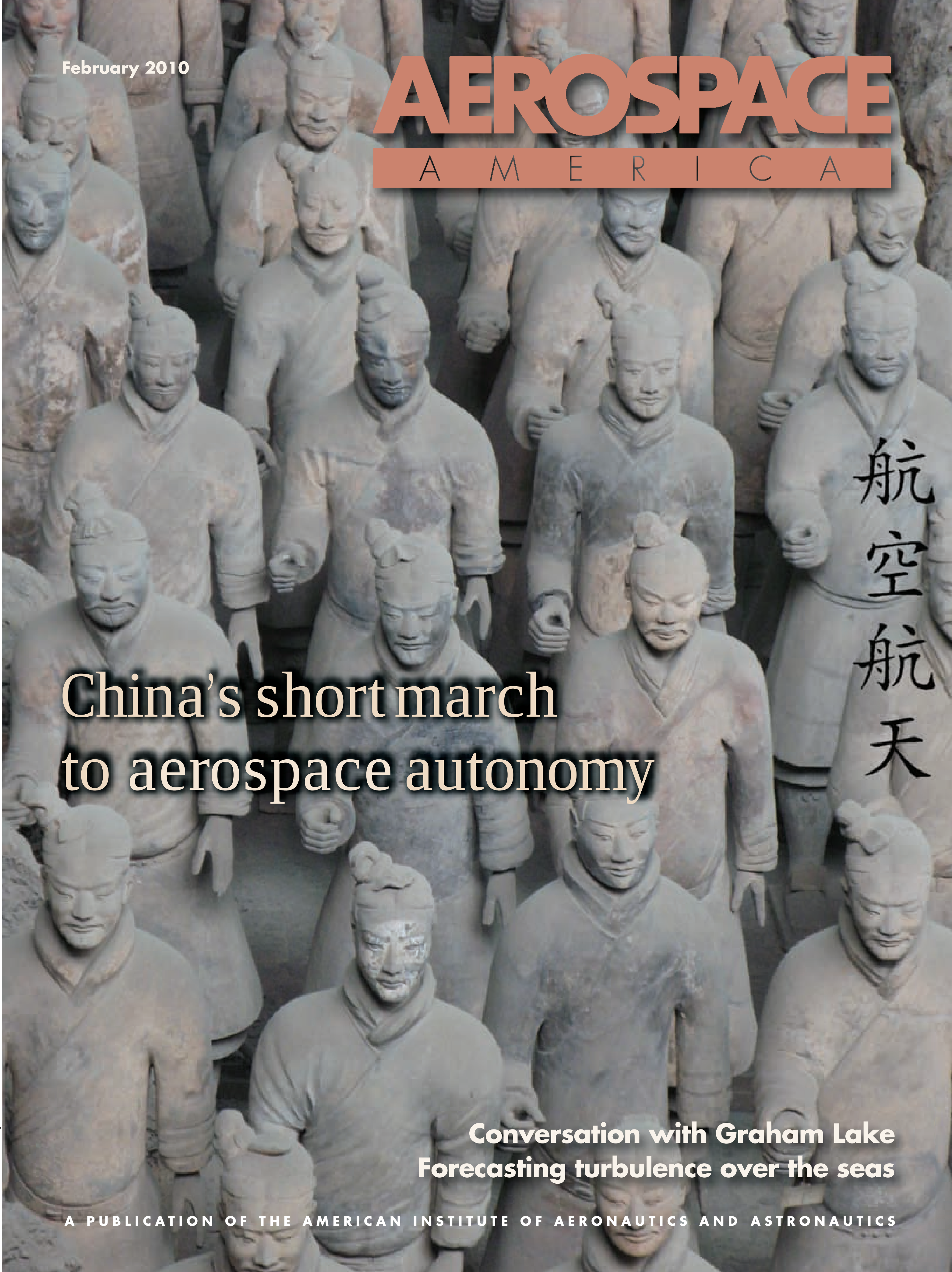

February 2010

AEROSPACE AMERICA

航空航天

China's short march to aerospace autonomy

Conversation with Graham Lake

Forecasting turbulence over the seas

A PUBLICATION OF THE AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS

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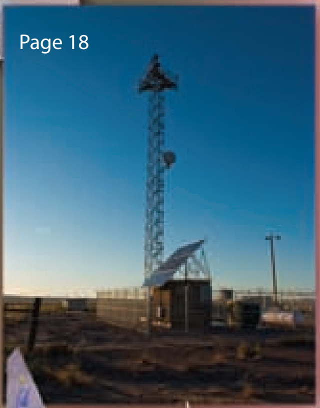

