used	3,989	3,750	3,750	*3,969*
		Specific Range/Altitude	0.251/FL 430	0.267/FL 430	0.267/FL 450	*0.252/FL 450*
Remarks		Certification Basis	FAR 25, 2015 Garmin G5000.	FAR 25, 2013 Garmin G5000.	RBAC/FAR/EASA CS 25, 2014	*ANAC, 2019; RBAC/FAR/EASA CS 25 pending*

JETS ≥20,000-LB. MTOW

			Gulfstream Aerospace	Embraer	Bombardier	*Textron Aviation*	Dassault
Manufacturer			Gulfstream Aerospace	Embraer	Bombardier	*Textron Aviation*	Dassault
Model			**G280** **G280**	**Legacy 650E** **EMB-135BJ***	**Challenger 350** **BD-100-1A10**	***Cessna Citation Longitude*** ***CE-700***	**Falcon 2000S** **Falcon 2000EX**
BCA **Equipped Price**			$24,500,000	$25,900,000	$26,673,000	*$26,995,000*	$29,950,000
Characteristics		Seating	2+9/10/19	2+13/14/19	2+10/11/19	*2+8/12/12*	2+10/10/19
		Wing Loading/Power Loading	80.0/2.60	97.2/2.97	77.6/2.77	*74.0/2.60*	77.7/2.93
		Noise (EPNdB): Lateral/Flyover/Approach	75.2/89.5/90.5	86.9/78.0/91.7	87.6/75.3/89.6	*88.4/72.9/89.9*	91.8/75.1/90.5
External Dimensions (ft.)		Length	66.8	86.4	68.7	*73.2*	66.3
		Height	21.3	22.2	20.0	*19.4*	23.3
		Span	63.0	68.9	69.0	*68.9*	70.2
Internal Dimensions (ft.)		**Length:** Main Seating/Net/Gross	17.7/25.8/32.3	30.3/42.4/49.1	16.6/25.2/28.6	*16.5/25.2/28.1*	17.1/26.2/31.0
		Height/Dropped Aisle Depth	6.1/4.5	6.0/0.2	6.0/flat floor	*6.0/flat floor*	6.2/flat floor
		Width: Max/Floor	6.9/5.4	6.9/5.2	7.2/5.1	*6.4/4.1*	7.7/6.3
Baggage		**Internal:** Cu. ft./lb.	154/1,980	286/1,441	106/750	*112/1,115*	131/1,600
		External: Cu. ft./lb.	—/—	—/—	—/—	*NA/NA*	8/92
Power		Engines	2 Hon HTF7250G	2 RR AE 3007A2	2 Hon HTF 7350	*2 Hon* *HTF7700L*	2 P&WC PW308C
		Output (lb. each)/Flat Rating	7,624/ISA+17C	9,020/ISA+15C	7,323/ISA+15C	*7,600/ISA+19C*	7,000/ISA+15C
		Inspection Interval/Manu. Service Plan Interval	OC/—	OC/—	OC/—	*OC/—*	7,000c/—
Weights (lb.)		Max Ramp	39,750	53,727	40,750	*39,700*	41,200
		Max Takeoff	39,600	53,572	40,600	*39,500*	41,000
		Max Landing	32,700	44,092	34,150	*33,500*	39,300
		Zero Fuel	28,200c	36,156c	28,200c	*26,000c*	29,700c
		BOW	24,200	31,217	24,800	*23,600*	24,750
		Max Payload	4,000	4,939	3,400	*2,400*	4,950
		Useful Load	15,550	22,510	15,950	*16,100*	16,450
		Max Fuel	14,600	20,600	14,045	*14,500*	14,600
		Available Payload w/Max Fuel	950	1,910	1,905	*1,600*	1,850
		Available Fuel w/Max Payload	11,550	17,571	12,550	*13,700*	11,500
Limits		MMO	0.850	0.800	0.830	*0.840*	0.862
		Trans. Alt. FL/VMO	FL 280/340	FL 276/320	FL 290/320	*FL 293/325*	FL 250/370
		PSI/Sea-Level Cabin	9.2/25,000	8.4/21,650	8.8/23,338	*9.7/25,400*	9.3/25,300
Airport Performance		TOFL (SL elev./ISA temp.)	4,750	5,741	4,829	*4,810*	4,325
		TOFL (5,000-ft. elev.@25C)	7,320	7,979	6,451	*6,810*	6,055
		Mission Weight	39,600	53,572	39,495	*38,725*	39,950
		NBAA IFR Range	3,600	3,953	3,250	*3,520*	3,600
		V2	137	144	133	*136*	123
		VREF	115	115	111	*110*	106
		Landing Distance	2,373	2,346	2,302	*2,597*	2,295
Climb		Time to Climb/Altitude	14/FL 370	21/FL 370	14/FL 370	*13/FL 370*	16/FL 370
		FAR 25 Engine-Out Rate (fpm)	845	633	552	*1,330*	528
		FAR 25 Engine-Out Gradient (ft./nm)	371	259	249	*456*	257
Ceilings (ft.)		Certificated	45,000	41,000	45,000	*45,000*	47,000
		All-Engine Service	45,000	41,000	44,000	*45,000*	43,265
		Engine-Out Service	27,500	23,128	27,800	*28,420*	22,187
Cruise	Long Range	TAS/Fuel Flow (lb./hr.)	459/1,488	425/1,901	459/1,590	*449/1,478*	437/1,400
		Altitude/Specific Range	FL 450/0.308	FL 410/0.224	FL 450/0.289	*FL 450/0.304*	FL 470/0.312
	High Speed	TAS/Fuel Flow (lb./hr.)	482/1,925	459/2,570	470/1,832	*478/1,937*	482/2,075
		Altitude/Specific Range	FL 430/0.250	FL 370/0.179	FL 430/0.257	*FL 430/0.247*	FL 410/0.232
NBAA IFR Ranges (FAR Part 23, 100-nm alternate; FAR Part 25, 200-nm alternate)	Max Payload (w/available fuel)	Nautical Miles	2,577	3,076	2,719	*3,074*	2,450
		Average Speed	448	417	447	*452*	426
		Trip Fuel	9,591	15,238	10,689	*11,600*	9,640
		Specific Range/Altitude	0.269/FL 450	0.202/FL 410	0.254/FL 450	*0.265/FL 450*	0.254/FL 450
	Max Fuel (w/available payload)	Nautical Miles	3,636	3,839	3,235	*3,422*	3,445
		Average Speed	452	417	449	*453*	429
		Trip Fuel	12,757	18,380	12,206	*12,763*	12,740
		Specific Range/Altitude	0.285/FL 450	0.209/FL 410	0.265/FL 450	*0.268/FL 450*	0.270/FL 470
	Four Passengers (w/available fuel)	Nautical Miles	3,646	3,919	3,250	*3,500*	3,540
		Average Speed	451	415	448	*454*	430
		Trip Fuel	12,761	18,422	12,212	*12,763*	12,740
		Specific Range/Altitude	0.286/FL 450	0.213/FL 410	0.266/FL 450	*0.274/FL 450*	0.278/FL 470
	Ferry	Nautical Miles	3,724	3,980	3,307	*3,500*	3,615
		Average Speed	452	414	450	*454*	430
		Trip Fuel	12,789	18,450	12,236	*12,787*	12,740
		Specific Range/Altitude	0.291/FL 450	0.216/FL 410	0.270/FL 450	*0.274/FL 450*	0.284/FL 470
Missions (4 passengers)	300 nm	Runway	2,957	3,346	3,611	*2,744*	2,795
		Flight Time	0+47	0+49	0+47	*0+44*	0+47
		Fuel Used	1,505	1,773	1,583	*1,516*	1,525
		Specific Range/Altitude	0.199/FL 450	0.169/FL 410	0.190/FL 450	*0.198/FL 450*	0.197/FL 470
	600 nm	Runway	2,997	3,518	3,656	*2,880*	2,855
		Flight Time	1+26	1+34	1+26	*1+23*	1+27
		Fuel Used	2,412	3,146	2,577	*2,457*	2,465
		Specific Range/Altitude	0.249/FL 450	0.191/FL 410	0.233/FL 450	*0.244/FL 450*	0.243/FL 470
	1,000 nm	Runway	3,136	3,573	3,718	*3,025*	2,920
		Flight Time	2+18	2+33	2+18	*2+16*	2+20
		Fuel Used	3,645	4,815	3,925	*3,746*	3,755
		Specific Range/Altitude	0.274/FL 450	0.208/FL 410	0.255/FL 450	*0.267/FL 450*	0.266/FL 470
Remarks		Certification Basis	FAR 25, 2012; EASA CS 25, 2013	FAR 25, 2011 *Factory modification DCA 145-000-00020/2008	FAR 25 A 98; JAR 25 Chg 15 Collins Pro Line 21 Advanced	*FAR 25 pending* *Garmin G5000.* *Pre-certification data estimates.*	FAR/EASA CS 25, 2013 EASy II flight deck. 2019 delivery price.

