AeroStrategy

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Aerospace Globalization 2.0: The Next Stage

Aerospace globalization is deepening and accelerating

Globalization is everywhere but nowhere, easy to see but hard to define. "It envelops us, like the weather," says one commentator. "We see it," says another, "in the closing of local shops, experience it with the help desk answered ten time zones away."

But what is globalization? The concept, appropriately for a world-encompassing phenomenon, is complex, controversial, elusive. Over the last 50 years, "the term has been used to describe a process, a condition, a system, a force, and an age," according to Prof. Manfred Steger. Perhaps we can settle on George Ritzer's composite definition, drawn from the work of dozens of experts: "An accelerating set of processes involving flows that encompass ever-greater numbers of the world's spaces and that lead to increasing integration and interconnectivity among those spaces."

The modern aerospace industry has always been global. Aircraft are, after all, capital intensive, standardized, and sold to a global market. But the work of globalization is ongoing. AeroStrategy believes there is a profound shift taking place in the way aircraft are conceived, produced, and

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supported. The aerospace industry is moving beyond Globalization 1.0, an era of multi-national cooperation, to what it calls *Globalization 2.0*, an era of "horizontal specialization," where original equipment manufacturers (OEMs) and service suppliers tightly integrate functions such as engineering, manufacturing, and customer support across multiple locations on a global basis.

In this *Commentary*, AeroStrategy explores the nature of Globalization 2.0. Among our discoveries:

- Aerospace globalization is accelerating, with the number of investments in the late 2000s an order of magnitude greater than the early 1990s
- Comparative advantage is shifting, with new regional hotbeds emerging for engineering, manufacturing, and MRO (maintenance, repair, and overhaul)
- Industry stakeholders, including firms and governments, must adopt new strategies to survive and prosper

Aerospace Globalization 2.0

A new model of horizontal specialization is growing in popularity

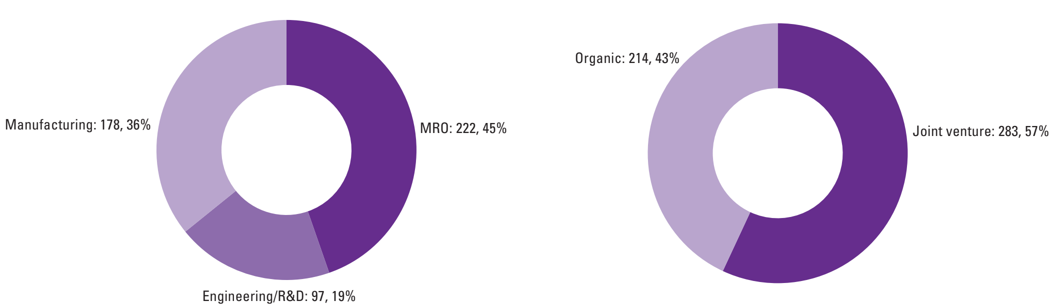
In Globalization 1.0, OEMs sourced parts, components, and subassemblies from foreign suppliers. European OEMs led the way as they leveraged multi-national cooperation to achieve scale and critical mass for new programs. EADS and Airbus are direct results, as are European fighter programs like the Tornado. Military offset and the quest for market access provided additional impetus.

In the mid-1990s, falling transportation and communications costs, the expansion of liberalized trade, advent of digital design tools, and end of the Cold War enlarged the possibilities for aerospace's industrial organization and hastened Globalization 2.0.

Vertical integration and co-location of activities in the home market, once standard, are less desirable today. A new model of horizontal specialization, where OEMs tightly integrate functions such as engineering, manufacturing, and customer support across multiple locations globally, is growing in popularity. This goes beyond the well-known B787 and A350XWB supply chain models that make extensive use of Tier I suppliers. OEMs are pursuing this more complex form of industrial organization for several reasons, including enhanced productivity, leveraging the global talent pool, improving market access, upgrading value propositions, and shortening cycle times.

To substantiate this shift, AeroStrategy analyzed the publicly announced investments of 121 leading aerospace OEMs and service companies going back to 1990. Focused on the most active functions – engineering/research and development (R&D), manufacturing, and MRO – the study identified 497 major investments expanding one or more, including 283 joint ventures (JVs) and 214 organic investments (new facilities or business units). Since the objective was to

Figure 1: 1990 - 2009 Aerospace Investments



Source: AeroStrategy analysis. Note: 2009 data is for January - August.

pinpoint where investments were made to establish *new* capabilities, AeroStrategy excluded acquisitions, which tend to shift ownership of *existing* capabilities.