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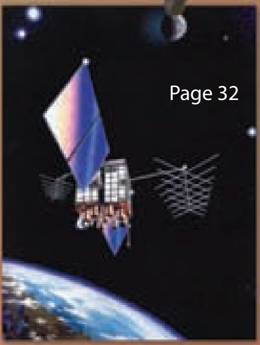

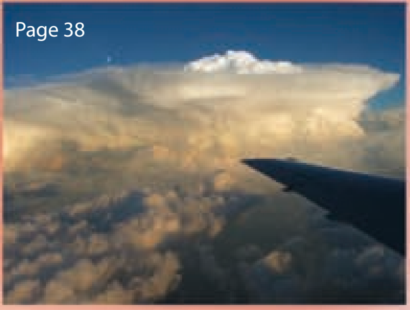

COVER
China is well on its way to becoming a significant player in the aerospace arena. Turn to page 24 to learn about their remarkable strides. Cover image: Xi'an Terra Cotta Warriors, dating from 210 B.C.

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Send Letters to the Editor to Elaine Camhi at the same address or elainec@aiaa.org

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AIAA
American Institute of Aeronautics and Astronautics

Commentary

Space debris: Turning goals into practice

We are discovering that developing space debris mitigation goals was far easier than achieving them.

The Inter-Agency Space Debris Coordination Committee is an international governmental forum for the coordination of activities related to issues of man-made and natural debris in space. IADC space debris mitigation guidelines are the benchmark for preserving the space environment and assuring safe space operations. They have been incorporated into agency regulations, commercial contracts and even laws. They may be costly and difficult to realize, but we must pursue them enthusiastically.

Removing objects from the LEO protected region within 25 years from end of mission is an example of the challenges. Orbit lifetime estimates are extremely imprecise—since atmospheric drag is the major perturbing force, estimated lifetime depends strongly on the variable composition and density of the atmosphere, the changing attitude of the satellite relative to the direction of motion and the change in mass as propellants are expended or exhausted.

These estimates also depend on when the lifetime is estimated. Deorbit during periods of high solar activity is easier than during periods of low solar activity. Extended launch delays may invalidate orbit lifetime estimates. Conservative designs based on periods of lower atmospheric density might diminish payload unnecessarily if the mission ends during high solar activity. Optimistic designs based on periods of high atmospheric density may not have sufficient stored energy for safe disposal.

In addition, orbit lifetime estimates are not testable or verifiable. The sample size may never be sufficient to correlate confidently actual lifetime with estimates. What must the reliability of disposal systems be, and what is the energy cost of incorporating exquisitely reliable disposal systems?

The real threat posed by a mission-ended spacecraft also depends on the actual orbit. What would the sanctions be for not adhering to the guideline? Could those who ignore the guideline be prevented from launching? Would anyone be willing to deorbit an offending spacecraft uncooperatively? How can we assure that the 25-year guideline has been met, and what can we do if it is not? Or, is 25 years not the best criterion, and should it be discarded?

Disposal from geostationary orbit has similar issues. Drag is insignificant, but the effect of solar radiation is variable, depending on solar cycles, satellite attitude and surface emissivity and absorptivity, which also vary.

Removing spent boosters from geostationary transfer orbits presents another dilemma. These orbits cross both the LEO and GEO protected regions. They also may require a long time to change favorably. Passivation guidelines compete with disposal guidelines if sufficient energy is to be available for deorbit. Boosters generally do not have enduring electrical systems, so the time required for deorbit may exceed battery life. With roughly a 100:1 penalty for each additional unit of mass in orbit, disposal mechanisms might compromise payload mass unacceptably.

Several IADC guidelines engender these technical and operational issues. Industry and governments must address them. IADC should consider them and either modify the guidelines or suggest how they might be achieved with acceptable mission and lifetime burdens. Preserving the near Earth environment for mutual benefit requires mutual sacrifice.

David Finkleman
CSSI

Changing aerospace cluster dynamics

WHAT IS THE BEST PLACE IN THE WORLD TO start up a new aerospace manufacturing business?

Over the past 100 years the global aerospace manufacturing industry has tended to develop around a few cities—Wichita, Montreal, Seattle and Toulouse, for example—that have become hubs for a growing number of suppliers and related businesses.