JETS ≥20,000-LB. MTOW

Manufacturer			Bombardier	Dassault	Dassault	Gulfstream Aerospace
Model			Challenger 650 CL-600-2B16	Falcon 2000LXS Falcon 2000EX	Falcon 900LX Falcon 900EX	G500 GVII-G500
BCA Equipped Price			$32,350,000	$35,100,000	$44,800,000	$46,500,000
Characteristics		Seating	2+12/13/19	2+8/10/19	2+12/12/19	2+13/19/19
		Wing Loading/Power Loading	98.6/2.61	81.2/3.06	92.9/3.27	83.8/2.63
		Noise (EPNdB): Lateral/Flyover/Approach	86.2/81.2/90.3	91.7/76.4/90.5	90.3/78.2/92.1	NA/NA/NA
External Dimensions (ft.)		Length	68.4	66.3	66.3	91.2
		Height	20.7	23.3	25.2	25.5
		Span	64.3	70.2	70.2	86.3
Internal Dimensions (ft.)		**Length:** Main Seating/Net/Gross	15.4/25.6/28.3	17.1/26.2/31.0	23.5/33.2/39.3	26.3/41.5/47.6
		Height/Dropped Aisle Depth	6.0/flat floor	6.2/flat floor	6.2/flat floor	6.2/flat floor
		Width: Max/Floor	7.9/6.9	7.7/6.3	7.7/6.3	7.6/6.1
Baggage		**Internal:** Cu. ft./lb.	112/900	131/1,600	127/2,866	175/2,250
		External: Cu. ft./lb.	—/—	8/92	—/—	—/—
Power		Engines	2 GE CF34-3B	2 P&WC PW308C	3 Hon TFE731-60	2 P&WC PW814GA
		Output (lb. each)/Flat Rating	9,220*/ISA+15C	7,000/ISA+15C	5,000/ISA+17C	15,144/ISA+15C
		Inspection Interval/Manu. Service Plan Interval	OC/—	7,000c/—	6,000c/—	OC/—
Weights (lb.)		Max Ramp	48,300	43,000	49,200	80,000
		Max Takeoff	48,200	42,800	49,000	79,600
		Max Landing	38,000	39,300	44,500	64,350
		Zero Fuel	32,000c	29,700c	30,864c	52,100c
		BOW	27,250	24,750	26,750	46,850
		Max Payload	4,750	4,950	4,114	5,250
		Useful Load	21,050	18,250	22,450	33,150
		Max Fuel	19,852	16,660	20,905	30,250
		Available Payload w/Max Fuel	1,198	1,590	1,545	2,900
		Available Fuel w/Max Payload	16,300	13,300	18,336	27,900
Limits		MMO	0.850	0.870	0.870	0.925
		Trans. Alt. FL/VMO	FL 222/348	FL 250/370	FL 250/370	NA/NA
		PSI/Sea-Level Cabin	8.8/23,000	9.3/25,300	9.6/25,300	10.7/31,900
Airport Performance		TOFL (SL elev./ISA temp.)	5,640	4,675	5,360	5,300
		TOFL (5,000-ft. elev.@25C)	9,233	6,840	7,615	7,340
		Mission Weight	47,802	42,010	48,255	79,600
		NBAA IFR Range	4,011	4,100	4,685	5,200
		V2	147	127	134	148
		VREF	117	106	111	118
		Landing Distance	2,365	2,295	2,455	2,620
Climb		Time to Climb/Altitude	21/FL 370	17/FL 370	19/FL 370	15/FL 370
		FAR 25 Engine-Out Rate (fpm)	581	463	723	NA
		FAR 25 Engine-Out Gradient (ft./nm)	237	221	324	NA
Ceilings (ft.)		Certificated	41,000	47,000	51,000	51,000
		All-Engine Service	38,250	42,315	39,630	NA
		Engine-Out Service	20,000	21,010	24,980	NA
Cruise	Long Range	TAS/Fuel Flow (lb./hr.)	424/1,832	437/1,485	431/1,665	488/2,445
		Altitude/Specific Range	FL 410/0.231	FL 450/0.294	FL 430/0.259	FL 470/0.200
	High Speed	TAS/Fuel Flow (lb./hr.)	470/2,448	483/2,325	474/2,225	516/3,087
		Altitude/Specific Range	FL 370/0.192	FL 390/0.208	FL 390/0.213	FL 430/0.167
NBAA IFR Ranges (FAR Part 23, 100-nm alternate; FAR Part 25, 200-nm alternate)	Max Payload (w/available fuel)	Nautical Miles	3,011	2,915	3,790	4,562
		Average Speed	417	427	422	478
		Trip Fuel	14,256	11,438	16,340	24,910
		Specific Range/Altitude	0.211/FL 410	0.255/FL 450	0.232/FL 430	0.183/FL 470
	Max Fuel (w/available payload)	Nautical Miles	3,974	3,990	4,565	5,212
		Average Speed	419	430	421	480
		Trip Fuel	17,939	14,798	18,909	27,368
		Specific Range/Altitude	0.222/FL 410	0.270/FL 470	0.241/FL 430	0.190/FL 490
	Four Passengers (w/available fuel)	Nautical Miles	4,011	4,065	4,650	5,292
		Average Speed	419	430	420	480
		Trip Fuel	17,953	14,798	18,909	27,400
		Specific Range/Altitude	0.223/FL 410	0.275/FL 470	0.246/FL 430	0.193/FL 490
	Ferry	Nautical Miles	4,085	4,155	4,740	5,362
		Average Speed	419	431	419	480
		Trip Fuel	17,982	14,798	18,909	27,425
		Specific Range/Altitude	0.227/FL 410	0.281/FL 470	0.251/FL 430	0.196/FL 510
Missions (4 passengers)	300 nm	Runway	3,389	2,795	2,730	3,480
		Flight Time	0+47	0+47	0+47	0+46
		Fuel Used	1,595	1,525	1,595	2,375
		Specific Range/Altitude	0.188/FL 410	0.197/FL 470	0.188/FL 470	0.126/FL 490
	600 nm	Runway	3,421	2,855	2,865	3,500
		Flight Time	1+27	1+27	1+27	1+23
		Fuel Used	2,835	2,465	2,625	3,647
		Specific Range/Altitude	0.212/FL 410	0.243/FL 470	0.229/FL 470	0.165/FL 490
	1,000 nm	Runway	3,483	2,920	2,880	3,525
		Flight Time	2+19	2+20	2+20	2+13
		Fuel Used	4,532	3,755	4,070	5,398
		Specific Range/Altitude	0.221/FL 410	0.266/FL 470	0.246/FL 450	0.185/FL 490
Remarks		Certification Basis	FAR 25, 1980/83/87/95/2006/15 Collins Pro Line 21 Advanced. *9,220 max takeoff; 8,729 normal takeoff.	FAR/EASA CS 25, 2013 EASy II flight deck. 2019 delivery price.	FAR 25/EASA 25, 1979/2010 EASy II flight deck. 2019 delivery price.	FAR 25, 2018; EASA CS 25 pending