Several major findings emerge including:

- Functionally, MRO is the most popular investment category (45%), followed by manufacturing (36%) engineering/R&D (19%)
- Joint ventures were more popular than organic investments
- The pace of globalization is accelerating. In the early 1990s, fewer than five investments per year was the norm among the sample group. By 2008, it was 63!

Those are the facts. More important is an understanding of what drove the accelerated rate of investment for each major function, a topic explored next in some detail.

Engineering and R&D

Historically, the vast majority of engineering/R&D work was conducted "in-house" by OEM engineers at large research centers, mainly in North America and Europe. Outsourcing was typically limited to local "job shops" or design firms that absorbed peak engineering demand.

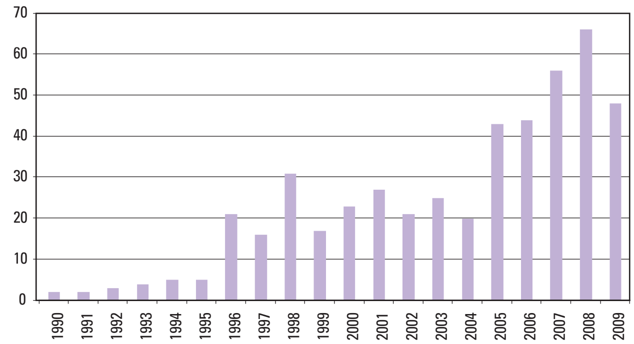
Several trends intersected in the 1990s to lay the foundation for new approaches to design and development. First was the maturation of digital design tools. The B777 was the first major air transport program developed digitally, without the use of prototypes. This heralded a new approach that segmented discrete tasks and bundled them into digital work packages. The build-out of the broadband infrastructure in the early 2000s enabled these packages to move around the globe, amplifying the potential for outsourcing and offshoring engineering. Finally, the end of the Cold War and the trade liberalization that followed dramatically expanded the talent pool for engineers, making skilled technicians accessible in Russia, Eastern Europe, India, China, and Latin America.

Boeing was one of the first OEMs to leverage these new circumstances when, in 1993, it established a small technical research center in Moscow employing 10 engineers. In 1998, Boeing expanded its presence by establishing the Engineering Design Center. Its first project: to redesign the B777's center bin arches. Today, Boeing employs approximately 2,000 engineers in Moscow, a facility that produced nearly one-third of the structural drawings for the 747 Large Cargo Freighter.

Honeywell has had a similar trajectory. In 1994, it founded a small outpost in Bangalore, India, starting with just six software engineers. Today, Bangalore is the headquarters of the Honeywell Technology Solutions Lab, with 5,500 employees and operations in India, China, Czech Republic, and the U.S. Bangalore is also home to GE's Jack Welch Technology Center, which employs 3,000 engineers. Further examples of engineering globalization abound, and they are not limited to major aircraft and engine OEMs. Eaton Aerospace and Rockwell Collins, for example, both operate engineering centers in India. And Spirit AeroSystems has an engineering services joint venture with Russia's United Aircraft Corporation called ProgressTech.

So, which locations were the most popular destinations for engineering investments? Understandably, Russia and India are among the most popular locations. After all, Russia has a superb aerospace engineering talent base, a legacy of the Cold War, and India is well-known for its engineers – particularly in software.

Figure 2: 1990 - 2009 Aerospace Investments



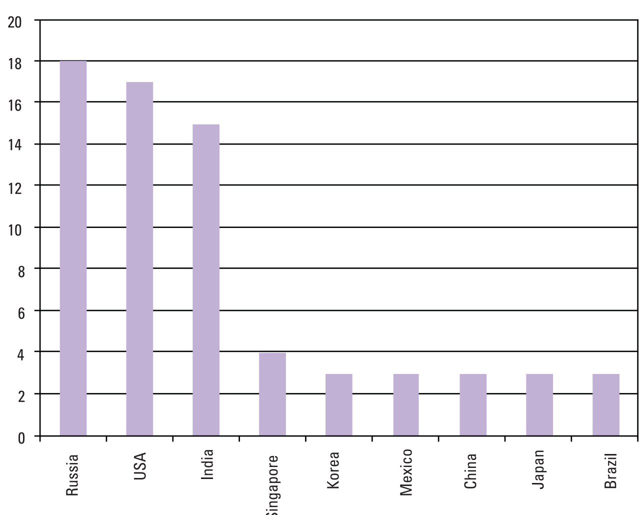
Source: AeroStrategy analysis. Note: 2009 data is for January - August.