The process of "cluster" developments is now well documented. From Detroit to Silicon Valley, the dynamics of why and how similar or competitive businesses choose to work next to each other have been analyzed in depth. Most clusters originally formed around a key organization that through its industry importance—as a major integrator or international airport—has provided a central magnetic pole of attraction. In more recent years other factors have increased the attractiveness of clusters. The development of research institutions, generous local and national government grants, the availability of a specialized workforce and just-in-time production manufacturing techniques have all played their part in concentrating aerospace manufacturing in a few regions of the world.

Michael Porter of Harvard University has created one of the most important recent analyses of cluster activity. He categorized such activity into four types: geographic (a concentration of different businesses in a single region), sectoral (a concentration of businesses working in the same sector), horizontal (the development of connections, such as shared IT networks, between businesses) and vertical (businesses at different levels in the supply chain).

But over the past few years the dynamics of traditional aerospace cluster activities have started to change.

There are new entrants to the market. The development of new aerospace businesses in China, Vietnam, Brazil, Mexico and, most recently, the United Arab Emirates has opened up new options for companies looking to grow their businesses. And some of the opportunities offered by companies in countries where aerospace is expanding rapidly will be greater than those offered by relocating around traditional clusters.

Christian Ketels

In addition, traditional clusters themselves have also started to change, no longer looking inward toward key customers but increasingly developing links with clusters in other parts of the world.

A new trend?

So are we seeing a change in the way clusters are developing? Are the days of traditional regional aerospace centers numbered, or is increasing globalization going to underline their importance?

"I think both," says John Copely, head of Farnborough Aerospace Consortium (FAC), a cluster of aerospace manufacturers in the southeast of the U.K. The FAC is typical of the many European clusters that are rapidly building links to new aerospace markets in the Middle East and Far East.

"Our office in Dubai is particularly important for us," notes Copely, "especially for small and medium enterprises looking to gain access to new markets. They typically use the office for a year or so before building up enough experience of the market. Clusters have always been about relationships, and what we are seeing is the evolution of the supply chain to a more international marketplace."

If cluster dynamics are following the global supply chain, then we should soon see this reflected in the way traditional sectoral clusters of North America and Europe work.

What this means, in very broad terms, is that traditional clusters in North America and Europe will do less manufacturing and concentrate more on developing high-end integration and high-technology skills, outsourcing the labor-intensive manufacturing work to clusters in low-wage economies.

This is exactly what seems to be happening. The key to transforming manufacturing clusters in North America and Europe to centers of aerospace excellence is access to innovation skills—corporate and academic. There is a new imperative for traditional manufacturing clusters to attract companies skilled in design and engineering, rapid prototyping, software development, part manufacturing, testing and research capabilities.

The government difference

In Europe the transformation process has been accelerated by government initiatives. The French government, for example, recognized the Aerospace Valley of Aquitaine and Midi-Pyrénées regions as a "global innovative cluster" in July 2005, and since then 212 partnership projects have been launched, including

Nikos Pantalos

143 projects financed for an overall budget of €450 million and public support of over €200 million.

The Aviation Cluster of the Hamburg Metropolitan Area launched the European Aerospace Cluster Partnership (EACP) in May 2009, a network of skills cooperation by a large number of European aerospace clusters.

According to Christian Ketels from the Institute for Strategy and Competitiveness at the Harvard Business School, "The dispersion of Europe's aerospace industry across many locations has often been brandished as a key competitive disadvantage versus the industry's global rivals. While consolidation in fewer strong clusters remains crucial, Europe's economic fundamentals will continue to result in more aerospace clusters than elsewhere. The collaboration across these clusters is crucial to turn this combination of different capabilities and assets across Europe into a competitive advantage, and reduce the costs of the geographic distance between them."

European hubs

Aerospace manufacturing in Europe is concentrated in a few key areas. Around 90% of Poland's aerospace manufacturing industry is in the country's Aviation Valley in southeast Poland, with more than 22,000 aerospace employees. In the U.K., over 60% of all aircraft manufacturing takes place in the northwest of the country. In France the Aerospace Valley of Aquitaine and Midi-Pyrénées is responsible for one-third of the country's aerospace turnover, employing over 100,000 people in 1,300 companies.

These clusters already have an intricate web of networked partnerships. The Hungarian Aerospace Cluster and the Hamburg-based Hanse-Aerospace Cluster are cooperating on joint research into cabin systems development projects. The Polish Mazovia cluster of small and medium-sized enterprises (SMEs) has begun talks with Germany's Berlin-Brandenburg Aerospace Alliance on UAV and VTOL UAV programs.