JETS ≥20,000-LB. MTOW

Manufacturer			Embraer	Bombardier	Dassault	Airbus
Model			**Lineage 1000E ERJ 190-100 ECJ**	**Global 5000 BD-700-1A11**	**Falcon 7X**	**A320 Prestige A320-251N***
***BCA* Equipped Price**			$49,900,000	$50,441,000	$53,800,000	$115,000,000**
Characteristics		Seating	3+13/19/19	3+13/15/19	3+12/14/19	4+18/179/—
		Wing Loading/Power Loading	120.7/3.25	90.6/3.14	92.0/3.64	126.2/3.21
		Noise (EPNdB): Lateral/Flyover/Approach	92.4/86.5/92.5	88.7/83.5/89.7	90.1/82.3/92.6	85.7/81.6/92.6
External Dimensions (ft.)		Length	118.9	96.8	76.7	123.3
		Height	34.7	25.5	26.2	38.6
		Span	94.2	94.0	86.0	117.4
Internal Dimensions (ft.)		**Length:** Main Seating/Net/Gross	67.2/76.6/84.3	27.2/40.7/45.7	26.2/39.1/46.5	89.9/89.9/—
		Height/Dropped Aisle Depth	6.6/flat floor	6.2/flat floor	6.2/flat floor	7.4/flat floor
		Width: Max/Floor	8.8/8.0	7.9/6.5	7.7/6.3	12.1/11.7
Baggage		**Internal:** Cu. ft./lb.	323/2,293	195/1,000	140/2,004	NA/NA
		External: Cu. ft./lb.	120/705	—/—	—/—	985/NA
Power		Engines	2 GE CF34-10E7-B	2 RR BR700-710A2-20	3 P&WC PW307A	2 CFMI LEAP-1A26
		Output (lb. each)/Flat Rating	18,500/ISA+15C	14,750/ISA+20C	6,402/ISA+17C	27,120/ISA+29C
		Inspection Interval/Manu. Service Plan Interval	OC/—	OC/—	7,200c/—	OC/—
Weights (lb.)		Max Ramp	120,591	92,750	70,200	175,045
		Max Takeoff	120,152	92,500	70,000	174,165
		Max Landing	100,972	78,600	62,400	148,592
		Zero Fuel	80,469c	58,000c	41,000c	141,757c
		BOW	70,548	50,861	36,600	110,000***
		Max Payload	9,921	7,139	4,400	31,757
		Useful Load	50,043	41,889	33,600	65,045
		Max Fuel	48,217	38,959	31,940	60,803
		Available Payload w/Max Fuel	1,826	2,930	1,660	4,243
		Available Fuel w/Max Payload	40,122	34,750	29,200	33,288
Limits		MMO	0.820	0.890	0.900	0.820
		Trans. Alt. FL/VMO	FL 289/320	FL 303/340	FL 270/370	FL 250/350
		PSI/Sea-Level Cabin	8.8/23,190	10.3/30,125	10.2/29,200	8.3/NA
Airport Performance		TOFL (SL elev./ISA temp.)	6,076	5,540	5,710	6,920
		TOFL (5,000-ft. elev.@25C)	9,500	7,223	8,045	9,355
		Mission Weight	112,038	90,370	69,140	171,950
		NBAA IFR Range	3,965	5,475	5,795	NA
		V2	140	133	133	NA
		VREF	110	107	106	NA
		Landing Distance	2,038	2,189	2,120	2,400
Climb		Time to Climb/Altitude	29/FL 350	18/FL 370	19/FL 370	23/FL 360
		FAR 25 Engine-Out Rate (fpm)	NA	704	597	NA
		FAR 25 Engine-Out Gradient (ft./nm)	NA	318	269	NA
Ceilings (ft.)		Certificated	41,000	51,000	51,000	39,000
		All-Engine Service	35,000	44,600	40,215	NA
		Engine-Out Service	19,178	20,600	25,480	NA
Cruise	Long Range	TAS/Fuel Flow (lb./hr.)	454/4,184	470/2,856	459/2,260	451/4,113
		Altitude/Specific Range	FL 380/0.109	FL 450/0.165	FL 430/0.203	FL 370/0.110
	High Speed	TAS/Fuel Flow (lb./hr.)	471/5,033	499/3,582	497/3,205	473/5,096
		Altitude/Specific Range	FL 350/0.094	FL 410/0.139	FL 390/0.155	350/0.093
NBAA IFR Ranges (FAR Part 23, 100-nm alternate; FAR Part 25, 200-nm alternate)	Max Payload (w/available fuel)	Nautical Miles	3,493	4,920	5,000	2,100
		Average Speed	442	463	453	428
		Trip Fuel	35,569	33,374	26,820	27,936
		Specific Range/Altitude	0.098/FL 400	0.147/FL 470	0.186/FL 450	0.075/FL 350
	Max Fuel (w/available payload)	Nautical Miles	4,532	5,486	5,670	6,000
		Average Speed	446	464	454	438
		Trip Fuel	43,962	35,723	29,560	54,000
		Specific Range/Altitude	0.103/FL 410	0.154/FL 470	0.192/FL 470	0.111/FL 390
	Four Passengers (w/available fuel)	Nautical Miles	4,602	5,475	5,760	6,100
		Average Speed	446	463	454	438
		Trip Fuel	44,240	35,719	29,560	54,000
		Specific Range/Altitude	0.104/FL 410	0.153/FL 470	0.195/FL 470	0.113/FL 390
	Ferry	Nautical Miles	4,640	5,526	5,840	62,000
		Average Speed	446	464	454	438
		Trip Fuel	44,264	35,743	29,560	54,000
		Specific Range/Altitude	0.105/FL 410	0.155/FL 470	0.198/FL 470	1.148/FL 390
Missions (4 passengers)	300 nm	Runway	3,002	2,487	2,500	3,670
		Flight Time	0+48	0+46	0+46	0+55
		Fuel Used	3,426	2,773	2,075	3,709
		Specific Range/Altitude	0.088/FL 390	0.108/FL 450	0.145/FL 450	0.081/FL 350
	600 nm	Runway	3,133	2,575	2,515	3,700
		Flight Time	1+26	1+23	1+25	1+34
		Fuel Used	5,862	4,445	3,285	6,157
		Specific Range/Altitude	0.102/FL 410	0.135/FL 490	0.183/FL 470	0.097/FL 390
	1,000 nm	Runway	3,251	2,697	2,640	3,760
		Flight Time	2+20	2+13	2+17	2+28
		Fuel Used	9,063	6,752	4,945	9,539
		Specific Range/Altitude	0.110/FL 410	0.148/FL 470	0.202/FL 470	0.105/FL 390
Remarks		Certification Basis	FAR/EASA 25, 2008	FAR 25, 1998/04; EASA 25, 2004 Global Vision flight deck	FAR/EASA 25, 2007 EASy II flight deck; DFCS. 2019 delivery price.	FAR 25, 1999/2016 *Also available as -271N with IAE PW1127G engines rated at 27,075 lbf; includes four additional center tanks and VIP cabin. ***BCA* estimate. ****BCA* estimate.

ULTRA-LONG-RANGE JETS

Manufacturer			Gulfstream Aerospace	Dassault	Gulfstream Aerospace	Bombardier
Model			G600 GVII-600	Falcon 8X Falcon 7X	G550 GV-SP	Global 6000 BD-700-1A10
BCA Equipped Price			$57,900,000	$59,300,000	$61,500,000	$62,310,000
Characteristics		Seating	4+16/19/19	3+12/14/19	4+16/18/19	4+13/15/19
		Wing Loading/Power Loading	81.5/3.02	95.9/3.62	80.1/2.96	97.5/3.37
		Noise (EPNdB): Lateral/Flyover/Approach	NA/NA/NA	88.7/80.1/90.6	79.3/90.2/90.8	88.7/83.5/89.7
External Dimensions (ft.)		Length	96.1	80.2	96.4	99.4
		Height	25.3	26.1	25.8	25.5
		Span	94.1	86.3	93.5	94.0
Internal Dimensions (ft.)		**Length:** Main Seating/Net/Gross	30.2/45.2/51.3	29.8/42.7/50.1	30.3/42.6/50.1	27.3/43.3/48.3
		Height/Dropped Aisle Depth	6.2/flat floor	6.2/flat floor	6.0/flat floor	6.2/flat floor
		Width: Max/Floor	7.6/6.1	7.7/6.3	7.0/5.4	7.9/6.5
Baggage		**Internal:** Cu. ft./lb.	175/2,250	140/2,004	170/2,500	195/1,000
		External: Cu. ft./lb.	—/—	—/—	—/—	—/—
Power		Engines	2 P&WC PW815GA	3 P&WC PW307D	2 RR BR700-710C4-11	2 RR BR700-710A2-20
		Output (lb. each)/Flat Rating	15,680/ISA+15C	6,722/ISA+17C	15,385/ISA+15C	14,750/ISA+20C
		Inspection Interval/Manu. Service Plan Interval	10,000t or OC/—	7,200c/—	8,000t or OC/—	OC/OC
Weights (lb.)		Max Ramp	95,000	73,200	91,400	99,750
		Max Takeoff	94,600	73,000	91,000	99,500
		Max Landing	76,800	62,400	75,300	78,600
		Zero Fuel	57,440c	41,000c	54,500c	58,000c
		BOW	51,470	36,800	48,700	52,230
		Max Payload	5,970	4,200	5,800	5,770
		Useful Load	43,530	36,400	42,700	47,520
		Max Fuel	41,730	35,141	40,994	45,050
		Available Payload w/Max Fuel	1,800	1,259	1,706	2,470
		Available Fuel w/Max Payload	37,560	32,200	36,900	41,750
Limits		MMO	0.925	0.900	0.885	0.890
		Trans. Alt. FL/VMO	NA/NA	FL 270/370	FL 270/340	FL 303/340
		PSI/Sea-Level Cabin	10.7/31,900	10.2/30,300	10.2/29,200	10.3/30,125
Airport Performance		TOFL (SL elev./ISA temp.)	5,900	5,880	5,910	6,476
		TOFL (5,000-ft. elev.@25C)	NA	8,540	9,070	7,880
		Mission Weight	94,600	72,591	91,000	94,513p
		NBAA IFR Range	6,200	6,415	6,738	5,594
		V2	NA	138	147	142
		VREF	NA	107	112	110
		Landing Distance	2,550	2,245	2,240	2,243
Climb		Time to Climb/Altitude	18/FL 370	20/FL 370	18/FL 370	21/FL 370
		FAR 25 Engine-Out Rate (fpm)	NA	774	594	474
		FAR 25 Engine-Out Gradient (ft./nm)	NA	339	242	200
Ceiling (ft.)		Certificated	51,000	51,000	51,000	51,000
		All-Engine Service	NA	40,075	42,700	42,400
		Engine-Out Service	NA	26,645	25,820	18,000
Cruise	Long Range	TAS	488	459	459	470
		Fuel Flow	2,865	2,254	2,563	3,046
		Altitude	FL 450	FL 430	FL 450	FL 450
		Specific Range	0.170	0.204	0.179	0.154
	High Speed	TAS	516	497	488	499
		Fuel Flow	3,945	3,172	3,228	3,796
		Altitude	FL 410	FL 390	FL 430	FL 410
		Specific Range	0.131	0.157	0.151	0.131
NBAA IFR Ranges (200-nm alternate)	Max Payload (w/available fuel)	Nautical Miles	5,609	5,555	5,767	5,882
		Average Speed	480	452	452	464
		Trip Fuel	34,617	29,507	33,993	40,415
		Specific Range/Altitude	0.162/FL 450	0.188/FL 470	0.170/FL 490	0.146/FL 470
	Max Fuel (w/available payload)	Nautical Miles	6,500	6,325	6,698	6,200
		Average Speed	481	453	454	464
		Trip Fuel	38,882	32,558	38,202	41,472
		Specific Range/Altitude	0.167/FL 490	0.194/FL 470	0.175/FL 490	0.149/FL 470
	Eight Passengers (w/available fuel)	Nautical Miles	6,518	6,235	6,708	6,124
		Average Speed	481	453	453	464
		Trip Fuel	38,887	32,204	38,205	41,437
		Specific Range/Altitude	0.168/FL 490	0.194/FL 470	0.176/FL 490	0.148/FL 470
	Ferry	Nautical Miles	6,658	6,475	6,853	6,233
		Average Speed	481	454	454	464
		Trip Fuel	38,930	32,653	38,251	41,487
		Specific Range/Altitude	0.171/FL 490	0.198/FL 470	0.179/FL 510	0.150/FL 470
Missions (8 passengers)	1,000 nm	Runway	NA	2,715	3,436	2,852
		Flight Time	2+12	2+12	2+20	2+13
		Fuel Used	5,798	5,440	5,599	6,842
		Specific Range/Altitude	0.172/FL 490	0.184/FL 450	0.179/FL 490	0.146/FL 470
	3,000 nm	Runway	NA	3,730	3,599	3,858
		Flight Time	6+19	6+19	6+42	6+20
		Fuel Used	16,352	15,945	15,474	19,538
		Specific Range/Altitude	0.183/FL 490	0.188/FL 450	0.194/FL 490	0.154/FL 470
	6,000 nm	Runway	NA	5,785	5,277	6,293
		Flight Time	12+29	12+45	13+15	12+39
		Fuel Used	35,191	32,200	33,428	41,053
		Specific Range/Altitude	0.170/FL 490	0.186/FL 470	0.179/FL 490	0.146/FL 490
Remarks		Certification Basis	FAR, EASA CS 25 pending	FAR/EASA 25, 2016 EASy III flight deck; DFCS. 2019 delivery price.	FAR 25 1997/2003; EASA 25 CS, 2004	FAR 25, 1998/2003; JAR 25 BEVS and new Global Vision flight deck standard.