Several trends intersected in the 1990s to enable new approaches to aircraft development

OEMs are seeking engineering talent pools wherever they exist

More surprising, the U.S. was the second most popular destination for engineering/R&D expansion, with many investments made by European firms. This underscores an important point: cost is not the only consideration. What drives engineering globalization *is more than just labor arbitrage*. OEMs also need to create better designs in shorter cycle times. The solution? Access engineering talent pools wherever they exist. EADS thus selected Wichita, the epicenter of business aviation, for its North American engineering center. Another tactic: tap engineering talent pools outside of aerospace. Consider recent investments in the state of Michigan, neither a low-cost location nor home to an aerospace cluster. In 2008, the Spanish aerostructures firm Aernnova opened an engineering center in Michigan with plans to employ up to 600. Aernnova's motivation was to leverage one of the world's largest concentrations of mechanical engineers courtesy of the faltering U.S. auto industry centered there.

Figure 3: Aerospace Investments - Engineering and R&D



Source: AeroStrategy analysis

Engineering services firms – key suppliers to OEMs – are also globalizing. North American and European suppliers such as Assystem, Belcan, and CDI have expanded their reach by establishing a global network of engineering centers. Moreover, they have demonstrated the capacity to handle sophisticated work packages that go well beyond traditional "job shop" contracts. Notably, Indian firms have become major engineering suppliers in a relatively short time, including Infosys, Infotech, HCL, Tata, and WIPRO.

With engineering becoming more globally integrated, how do firms deal with defense programs, which account for as much as half of all aerospace engineering work? Clearly military aerospace is not an open market – particularly with local content requirements and national security restrictions such as the U.S.'s International Traffic in Arms Regulations (ITAR) governing where engineering activities are performed and the nationality of those performing them. However, here again, firms are seeking talent pools in unconventional locations. Pratt & Whitney and Honeywell, for example, have engineering centers in Puerto Rico, a U.S. territory. And some engineering services firms are establishing low-cost domestic design centers in university towns like West Lafayette, Indiana (home of Purdue University).

Manufacturing

Manufacturing is the most visible manifestation of Globalization 2.0. Again, the motivation goes beyond mere cost savings to include enhanced market access, meeting offset obligations, and hedging currency risk.

The intersection of manufacturing globalization and a new Tier I supply chain model is likely accelerating the phenomenon. As Tier I suppliers take on responsibility for sourcing parts and components for their own systems, they themselves face "make-buy" decisions. Many are choosing to set up new facilities in low-cost locations.

Which country has garnered the most manufacturing investments? It is Mexico, a nation that, until recently, couldn't be found on the aerospace map. Why? Investors cite several reasons:

- Access to a low-cost, dependable, and skilled labor force, as evidenced by Mexico's strong record in the

automotive and consumer electronics industries
- Completion of the U.S.-Mexico bilateral aviation safety agreement, which lets manufacturers certify and ship components directly from Mexican factories
- Proximity to U.S. and Canadian aerospace supply chains, facilitating reliable, low-cost ground transportation
- Confidence in Mexico's willingness to protect intellectual property
- Mexico's elimination of duties for aeronautic components