Increasingly important are the growing networks of alliances between industrial clusters and research/academic organizations. The Hamburg/Northern Germany and French Aerospace Valley clusters have an agreement to further educational links, exchange trainees and develop joint degree studies.


John Copley

Such links with academia will become particularly important if companies are to access the new skills required in the coming years and influence universities to prioritize the syllabus so new graduates understand the needs of the market when they qualify. "This has traditionally been a fairly slow process," says the FAC's Copely.

Market demand and new niches

In Europe there tend to be two major types of clusters. There are traditional large groups of companies transforming legacy manufacturing centers into "innovation" regions. But there are smaller clusters as well, many in central and eastern Europe, building toward a niche position within the global aerospace supply chain as a result of market demand rather than the incentives provided by local or national governments.

The EACP will develop new links between European aerospace clusters and has been partly funded by the European Commission—in recognition of the need to develop SMEs through cluster initiatives.

According to Nikos Pantalos, senior level policy officer of the European Commission: "Clusters are recognized as promising platforms for promoting innovation and strengthening the competitiveness of firms, especially of SMEs, to better face the global competition and create more jobs and companies in the EU. Many cluster initiatives have been developed at national and regional levels to support clusters, but there is a need for striving for more excellence and cooperation at the EU level in order to develop more world-class clusters in EU countries."

While European and North American clusters are developing new skills and new "virtual" cluster links with groups of companies in other parts of the world, there is a new generation of manufacturing clusters developing in low-wage economies to handle some of the manufacturing work no longer undertaken by U.S. and European companies. But these are very different from the traditional clusters developed in Europe and North America, and their dynamics are very different.

For example, according to the Mexican aerospace industry trade association FEMIA, aerospace industry exports will reach $6 billion by the end of 2012. Mexico has developed its aerospace manufacturing activities through a series of clusters located mainly in the Mexicali-Tecate-Tijuana corridor and Baja, Calif. But unlike traditional North American and European clusters these do not have central airframer companies acting as an attracting force around which smaller companies gather. There are plans for Cessna, Bombardier, Bell and MD Helicopters to assemble complete airframes in the country, but none has done so yet.

Brazil, which does very well in exporting complete airframes, has concentrated its aerospace sector in the city of São José dos Campos, in São Paulo State. But with Embraer, the country's largest aerospace company, importing around 95% of its aircraft systems, structures and components from outside the country, the size of the São José dos Campos cluster is much smaller than an equivalent operation would be in Canada, the U.S. or Europe.

Malaysia's government has identified complex composite structures as the main driver for its aerospace industry and a "sectoral" cluster developing around this area of expertise. Composites Technology Research Malaysia was

(Continued on page 9)

Crouching tiger, puffing dragon

The year 2009 seemed filled with glory for China: U.S. President Barack Obama's official visit to Beijing, the 60th anniversary of the PRC's founding, plans emerging to put a man on the Moon, and new fighter jets on the drawing board. Politics and anniversaries aside, whether or not the pace of China's technological advances has increased dramatically in the past few months, or whether people outside—particularly in the U.S.—have been paying more attention, there is no denying that China seems to be on a roll in terms of furthering its aerospace capabilities.

After becoming the third nation to put a man in space, having done so in 2003, China now appears intent on landing one on the Moon by 2020, possibly before the U.S. is able to return there. And the deputy air force chief, Gen. He Weirong, says a fighter equivalent to the Lockheed Martin F-22 should enter service by 2017-2019, somewhat ahead of the prediction by U.S. Defense Secretary Robert Gates in July that China would not have such an aircraft before 2020.

But all is not completely as it seems in this developing picture of China catching up with technology, flexing its political muscles on the world stage and in just about every respect seeking to portray itself as the new superpower. In like manner, all is not as it seems with the image of the U.S., as perceived from the outside, as riddled with angst about its technological capability and with worry about threats to its dominant position as the leading world power.

Reexamining predictions

It is interesting to reread a study written by Adam Segal and Maurice R. Greenberg, senior fellow for China studies at the Council on Foreign Relations, and published in 2004 in the New York-based independent *Foreign Affairs* magazine. Segal's position was that longstanding U.S. supremacy in technology could no longer be taken for granted as Asian nations including China ramped up spending on R&D and emphasized scientific and technological training.


On October 15, 2003, a Long March 2F launched Shenzhou 5, China's first manned spaceflight.