ULTRA-LONG-RANGE JETS

Manufacturer			Gulfstream Aerospace	Gulfstream Aerospace	Bombardier	*Boeing*
Model			G650 GVI	G650ER GVI	Global 7500 BD-700-1A10	*BBJ MAX7 737-7*
***BCA* Equipped Price**			$69,500,000	$71,500,000	$72,800,000	*$91,200,000*
Characteristics		Seating	4+16/19/19	4+16/19/19	4+17/19/19	*4+19/71/172*
		Wing Loading/Power Loading	77.6/2.95	80.7/3.07	91.6/3.04	*132.0/3.02*
		Noise (EPNdB): Lateral/Flyover/Approach	77.5/89.8/88.3	78.7/89.6/88.3	91.6/80.3/88.8	*NA/NA/NA*
External Dimensions (ft.)		Length	99.8	99.8	111.0	*116.7*
		Height	25.7	25.7	27.0	*40.3*
		Span	99.6	99.6	104.0	*117.8*
Internal Dimensions (ft.)		**Length:** Main Seating/Net/Gross	32.7/46.8/53.6	32.7/46.8/53.6	36.0/54.4/60.6	*83.9/85.5/85.5*
		Height/Dropped Aisle Depth	6.3/flat floor	6.3/flat floor	6.2/flat floor	*7.1/flat floor*
		Width: Max/Floor	8.2/6.7	8.2/6.7	8.0/6.8	*11.6/10.7*
Baggage		**Internal:** Cu. ft./lb.	195/2,500	195/2,500	195/—	*NA/NA*
		External: Cu. ft./lb.	—/—-	—/—	—/—	*274/NA*
Power		Engines	2 RR BR700-725A1-12	2 RR BR700-725A1-12	2 GE Passport 20-19BB1A	*2 CFMI LEAP-1B*
		Output (lb. each)/Flat Rating	16,900/ISA+15C	16,900/ISA+15C	18,920/ISA+15C	*29,300/ISA+15C*
		Inspection Interval/Manu. Service Plan Interval	10,000t/—	10,000t/—	OC/OC	*OC/—*
Weights (lb.)		Max Ramp	100,000	104,000	115,100	*177,500*
		Max Takeoff	99,600	103,600	114,850	*177,000*
		Max Landing	83,500	83,500	87,600	*145,600*
		Zero Fuel	60,500c	60,500c	67,500c	*138,700c*
		BOW	54,500	54,500	61,700	*105,830*
		Max Payload	6,000	6,000	5,800	*35,400*
		Useful Load	45,500	49,500	53,400	*71,670*
		Max Fuel	44,200	48,200	51,510	*70,109*
		Available Payload w/Max Fuel	1,300	1,300	1,890	*1,561*
		Available Fuel w/Max Payload	39,500	43,500	47,600	*36,300*
Limits		M_{MO}	0.925	0.925	0.925	*0.820*
		Trans. Alt. FL/V_{MO}	FL 290/340	FL 290/340	FL 320/350	*FL 260/340*
		PSI/Sea-Level Cabin	10.7/31,900	10.7/31,900	10.3/30,125	*9.0/24,000*
Airport Performance		TOFL (SL elev./ISA temp.)	5,858	6,299	5,800	*6,630*
		TOFL (5,000-ft. elev.@25C)	9,000	11,139	8,679	*NA*
		Mission Weight	99,600	103,600	114,850p	*NA*
		NBAA IFR Range	6,912	7,437	7,800	*NA*
		V_2	146	148	137	*NA*
		V_{REF}	114	114	108	*122*
		Landing Distance	2,680	2,680	2,240	*2,440*
Climb		Time to Climb/Altitude	19/FL 370	21/FL 370	20/FL 370	*24/350*
		FAR 25 Engine-Out Rate (fpm)	NA	NA	418	*NA*
		FAR 25 Engine-Out Gradient (ft./nm)	NA	NA	183	*NA*
Ceiling (ft.)		Certificated	51,000	51,000	51,000	*41,000*
		All-Engine Service	42,700	41,000	43,000	*NA*
		Engine-Out Service	25,000	25,000	25,000	*NA*
Cruise	Long Range	TAS	488	488	488	*455*
		Fuel Flow	2,825	2,883	2,983	*NA*
		Altitude	FL 450	FL 450	FL 450	*FL 380*
		Specific Range	0.173	0.169	0.164	*NA*
	High Speed	TAS	516	516	516	*471*
		Fuel Flow	3,136	3,136	3,224	*NA*
		Altitude	FL 450	FL 450	FL 450	*FL 360*
		Specific Range	0.165	0.165	0.160	*NA*
NBAA IFR Ranges (200-nm alternate)	Max Payload (w/available fuel)	Nautical Miles	5,934	6,459	6,902	*2,692*
		Average Speed	481	481	474	*NA*
		Trip Fuel	36,285	40,285	44,610	*NA*
		Specific Range/Altitude	0.164/FL 490	0.160/FL 490	0.155/FL 470	*NA/FL 370*
	Max Fuel (w/available payload)	Nautical Miles	6,981	7,507	7,700	*NA*
		Average Speed	482	482	475	*NA*
		Trip Fuel	41,129	45,129	48,512	*NA*
		Specific Range/Altitude	0.170/FL 510	0.166/FL 510	0.159/FL 510	*NA/FL 390*
	Eight Passengers (w/available fuel)	Nautical Miles	6,912	7,437	7,725	*7,000*
		Average Speed	481	482	475	*NA*
		Trip Fuel	40,820	44,820	48,519	*NA*
		Specific Range/Altitude	0.169/FL 510	0.166/FL 510	0.159/FL 510	*NA/FL 390*
	Ferry	Nautical Miles	7,105	7,636	7,860	*NA*
		Average Speed	482	482	476	*NA*
		Trip Fuel	41,168	45,168	48,560	*NA*
		Specific Range/Altitude	0.173/FL 510	0.169/FL 510	0.162/FL 510	*NA/FL 390*
Missions (8 passengers)	1,000 nm	Runway	3,241	3,241	3,442	*NA*
		Flight Time	2+10	2+10	2+24	*NA*
		Fuel Used	5,942	5,942	6,129	*NA*
		Specific Range/Altitude	0.168/FL 510	0.168/FL 510	0.163/FL 510	*NA/NA*
	3,000 nm	Runway	3,591	3,591	3,567	*NA*
		Flight Time	6+17	6+17	6+31	*NA*
		Fuel Used	16,280	16,280	17,059	*NA*
		Specific Range/Altitude	0.184/FL 510	0.184/FL 510	0.176/FL 510	*NA/NA*
	6,000 nm	Runway	5,241	5,241	4,678	*NA*
		Flight Time	12+28	12+28	12+42	*NA*
		Fuel Used	34,622	34,622	36,011	*NA*
		Specific Range/Altitude	0.173/FL 510	0.173/FL 510	0.167/FL 510	*NA/NA*
Remarks		Certification Basis	FAR, EASA CS 25, 2012	FAR 25, 2014	FAR 25, TC, EASA, 2018	*FAR 25, 2018 15,500-lb. Interior allowance. All data preliminary.*