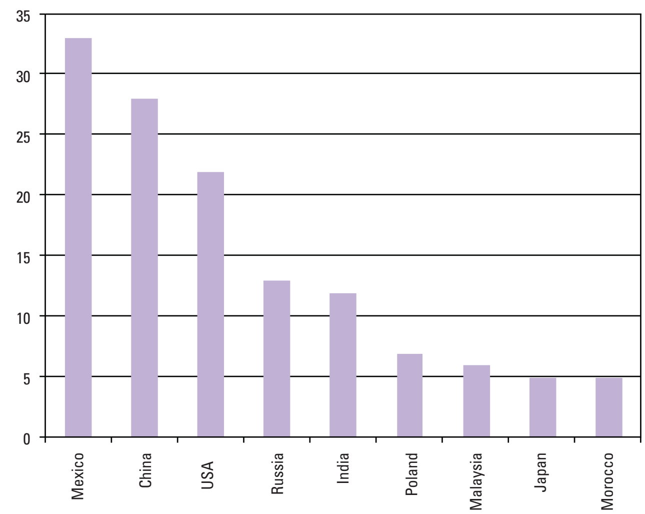
As a result, dozens of OEMs have invested in Mexico in recent years, and the country now has total aerospace employment in excess of 20,000, with exports of more than US$3 billion – a figure that will grow significantly in the years ahead. Aerospace investment in 2008 alone was US$1 billion. Most investments in Mexico go into wholly-owned facilities because its indigenous aerospace sector is modest, and there is only a limited roster of potential joint venture partners.

Not surprisingly, China is another popular location for manufacturing investment. Like Mexico, a key attraction is its large, low-cost labor force. But unlike Mexico, it has a broad aerospace supplier base, as well as aspirations to be a major aircraft producer in its own right. Perhaps the best known investment is the Airbus A320 production facility in Tianjin. Similarly, Embraer has set up an ERJ final assembly site in Harbin. Investment in China may be set to expand further with the creation of Commercial Aircraft Corporation of China (COMAC) to oversee development of the 150-seat commercial jet. Chinese government support for COMAC is strong and Western OEMs will be key suppliers. As OEMs seek to ensure market access, more investments, like Goodrich's recent JVs to produce landing gear and engine nacelle components with Xi'an Aircraft International, are sure to follow. However, a key concern for many Western OEMs in China remains adequate intellectual property protection.

Russia has succeeded in attracting niche manufacturing investment with some leveraging Russia's comparative advantage in aerospace raw materials such as titanium. A good example is Ural Boeing Manufacturing, a JV between Boeing and VSMPO-AVISMA intended to machine titanium forgings for B787s and Russian aircraft. Other investments, such as PowerJet (NPO Saturn/Snecma JV) are tied to the Superjet initiative.

Globalization 2.0 is already producing unlikely winners. Take Morocco. In the last decade the aerospace sector there has grown from near-zero to a US$250-million industry employing 7,000 people. Investors include EADS, SAFRAN, Boeing, and Zodiac. Morocco's attractions for Europe parallel those of Mexico relative to the U.S.: geographic proximity, historical ties to France, and low tariffs.

Figure 4: Aerospace Investments - Manufacturing



Source: AeroStrategy analysis

Mexico has garnered the most manufacturing investments

Maintenance, Repair, and Overhaul

Globalization 2.0 goes beyond the production and design of aircraft to their support. This isn't surprising. Aviation is global, with operators geographically dispersed.

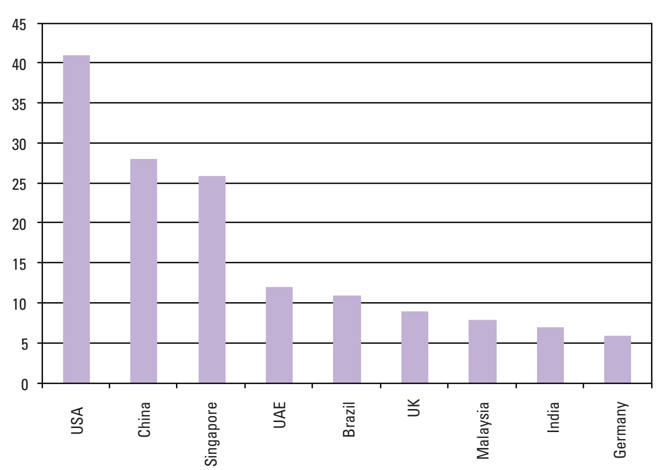
Today, the regions boasting fastest air traffic growth – Asia-Pacific, Middle East, and Latin America – are where maintenance and customer support

Globalization 2.0 is producing some unlikely winners

infrastructure is the thinnest. As a result, OEMs and MROs have ramped up their investment in maintenance and service parts distribution centers to create customer support networks that are truly global. A good example is Bombardier's recent investments in spare parts depots in Montreal, Beijing, Sydney, Singapore, Dubai, and São Paulo to complement its primary distribution facilities in Chicago and Frankfurt.