Pointing to the need for funding in research, Segal said: "A record $422-billion budget deficit, for example, may undermine future government support for R&D. Recent shifts in federal spending will leave basic research—that driven by scientific curiosity rather than specific commercial applications—underfunded, depriving the economy of the building blocks of future innovation."

Since then, of course, the U.S. national debt has ballooned to $8.8 trillion in 2009 and is forecast to rise to $17.4 trillion by 2017, said Alice Rivlin, former vice chair of the Federal Reserve Board and founding director of the Congressional Budget Office, in December. Ironically, much of the budget deficit has been funded by China, seeking a use for the proceeds of the massive trade surplus it has with the U.S.

The implications for aerospace and for science and engineering in general, in what is often perceived as a two-horse race between the U.S. and China, are obvious. As Segal's study said: "Above all, [the U.S.] must not assume that future innovation will occur automatically. Only through renewed attention to science funding, educational reform, the health of labor and capital markets, and the vitality of the business environment can the United States maintain its edge—and the most innovative economy in the world."

A Potemkin economy?

But at the same time, it is necessary to bear in mind that cultural differences play a major role in how the state of play in both the Chinese and U.S. technological worlds is presented. Russia's infamous Potemkin villages come to mind: These were facades of street fronts and entire pasteboard villages supposedly built and peopled by imported peasants in 1787 to impress Empress Catherine the Great and to hide depressed living conditions when she toured the Ukraine and Crimea by river. The U.S. has a recession-damaged economy that is open to public inspection; China has an economy that is whatever officials declare it to be, much of it out of sight of foreign researchers.

In short, the situation of the U.S. with regard to technological innovation, though it could be far better, is not as bad as it looks, and China's may not be as good as it looks.

It is also necessary to remember that the sort of questioning, self-examination and criticism of and about officialdom that happens regularly in the U.S. takes place freely and openly, while in China such a process can be conducted only behind firmly closed doors.

Comparing students' skills

Shifting forward in time, there was a warning in February 2009 about the quality of scientific education in both China and the U.S. contained in a study published in *Science Daily*, a Maryland-based Internet Web site that presents news about science in general. The study looked at skill levels among nearly 6,000 freshmen at three U.S. and four Chinese universities, and found that while Chinese students were way ahead in knowledge of science facts, both nationalities were roughly equal in terms of reasoning ability—but both scored poorly considering that the students expected to major in science or engineering.

Associate professor of physics at Ohio State University Lei Bao, lead author of the study, said: "Our study shows that, contrary to what many people would expect, even when students are rigorously taught the facts, they don't necessarily develop the reasoning skills they need to succeed. Because students need both knowledge and reasoning, we need to explore teaching methods that target both."

Again, cultural differences come into play. A book published in 2009 by Cambridge University Press, *China's Emerging Technological Edge (Assessing the Role of High-End Talent)*, makes the point that comparisons of U.S. and Chinese education systems inevitably match apples against oranges because of different classification terminology. In short, counting how many doctoral degrees are issued (more to foreign students than to locals in the U.S.) and showing that enrollment in science and engineering courses in China has risen at 20% a year since 1999 is "Chicken Little" analysis: "The sky is falling."

Cao Jianlin

The authors of the book are Denis Fred Simon, professor of international affairs and director of the Program on U.S.-China Technology, Economic and Business Relations at Pennsylvania State University, and Cong Cao, senior research associate at the Neil D. Levin Graduate Institute of International Relations and Commerce, State University of New York. Their analysis shows that China's cadre of scientists and engineers is far from overflowing with top people, and that the situation is going to get worse. The major problem, they say, is quality—scientists and engineers there may be, but the good ones are spread very thin.

The result is what has been fairly well known about China for years: There are pools of excellence dotted around the country, but little depth of knowledge, and the upcoming retirement bulge can only worsen the problem.

Sending Chinese students to universities in the U.S. or elsewhere overseas is a double-edged sword for Beijing. As Simon and Cao point out, a significant number of these students remain abroad—the best and the brightest, taking advantage of better earning power, opportunities and freedoms outside China. So the effect is a downgrading of the talent pool at home. Also, while the numbers leaving or returning home have fluctuated in response to various events, such as the Tiananmen Square massacre in Beijing in June 1989, visa restrictions in the U.S. after September 11, 2001, the collapse of the dotcom bubble and the recession in Silicon Valley, the result is a net (though unquantified) brain drain.