ULTRA-LONG-RANGE JETS

			Boeing	Airbus	Boeing
Manufacturer			Boeing	Airbus	Boeing
Model			BBJ MAX8 737-8	ACJ319NEO A319-151N*	BBJ MAX9 737-9
BCA Equipped Price			$99,000,000	$105,000,000**	$107,900,000
Characteristics		Seating	4+19/71/189	4+19/19/156	4+19/75/220
		Wing Loading/Power Loading	135.1/3.09	123.5/3.55	145.2/3.32
		Noise (EPNdB): Lateral/Flyover/Approach	NA/NA/NA	84.9/81.4/92.0	NA/NA/NA
External Dimensions (ft.)		Length	129.7	111.0	138.3
		Height	40.3	38.6	40.3
		Span	117.8	117.4	117.8
Internal Dimensions (ft.)		**Length:** Main Seating/Net/Gross	91.9/98.5/98.5	79.0/79.0/—	100.6/107.2/107.2
		Height/Dropped Aisle Depth	7.1/flat floor	7.4/flat floor	7.1/flat floor
		Width: Max/Floor	11.6/10.7	12.2/11.6	11.6/10.7
Baggage		**Internal:** Cu. ft./lb.	NA/NA	160/NA	NA/NA
		External: Cu. ft./lb.	654/NA	128/NA	821/NA
Power		Engines	2 CFMI LEAP-1B	2 CFMI LEAP-1A24	2 CFMI LEAP-1B
		Output (lb. each)/Flat Rating	29,300/ISA+15C	24,010/ISA+30C	29,300/ISA+15C
		Inspection Interval/Manu. Service Plan Interval	OC/—	OC/—	OC/—
Weights (lb.)		Max Ramp	181,700	171,299	195,200
		Max Takeoff	181,200	170,417	194,700
		Max Landing	152,800	140,875	163,900
		Zero Fuel	145,400c	132,939c	156,500c
		BOW	109,890	104,000***	117,900
		Max Payload	35,510	28,939	38,600
		Useful Load	71,810	67,299	77,300
		Max Fuel	70,149	66,196	73,734
		Available Payload w/Max Fuel	1,661	1,103	3,567
		Available Fuel w/Max Payload	36,300	38,360	38,700
Limits		MMO	0.820	0.820	0.820
		Trans. Alt. FL/VMO	FL 260/340	FL 250/350	FL 260/340
		PSI/Sea-Level Cabin	9.0/24,000	9.0/24,000	9.0/24,000
Airport Performance		TOFL (SL elev./ISA temp.)	6,630	6,036	8,200
		TOFL (5,000-ft. elev.@25C)	NA	8,360	NA
		Mission Weight	NA	NA	NA
		NBAA IFR Range	NA	NA	NA
		V2	NA	137	NA
		VREF	122	111	124
		Landing Distance	2,440	2,220	2,570
Climb		Time to Climb/Altitude	24/FL 350	22/360	26/FL 330
		FAR 25 Engine-Out Rate (fpm)	NA	NA	NA
		FAR 25 Engine-Out Gradient (ft./nm)	NA	NA	NA
Ceiling (ft.)		Certificated	41,000	41,000	41,000
		All-Engine Service	NA	36,000	NA
		Engine-Out Service	NA	18,000	NA
Cruise	Long Range	TAS	455	447	457
		Fuel Flow	NA	4,100	NA
		Altitude	FL 380	FL 370	FL 360
		Specific Range	NA	0.109	NA
	High Speed	TAS	471	470	471
		Fuel Flow	NA	5,050	NA
		Altitude	FL 360	FL 370	FL 360
		Specific Range	NA	0.093	NA
NBAA IFR Ranges (200-nm alternate)	Max Payload (w/available fuel)	Nautical Miles	2,692	2,679	2,628
		Average Speed	NA	434	NA
		Trip Fuel	NA	NA	NA
		Specific Range/Altitude	NA/FL 370	NA/FL 370	NA/FL 350
	Max Fuel (w/available payload)	Nautical Miles	NA	6,750	NA
		Average Speed	NA	442	NA
		Trip Fuel	NA	61,785	NA
		Specific Range/Altitude	NA/FL 390	0.109/FL 410	NA/FL 390
	Eight Passengers (w/available fuel)	Nautical Miles	6,640	6,750	6,515
		Average Speed	NA	442	NA
		Trip Fuel	NA	61,785	NA
		Specific Range/Altitude	NA/FL 390	0.109/FL 410	NA/FL 410
	Ferry	Nautical Miles	NA	6,800	NA
		Average Speed	NA	442	NA
		Trip Fuel	NA	61,785	NA
		Specific Range/Altitude	NA/FL 390	0.110/FL 410	NA/FL 410
Missions (8 passengers)	1,000 nm	Runway	NA	4,075	NA
		Flight Time	NA	2+26	NA
		Fuel Used	NA	9,017	NA
		Specific Range/Altitude	NA/NA	0.111/FL 410	NA/NA
	3,000 nm	Runway	NA	4,280	NA
		Flight Time	NA	6+54	NA
		Fuel Used	NA	26,148	NA
		Specific Range/Altitude	NA/NA	0.115/FL 410	NA/NA
	6,000 nm	Runway	NA	6,160	NA
		Flight Time	NA	13+35	NA
		Fuel Used	NA	56,981	NA
		Specific Range/Altitude	NA/NA	0.105/FL 410	NA/NA
Remarks		Certification Basis	FAR 25 A137, 2017 18,000-lb. Interior allowance. All data preliminary.	FAR 25, 1999/2018 *Also available with IAEV2527M-A5 engines with 26,500 lbf; includes five additional center tanks plus VIP cabin. ***BCA* estimate. ****BCA* estimate.	FAR 25 A141, 2018 21,000-lb. Interior allowance. All data preliminary.

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Charter, Fractional, Ownership, Managed?

Which choice **is right for you?**

TODAY'S MARKET FOR PRIVATE AVIATION OFFERS A DIZZYING ARray of choices. What benchmarks do advisors use when guiding customers among them?

In a simple world, the expected number of flight hours for the year would dictate the choice of charter, jet card, fractional or "full" or managed ownership. But there is substantial overlap among the options because of the needs and wants of customers.

So, while acknowledging the flaws of benchmarking choices by flight hours, here are overlapping ranges:

0-25 Hr.	Trip-by-Trip Charter
25-100 Hr.	Jet Card
25-250 Hr.	Fractional
150-400 Hr.	Ownership

Trip-by-Trip Charter: Do you only use private aircraft occasionally? Do you know what you need/want for aircraft size and capability? Charter companies were the original charter brokers. They forged relationships with the local businesses that used charter, and they built informal networks to cover the need for substitutes and larger aircraft — *i.e.* "You need a Gulfstream for the next trip? Don't worry. I know a guy."

As the industry grew, charter companies hired people whose sole job was to build these customer and charter network relationships. And then those people began to leave (with their lists) and become brokers.

So, if you want to book trip-by-trip charter, build a relationship with a charter company or a broker. And as your usage increases, they will tell you about jet cards.

Jet Card: What is it? Jet cards grew out of an older business model called "block charter." Commit to buying 50 flight hours from your local charter company and receive a nice discount. Today, there are hundreds of choices. In fact, the only common denominator is a discount for a block charter commitment.

Many, if not most, of the offerings are made by brokers, not charter companies themselves. Don't be fooled by a low hourly rate: The devil is in the details, and the details are a maze of fuel surcharges, daily flight minimums, service area limitations and dozens of other factors.