Two of the most popular countries for MRO investments are Singapore and China – but for different reasons. Singapore became a regional MRO and logistics hub by leveraging its business-friendly environment and highly trained work force to capture a large number of technology-intensive maintenance centers and service parts distribution centers. China, in contrast, has attracted investment for labor

Figure 5: Aerospace Investments - MRO



Source: AeroStrategy analysis

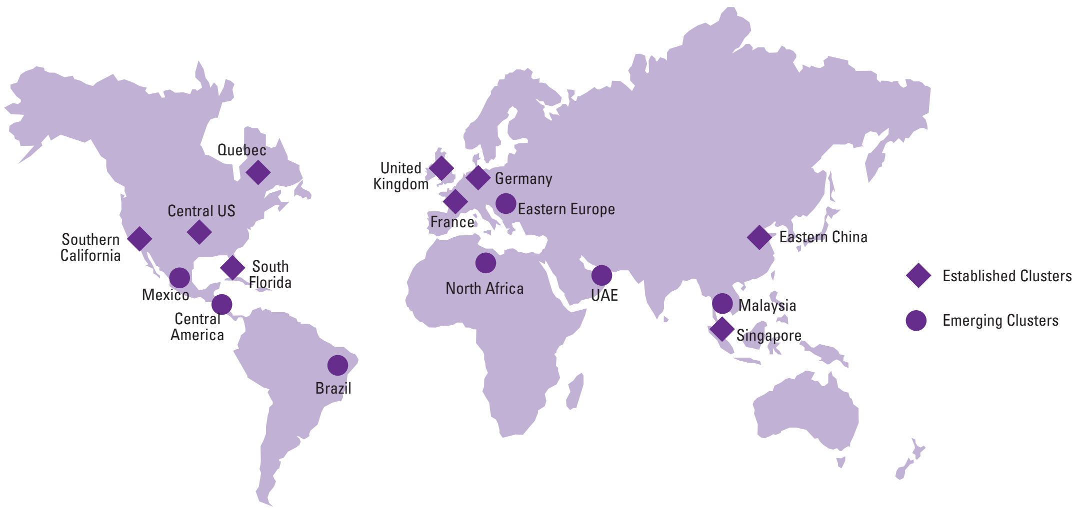
intensive activities, such as airframe heavy maintenance, as well as for distribution centers principally because of the burgeoning Chinese market. Investors in airframe heavy maintenance facilities include well-known suppliers Ameco Beijing, STARCO, TAECO, and Boeing Shanghai Aviation. To this, one can add the veritable Who's Who of civil aerospace OEMs that have already established a presence in China to service its booming fleet.

Equally interesting is the U.S. position as the leading location for MRO investments. This is largely due to the significant build-out of business aviation MRO infrastructure during the booming 1990s and 2000s, driven by the 70% of the business jet fleet that resides there. Investment by European firms is another factor. One example is TAESL, an engine overhaul JV between Rolls-Royce and American Airlines.

The United Arab Emirates, fourth on the list, is arguably the biggest surprise. Why the lofty ranking for a country of less than five million people? First is the nation's aim of becoming a global air transport hub – Dubai International Airport is now the sixth busiest in the world for international traffic – and the consequent growth of airline fleets such as Emirates. A second factor is the active role of UAE governments in establishing an in-country aerospace cluster. A well-known initiative is Dubai Aerospace Enterprise, launched in 2006, that comprises maintenance, manufacturing, leasing, and infrastructure businesses. More recently, Abu Dhabi's Mubadala has come to the fore, completing several high-profile JVs/investments. The combination of growth and government support has attracted investments by Bombardier, B/E Aerospace, GE, Goodrich, Jet Aviation, Rolls-Royce, Sikorsky, and Thales.

These and other investments are creating new MRO hubs that are literally changing the landscape of the aerospace maintenance infrastructure. Brazil, Mexico, and Central America are attracting investments for labor intensive activities such as airframe heavy maintenance that complement existing MRO clusters in Southern California, the Central U.S., South Florida, and Quebec. And in Europe, the Middle East, and Africa, a similar pattern holds, with North Africa and Eastern Europe attracting investment for labor intensive activities.

Figure 6: Global Aerospace MRO Clusters



Source: AeroStrategy analysis

Stakeholder Implications

The ramifications of Globalization 2.0, both challenges and opportunities, are fundamental and wide-reaching for governments and firms.

For OEMs, processes and organizational architectures for development and production are forever changed. The era of horizontal specialization, in which firms tightly integrate engineering, manufacturing and customer support across multiple locations, has arrived and firms must adapt. They must take stock of how Globalization 2.0 supports or disrupts current business strategies. Consider, as Pankaj Ghemat points out in his excellent book *Redefining Global Strategy*, the three broad motives for globalizing: arbitrage, aggregation, and adaptation.

Arbitrage is the one of the prime motivators for Globalization 2.0, labor costs especially. Embraer has leveraged its competitive advantage in labor to become a leading regional and business jet OEM in a relatively short time – an act China's COMAC hopes to emulate in the 150-seat segment. But the popularity of R&D centers in high-cost regions shows that arbitrage is about more than exploiting labor cost differences – it is about leveraging global talent pools. The much decried engineering talent shortage may thus be overblown. In the words of a major OEM's chief engineer, "We don't see the shortage of engineers that others do because we view the entire globe, not just our home country, as our recruitment pool."

Aggregation – overcoming differences among countries by grouping them based on similarities – is a second globalizing stimulus. A growing number of aerospace firms view the market through the prism of broad regional groupings such as North America and Asia-Pacific. Sophisticated regional supply chains are emerging that see manufacturing as ecosystems that span the full range of processes, from raw material mills to final assembly. SAFRAN, for example, has established a North American organization to support its drive for a greater share of U.S. defense and security spending. It now employs more than 9,000 in 35 companies spanning the U.S., Canada, and Mexico. Aggregation has also proved useful in aircraft support, encouraging OEMs and MROs to establish regional service parts and customer support centers. Most customers prefer to deal with in-region suppliers rather than calling "headquarters" many time zones away.

The ramifications of Globalization 2.0 are fundamental and wide-reaching for governments and firms

Finally, *Adaptation* – adjusting to differences across countries – is especially true in military markets where unique mission requirements, communications protocols, and sustainment requirements mandate that some country-specific customization is required. Witness the success of BAE Systems in penetrating the U.S. defense electronics market.

Regardless of which "A" firms choose to emphasize, the overarching objective of globalization is clear: to improve productivity or expand market access while enhancing core competencies and protecting key intellectual property.

For governments, the effects of Globalization 2.0, including the global dispersement of aerospace capabilities, are far-reaching. Governments from developed economies face the jeopardy of new national competitors and the loss of high value jobs, while emerging economies enjoy fresh opportunities to raise their aerospace profile. Behold the rise of Mexico and China, two countries rarely considered for aerospace investment just a decade ago!

Governments must honestly appraise their comparative advantages in a new light. Singapore, for example, foresaw the erosion of labor cost advantage and developed a national strategy to move into higher value added activities. It has, as a result, become a hotbed for capital intensive MRO and a prime destination for R&D centers. And it will host the first Western OEM (Rolls-Royce) civil aeroengine production facility in Asia.

It behooves governments to develop national aerospace strategies that create or leverage genuine competitive differentiation. Which segments or value chain activities should be emphasized, and what is the "national value proposition" for potential investors? Answering these questions will drive governments to think in terms of cluster strategies that embrace the input of aerospace firms and industry associations. However, governments must remember that clusters are not created by propping up national champions or subsidies; they are created by establishing the most viable "ecology" for an aerospace ecosystem to emerge.

The challenge of updating national aerospace strategies will be particularly vexing for developed economies in North America and Europe that have long enjoyed aerospace dominance and positive trade balances. While large OEM clusters and military procurement budgets should sustain vibrant aerospace activity, the siren song of protectionism is likely to gain favor in some countries. Witness the recent legislation working its way through the U.S. Congress that could limit airline access to non-U.S. repair stations.

Reviewing all of the evidence, the aerospace industry is becoming more integrated and competitive as a result of the Globalization 2.0 phenomenon. Aerospace industry stakeholders, take note. Plot a new trajectory and strap yourself in.

AeroStrategy is a management consulting firm, specializing in strategy and market analysis for the aviation and aerospace industries. We value your feedback and welcome your letters and comments on any aspect of this AeroStrategy commentary.

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