Before deciding on a jet card, decide what matters most. Longtime readers of *Cause & Circumstance* don't view operator safety as a given. Yet some customers assume that any and all operators are safe, and, therefore, why not seek out the lowest price? Price should never be the sole factor in any aviation decision.

Is there a real company that you will be trusting with your funds and your safety? What is its criteria for selecting operators? Talk to other customers before committing.

Fractional: Fractional aircraft ownership programs officially date back to the inception of NetJets in 1987. That is when the N-numbers ending in QS began. Now ubiquitous on FBO ramps, "QS" stands for "quarter-share."

Although FAR Part 91, Subpart K was created just for fractional ownership operations, today many of the flights are operated under Part 135, either because the customer bought or leased less than the minimum interest required for fractional operations, or simply because the customer elected not to share operational control with the program manager.

Fractional programs helped spawn the growth of jet cards with the Marquis Jet Card, which allowed customers to purchase 25 flight hours in the NetJets program. Today, fractional and at least some jet cards are very similar. Do you sometimes need two jets on the same day? No problem. Heavy jet today, light jet tomorrow? Sure. Because of the flexibility of fractional, some companies buy more than 400 hr. a year, even though they could easily justify "whole" aircraft ownership.

Management Company: There is a step between owning a fractional aircraft share and having your very own flight department. Own your own aircraft, but have it managed by a charter/management company.

You can have the aircraft managed by a charter company, and still have your trusted crew. And the aircraft can be chartered to others when you are not using it if you want to offset overhead. Most companies give you the choice of being the direct (W-2) employer of the crew, or the management company will manage payroll and benefits.

However, if your W-2 crew is to fly for the charter company under Part 135, then those pilots will need to sign "agency agreements" to acknowledge that they are under the operational control of the charter company on Part 135 flights.

But how do you choose a management company? Price should not be the first criteria. Talk to other owners that use the company. Typically, the choice is between a large national operation, such as Executive Jet Management, sister company to NetJets, or a local charter company. Many owners prefer the local touch and having a private facility at their home base. Jet Linx is a national company that provides numerous local bases, so that the aircraft owners can have the private facility experience at each base.

To charter, or not to charter: Done right, chartering out your aircraft when you aren't using it offsets your cost of ownership. Done wrong, additional maintenance costs eat up the income and wear and tear reduces the resale value of the aircraft. Where is the happy medium? There isn't a simple hour benchmark answer.

You will need spreadsheets and specific operating costs to find the balance that works for you. On the plus side, the charter market today is ravenous for additional aircraft. If you want charter hours for your aircraft, you will get them.

Ownership: For those who need, or can simply afford to own an aircraft and employ their own flight department, the satisfaction that comes with trusted people and custom, trusted equipment is still the ultimate in private aviation. There are a number of flight departments today that operate less than 200 flight hours per year. Conventional wisdom would dictate that these users would be better served by fractional ownership or charter. The owners know that. They just don't care. BCA


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Cessna Conquest II

Under-valued, speedy, **fuel efficient turboprop**

CESSNA 441 CONQUEST II'S BLEND OF 300+ KT. CRUISE SPEEDS and top-notch fuel efficiency should be stimulating buyer interest, especially in light of fuel price increases and pressures to "go green." But it isn't. Instead, potential buyers are migrating toward light jets. Yet, Conquest II can fly typical missions and arrive within ten minutes of a jet while burning one-third less fuel. Cessna built 362 units from 1977 through 1986 and 290 aircraft remain in service. The value of midlife aircraft in good condition has sagged from $1 million to $1.9 million in 22011, to $750,000-900,000 today, according to Lawson Brown of Aviation Unlimited at San Diego — Montgomery Field.

Honeywell's TPE331-8 originally powered the aircraft, providing exceptional fuel efficiency, but lackluster climb performance above FL 220. The -8 also has 1,500 hr./3,000 hr. HSI and TBO intervals.

Most aircraft now have been upgraded to -10 engines, enabling them to climb directly to FL 350. At FL 290, a -10 powered aircraft at midweight can cruise at 316 KTAS while burning 480 pph. As a bonus, the engine has 2,500-hr. HSI and 5,000-hr. TBO intervals. Operators say that hot section inspections run between $50,000 to $75,000 per engine while overhauls costs about $225,000 per engine, says Bruce Raynor, director of maintenance at TechnicAir in Fresno, California.

TOMAS DEL CORO/LAS VEGAS/WIKIMEDIA COMMONS

The improved high-altitude performance of -10 equipped aircraft makes RVSM approval a virtual must for any buyer needing the aircraft's full 2,000-nm range potential, especially 1981 and later models, starting at s.n. 173, that are certified to fly at FL 350, That's a 2,000-ft. higher certified ceiling than earlier models. Max range speed at FL 350 averages 260 KTAS and fuel flow is a miserly 310 pph, assuming the aircraft has -10 engines. TechnicAir offers an RVSM STC using Thommen AD32 digital air data altimeters that costs $95,000. Another firm's STC uses IS&S integrated air data altimeters that are RVSM compliant.

Most aircraft also now have been through the comprehensive 2007 Supplement Inspection Document process that checks for corrosion and fatigue. The base inspection costs about $200,000. The final bill can reach $300,000 depending upon the aircraft's previous care. Deadline for compliance was December 2008. Aircraft that haven't undergone the SID process have little resale value.

TechnicAir in Fresno, Royal Atlantic Aviation in Melbourne, West Star in Grand Junction and Yingling in Wichita are among the top MRO shops that have performed Conquest SID checks.

In mid-2007, Cessna virtually imposed a 22,500-hr. life limit on the aircraft by stating that it "cannot assure the continued airworthiness of the aircraft after that limit is reached." Aircraft with more than half their useful lives remaining are commanding considerably more in the resale market. If you're flying less than 300 hr. per year, a midlife aircraft will last three more decades.

The average Conquest II, though, has a 6,400 lb. to 6,500-lb. BOW with one pilot. That allows only a 200 lb. to 300-lb. payload with full fuel. Each additional 200 lb. passenger costs about 125 nm to 150 nm of range, depending upon aircraft weight and cruise speed. But Boundary Layer Research in Everett, Washington offers a $17,000 vortex generator and main landing gear oleo strut metering pin modification package [not including labor] that boosts MTOW by 490 lb., greatly enhancing aircraft utility.

Cabins typically are configured with six to nine seats, including a forward, four-seat club section and individual chairs in the aft cabin. A belted potty was an option. Most baggage may stored in the aft cabin, but it's advisable first to load the two unpressurized storage bays in the nose because aircraft tend to be tail heavy.

Most aircraft came equipped with Cessna ARC 1000-series avionics, although many buyers upgraded to Rockwell Collins APS-65 avionics. A few aircraft were fitted with Honeywell SPZ-500 avionics, similar to early Citation I jets.

Many aircraft now have been upgraded with Garmin avionics, including GTX-3XX series Mode S ES ADS-B transponders. Some buyers have installed Garmin G600 flat-panel avionics on one of both sides. Many aircraft also are equipped with a traffic advisory system, a highly desirable upgrade.

Rayner says 100-hr. Phase 2 inspections cost about $1,955, 200-hr. Phase 3 checks run $4,370 and 24-month Phase D inspections cost about $10,170, not including discrepancies.

Among Conquest II's main competitors is the Beechcraft B200 King Air with slower cruise speeds, higher fuel consumption and 200-nm less range, but a roomier cabin. Mitsubishi's MU-2B-60 has almost the same cruise speed and excellent fuel efficiency, but it flies lower and it's more challenging to fly. Piper's Cheyenne III flies fast, but it has poorer fuel efficiency than the Conquest II and 250+ miles less range. The Cheyenne 400 can fly 45 kt. faster, but it has the Jet-A thirst of a light jet.

Conquest II's combination of cabin comfort, speed and fuel efficiency, along with 2,150-nm range, make it bargain in the used aircraft market. What other twin-turboprop can fly coast-to-coast U.S. eastbound? With the 22,500-hr. economic life limit still far in the future for most aircraft, this versatile aircraft will provide great transportation value for decades to come. BCA

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On Duty

Edited by Jessica A. Salerno *jessica.salerno@informa.com*

News of promotions, appointments and honors involving professionals within the business aviation community

▶ **Aerion**, Reno, Nevada, announced that **Matthew Cram** has been named deputy general counsel, supporting the company in a variety of legal, contractual and corporate Governance matters as its develops the AS2 supersonic business jet.

▶ **Aerospace Technologies Group**, Boca Raton, Florida, announced the appointment of **Mario Ceste** to the role of chief executive officer. Ceste succeeds **Simon Kay**, who has helped drive the organization's overall strategy and vision over the past 17 years.

▶ **Air Charter Service**, Los Angeles, California, appointed **Richard Carrick** as a nonexecutive director on its board of directors. Carrick has served as CEO of My Travel and Hoseasons, and spent six years at PrivateFly.

▶ **Air Partner**, United Kingdom, appointed **Kevin Mcnaughton** managing director of. Mcnaughton served as company director and head of European sales at NetJets. **Steve Dosman**, **Robert Chapman** and **Gareth Dore** have joined **Baines Simmons**, part of the Consulting and Training Div. of Air Partner. Dosman will be an initial airworthiness consultant. He previously spent 23 years at a large DOA/DAOS design organization. Chapman will work in training and consulting as it relates to safety risk. He has worked in risk management for more than 25 years. Gareth is a former Royal Air Force search-and-rescue pilot. He will support Simmons' STEP program training. **Paul Dollman** has been appointed a non-executive director of Air Partner. He also will chair its Audit and Risk Committee, effective June 26.

▶ **Asian Business Aviation Association** (AsBAA), Hong Kong, appointed **Omar Hosari** to the Board of Governors. Hosari is co-owner, founder and CEO of **UAS International Trip Support**. UAS is a sister company of **Deer Jet**.


MATTHEW CRAM


MARIO CESTE


JULIE BLACK


JAY SCOTT


DAVID CLIFTON

▶ **Aviation Week Network's Airport Strategy and Marketing** (ASM), New York, New York, announced that **Chris Warren** has been named director of Air Service Development. His U.S.-based role marks the expansion of ASM's footprint in North America.

▶ **BACA**, London, United Kingdom, elected **Julie Black** as deputy chair of BACA—The Air Charter Association. She takes on the role with immediate effect working alongside **Nick West**, chairman of the association.

▶ **CAS**, Ontario, California, announced the appointment of **Jay Scott** as director of Operations for the Recovery, Repair and Modifications division.


TREVOR YUSCHYSHYN


JEFF SCHIPPER


ANDREW PEARCE


PAUL DUNFORD


MARK WITHROW

▶ **CPI Aerostructures**, Edgewood, New York, named **Janet Cooper** to the board of directors. **Harvey Bazaar**, a director and chair of the audit committee since 2006, plans to retire from the board after the next annual meeting. Cooper serves as a director and chair of the audit committee of The Toro Co., and as a director and member of the audit committee of Lennox International.

▶ **Cutter Aviation**, Phoenix, Arizona, promoted **Taylor Butterfield** to manager of charter and flight management department at its Phoenix location. He joined Cutter as a pilot in 2016. **David Clifton** has been appointed to the position of director of Technical and Flight Support Service responsible for supervising all aspects of Cutter's 145 Repair Stations in Phoenix, Addison, San Antonio and Denner.

▶ **Dassault Falcon Jet**, Teterboro, New Jersey, appointed **Jean Kayanakis** senior vice president of Dassault's Worldwide Falcon Customer Service and Service Center Network. Kayanakis most recently served as general manager of Dassault Falcon Service.

▶ **Duncan Aviation**, Lincoln, Nebraska, announced that **Trevor Yuschyshyn** has joined the company as regional manager, Canada. **Jeff Schipper** has been named manager of modifications at Duncan Aviation in Provo, Utah. Schipper joined Duncan in 1990. Yuschyshyn most recently served as director of maintenance of a company that managed a fleet of aircraft. **Michael Kussatz** has returned to Duncan Aviation from Garmin International to be regional avionics sales manager for its East Coast Satellite Avionics Shop network. Kussatz originally joined Duncan after earning a degree in aviation technology, working in sales and as a project manager. **Joe Cugnetti** has become a Bombardier service sales representative.

▶ **Flying Colours Corp.**, Peterborough, Ontario, named **Andrew Pearce** as the company's first European sales manager. Pearce has spent 35 years in MRO, completions and aircraft sales with Canadian, Middle Eastern and European business aviation companies. **Paul Dunford** has been appointed to the newly created position of managing director of international operations. Dunford joined the company in 2014 as general manager of Asia. **Too Hin Wee** has been appointed general manager of the company's facility in Singapore. He takes over from **Paul Dunford**, who was appointed to the newly created position of managing director of international operations. Hin Wee will be based at Singapore's

Seletar Aerospace Park. He has 20 years of aviation technical and maintenance experience for the role.

▶ **GE Aviation**, Cleveland, Ohio, named **Mark Withrow** plant leader for the GE Aviation Strother facility in Crowley County, Kansas. Withrow joins the company from Kaman Corporation, where he served as vice president and general manager of U.S. composites., He will be responsible for providing leadership and quality oversight to more than 800 employees at the Strother facility.

▶ **GrandView Aviation**, Baltimore, Maryland, promoted **Peter Pahygiannis** to chief pilot. **Benzion Zwebner** has been promoted to assistant chief pilot. Pahygiannis has 32 years of experience and 18,000 flight hours. Zwebner previously served as captain at Trans State Airlines.

▶ **Honeywell**, Charlotte, North Carolina, appointed **Brian Davis** president of **Honeywell ASEAN** (Association of Southeast Asian Nations). Davis succeeds **Briand Greer**, who plans to retire in June. Davis joined Honeywell in 2006 and has held multiple senior leadership roles.

▶ **Jet Aviation Group**, Zurich, Switzerland, announced that **Dave Paddock** will assume the role of president beginning July 1. Paddock joined Jet Aviation in 2007 and has been serving as senior vice president of its U.S. operations since 2015. **Jeremie Caillet** has been appointed vice president of VIP completion programs for Jet Aviation. Caillet succeeds **Neil Boyle**, who is retiring at the end of May. Boyle will remain active with the company's senior advisory board. Caillet joined Jet Aviation in 2008 as engineering team leader.

▶ **Metrojet**, Hong Kong, announced that **Denzil White** has returned to the business jet operator and maintainer, as managing director of its aircraft management and charter division. **Janet Chen** joined the company as regional sales manager for MRO services. White most recently served at Hongkong Jet. Chen formerly was at **HAECO Private Jet Solutions**. She will be based in mainland China.

▶ **Pentastar Aviation**, Waterford, Michigan, announced team members **Krissy Ross** and **Doug Levangie** have been recognized by the National Air Transportation Association (NATA) with 2018-29-019 Industry Excellence Awards.

▶ **Swiss Aviation Consulting Group**, Hünenberg, Switzerland named **Roland Seidel** CEO. Seidel was previously the head of technical asset management of a Swiss transportation company and acting deputy CEO of Lufthansa Systems Flightnav products. Seidel replaces **Daniel Luetolf**, who will continue his role as executive chairman of SAC's holding company.

▶ **TrueNoord**, The Netherlands, appointed **Michael Adams** European sales director. Adams will be based in the company's Dublin office. He comes to TrueNoord from ACIA Aero Leasing where he served as senior executive sales.

▶ **Vertis Aviation**, Zug, Switzerland, announced that **Leslie Hart** has joined the business development team. Hart will be based in Johannesburg. For the past three years, he has been working in charter aircraft management. **BCA**

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Products & Services Previews

By Jessica A. Salerno jessica.salerno@informa.com

1. NBAA's New Website Retargeting Program

The National Business Aviation Association has launched a "retargeting" program that allows participants to target those visiting the NBAA website with banner advertising as visitors search other sites across the internet. NBAA has partnered with Multiview, a business-to-business marketing firm, that has placed a line of code on the NBAA website that allows it to track those who visit the NBAA website, according to information from Multiview. It then retargets the visitors with banner ads showcasing products and services as they frequent other websites. The cost to NBAA members who sign up for the ad campaign runs from $4,950 for 120,000 "impressions," or banner displays, to $12,980 for 500,000 impressions over a 12-month span. The advertiser does not gain personal information from the person visiting the site or from NBAA. They only know that, for whatever reason, the person visited the NBAA website, he said. The service is a value to members. "Many of our members are service providers and small companies," he said. And they have small marketing budgets. The campaign, which launched in January, is limited to 100 companies. Nearly 100 have signed up so far.

National Business Aviation Association
www.nbaa.org

2. Magellan Launches Elevate Membership Program

Boston-based Magellan Jets has launched Elevate, a new private jet membership program, calling it "risk-free membership" with a 30-day satisfaction guarantee. "The launch of Elevate is by design removing the red tape that has restricted the benefits and freedom of private jet travel for too long," Magellan Jets President and co-founder Anthony Tivnon said. "Simplicity, reliability and flexibility is how we evaluate our members' experience." Unlike other membership programs that lock clients into a contract before having taken their first flight, "Magellan Jets is so confident members' expectations will be exceeded with Elevate, we will refund a member's remaining funds up to 30 days from their first flight," Tivnon said. Magellan members may purchase hours in any of 10 aircraft types, from the Phenom 300 light jet to the large-cabin Gulfstream 450, without blackout days or peak surcharges. Magellan members also have access to 24/7 Live Flight Support and Compliance teams that select aircraft from the pre-selected Magellan Jets Preferred Network. Magellan emphasizes member privacy, it said. Unlike some operators whose flights can be tracked, "Magellan offers complete anonymity."

Magellan Jets
www.magellanjets.com

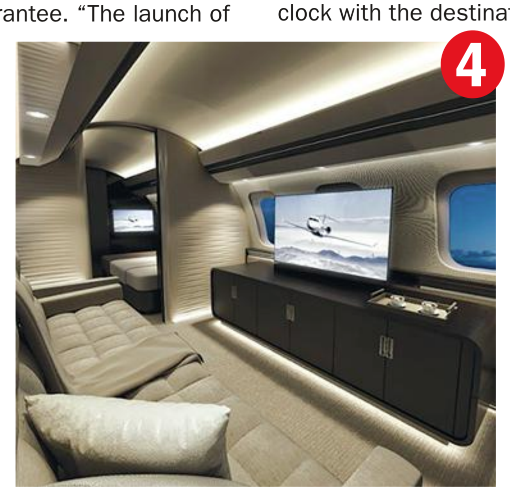
3. FlightSafety Adds Aircraft Cabin Systems to Technician Program

FlightSafety International has expanded its master technician program to include aircraft cabin systems. The program offers a curriculum that follows a five-step process. It is designed to train technicians to service and maintain the cabin of an aircraft at the "highest level," the company said. To complete the program, technicians must finish several courses, including avionics standard practices, aeroIT cabin connectivity, integrated cabin management systems and the cabin systems operational maintenance program.

Flight Safety International
www.flightsafety.com

4. Bombardier Introduces Soleil Lighting for Global 7500

The Soleil lighting system, designed and tested at Bombardier, helps synchronize a passenger's internal clock with the destination's time zone. The science behind the system is based on circadian rhythm. "Lighting is a significant element that can help blend your body or synchronize your body using red and blue wavelengths," Bombardier's manager of industrial design Tim Fagan said. A person's internal clock is heavily influenced by daylight. During the course of a day, the sky contains variations of blue light, then red light as the sun goes down. Color tones and variations help a body anticipate sleep, which regulates the production of melatonin, Fagan said. The Soleil lighting system features Daylight



Simulation integrated with the aircraft's Flight Management System and uses combinations of red and blue light wavelengths. The aircraft is equipped with twice the amount of individual LEDs compared to other cabin lighting methods. The system is dynamic and based on a logarithm designed in-house that takes into account time of takeoff and landing and time of year for sunrise and sunset, Fagan said. The system controls the lighting and its color and intensity. It also can be programmed to schedule the optimal time for meal services. Passengers control the system through their phone or tablet. The feature is standard on Global 7500s and is embedded in the aircraft's nice Touch cabin management system. The Soleil lighting system is ideally suited for the Global 7500 with its long-range mission profile, the company said. The aircraft has demonstrated the capability of long-haul flights over 16 hr.

Bombardier Aerospace
www.bombardier.com

5. Greg Norman Named Delta Private Jets' 2019 Brand Ambassador

Delta Private Jets has selected golf professional Greg Norman to be its brand ambassador for 2019. The aircraft charter service's campaign featuring Norman, known as "The Great White Shark," is scheduled to launch this summer and incorporate print, digital and social media channels. Delta Private Jets said it plans to host golf tournaments, social events and special-client events. Norman has won more than 90 golf tournaments, including two Open Championships.

Delta Private Jets
www.deltaprivatejets.com

6. PrivateFly Offers 'City Pairs' Pricing in Europe

PrivateFly, an on-demand charter service based in England, has launched "City Pairs" pricing, providing fixed, discounted rates for destination pairings in Europe this summer on the Nextant 400XTi aircraft, the company said. The offer includes flights to London, Paris, Milan, Geneva and Rome; and to Nice, France; and Palma and Ibiza, Spain. Prices range from €4,500 ($5,038) for a one-way flight between London and Paris to €9,000 ($10,077) from London to Ibiza. Prices are for chartering the whole aircraft, which can accommodate groups of up to six. The prices are 30% lower than average year-round prices on similar aircraft, the company said.

PrivateFly
www.privatefly.com

7. Jet Aviation Acquires Stake in Scottsdale Jet Center

Jet Aviation has acquired a stake in the Scottsdale Jet Center in Scottsdale, Arizona, with plans to build and operate a new Jet Aviation-branded fixed-base operation and tenant hangar by late 2020. The new facility, which includes a new FBO terminal and 30,000 sq. ft. of hangar space, is intended to complement existing tenant facilities at the Scottsdale Airport. It will allow Jet Aviation to operate in eight of the top 15 business aviation markets, the company said. Jet Aviation plans for additional development at the facility.

Scottsdale Jet Center currently leases 45,000 sf of office space, 24,000 sf of T-hangar space, tie-down spaces, and shades. Planning for the new FBO terminal and 30,000 sf hangar is currently underway, with opening planned for late 2020. Thereafter, Jet Aviation plans additional phases of development to support growing customer demand.

Jet Aviation
www.jetaviation.com

8. Twin Commander Offers Free Upgrade Kits to Comply With SB

Twin Commander is offering two free upgrade kits for Service Bulletin 241, which addresses potential cracking in the aft pressure bulkhead of Twin Commander 690/A/B model aircraft. FAA Airworthiness Directive 2013-09-05 is a mandatory maintenance item for owners of the aircraft. Owners who have not yet complied with Service Bulletin 241, the AD's compliance method, are eligible for the free kit, which has a value of $16,325, the company said.

Twin Commander
www.twincommander.com

9. Garmin Receives FAA Approval For GFC 500 For Cessna 180/185

Garmin has received FAA approval for its GFC 500 autopilot for the Cessna 180 and 185 aircraft. The GFC 500 will soon be approved for the Bonanza 36 and A36 as well, the company said. The GFC 500 integrates Garmin's G5 electronic flight instrument or a combination of the G5 and G500 TXi flight display. The autopilot mode controller contains large dedicated keys and knobs, a control wheel for easy adjustments to pitch, airspeed and vertical speed and a level button that returns the aircraft to straight-and-level flight, it said. As a standard feature, pilots receive Garmin ESP with the GFC 500 autopilot, which helps the pilot maintain a stable flight condition. ESP functions independently of the autopilot.

Garmin
www.garmin.com

BCA 50 Years Ago

June 1969 News

Seven percent **investment tax credit repeal** proposed by President Nixon has industry executives **worried over possible effects.** – *BCA Staff*

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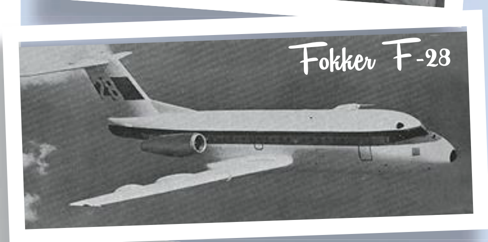
Failure to use checklists, even on relatively simple aircraft, kills too many pilots, says the NTSB in a special accident report. During a five year period ending in 1967, "inadequacies in preflight preparation or planning" was listed as the causal factor in 1,511 general aviation accidents. Sixteen percent of these were fatal." (See *Cause and Circumstance* this issue for an accicent report relating to checklists.)

2,000 mi. nonstop in a standard King Air: Mr. and Mrs. Leonard Greene (Safe Flight Corp.) make their final flight plans at Boeing Field, Seattle. Its two pilots aboard, N880X is hooked to a truck for taxi to takeoff position. The King Air landed in Williamsport, Pennsylvania, 8 hr. and 43 min. after takeoff, setting a world's record for non-stop speed, endurance and range in that weight class.



Fokker F-28 Business Jet-Airliner has won U.S certification. F-28, a 20-place twin-turbofan, is marketed by Fairchild Hiller, Germantown, Maryland. The fanjet lists for $2.8 million.

King Air 100: The latest version of Beech Aircraft's popular and best selling turboprop is being shown publicly for the fist time at the 1969 Reading Show. The new version is 50-in. longer (all in the cabin) than the B90 and has 750-lb. greater max gross weight.

New from Piper is the "C" model Comanche, which is a marketing attempt to beef up sales records of the aircraft. Panel has been redesigned, there are new bucket seats and max speed was increased to 195 mph.

In a recent flight test, the fighter-nose Stolifter prototype got off the runway in 275 ft. and back on again using only 200 ft. to come to a full stop. **BCA**

THE ARCHIVE

Mute witness to the 20th Annual Reading Air Show, banner-bedecked Reading Control Tower summarizes a curious combination of serious business and country fair folderol that draws hundreds of aviation's VIPs every year. Vital statistics: Expected attendance is about 12,000 people with 150 exhibitors.

"Dazzling Beauty for the DH-125" Alumigrip is the standard aircraft coating, the 1969 ad says.


GARMIN
Trip Planning
KOXC → KORL
Navigation Log
TO SERVE YOU BETTER, WE'VE JOINED TOGETHER.
GARMIN WELCOMES FLTPLAN