Qian Xuesen

At home in China, say Simon and Cao, "the curriculum inside many fields tends to be narrow, covering only the specific area of study. As a result, Chinese universities have become technique focused....Rote learning, in which students who can answer questions in classrooms may not be able to solve and manage real-life problems, still dominates higher education....Creative thinking, entrepreneurship, interpersonal and intercultural skills, among others, have not been part of the pedagogy or curriculum, even at key institutions."

Official acknowledgment

Such thoughts were behind comments made by the "Father of Chinese Rocketry," Qian Xuesen, shortly before he died in October 2009 at the age of 98. In the official Beijing Xinhua news agency obituary, Qian was referred to as an "excellent member of the Communist Party," which he joined in 1959 after being deported from the U.S., where he lived from 1935 to 1955. Qian studied in the U.S. and rose to high positions within the U.S. military's scientific establishment, becoming an expert in rocketry. He was arrested in 1950 on suspicions that he had communist sympathies, and was unsuccessful in attempting to stay in the U.S.

Chinese liberal intellectual Yang Hengjun said to Xinhua in an interview that Qian had harbored critical views on the future of education in China, which he expressed to Premier Wen Jiabao, who visited Qian while his health was failing.

"Qian Xuesen's words were harsh—he told Wen that Chinese universities could not raise first-class scientists....The reason, as we all know, is that our universities are auxiliaries to the political system, and they are heavily influenced by the political system," Yang said. "Qian Xuesen had always been meek to the authorities, but he finally asked a big question."

That these comments were published by the government's own agency illustrates official awareness of and anxiety about the situation.

Security concerns

International cooperation in technology and education is fine, but can be limited by major differences in the approach to technology and its uses, brought about by security concerns. A report from the American Association for the Advancement of Science (AAAS) in April 2009 on its conference marking 30 years of cooperation in science and technology between the U.S. and China, said that China's vice minister for science and technology, Cao Jianlin, and the U.S. speakers "cited concerns over dual-use policies that limit export of technology that may be intended for civilian purposes but which could have military uses.

"According to the U.S. speakers, Congress has been strongly suspicious of efforts to share information and hardware with China and other nations—but that is short-sighted and self-defeating, they said."

AAAS is not the only learned body that is complaining. In January 2009, a report from the National Research Council said: "Many U.S. export and visa controls, developed during the Cold War era to prevent the transfer of technological and scientific advances to our enemies, now harm U.S. national security and economic prosperity. The current regulations were designed for a world that no longer exists and are unsuitable for today's adversaries. Immediate executive action is needed to restructure this system to prevent further declines in U.S. scientific and technological competitiveness."

Without such a change, and without a greater appreciation of the cultural differences between an open U.S. culture (even with public relations "spin") and a Chinese culture that, even after considerable opening up is still far from having the same level of access to information or the same manner of interpretation of data, clashes of interpretation will remain inevitable.

It has often been said by foreigners that, when working for Western companies in China, local engineers want to try to run before they have learned how to walk. The other side of that coin is the comment made in Simon and Cao's book—specifically about ethnic Chinese brought up overseas, but equally applicable to many foreign managers or other "experts"—that "they don't know what they don't know, and they don't know how much they don't know" about living in the local culture. The comment, of course, can be aimed in both directions.

The ethos that encourages individualism, and at times demands tough introspection in the West in general and in the U.S. in particular, needs considerably more time to evolve in China, where the tendency is to follow a leader without question and not take risks in thinking too far outside the box.

That evolution must run the gamut from technical and scientific education to international standards, project management, and the creation by scientists and engineers of "invisible colleges" (to use Simon and Cao's term) of colleagues and peer group members outside their immediate work circles with whom they can exchange ideas and from whom they can seek inspiration when problem solving.

Other Asian centers of industry such as South Korea, Taiwan and Singapore have, to a greater or lesser extent, undergone just such a transition in their thinking and their education systems, while still retaining local characteristics. Without such an evolution, and considerable patience from actual and potential U.S. and other partners with China, the continuing development of the relationship is inevitably going to suffer from the complexities of trying to guess real motives and establish what is truly happening on both sides of the Pacific.

Michael Westlake
michael_westlake@yahoo.com

(Continued from page 5)

established by the government in 1990 and has developed to include Airbus, Boeing and Goodrich as major customers. Since then, other composite manufacturers have also been attracted to Malaysia: Asian Composites Manufacturing, a joint venture by Sime Darby Berhad and Naluri Berhad of Malaysia and Boeing and Hexcel of the U.S., set up shop in 2001, and Spirit AeroSystems Malaysia opened a composite facility in 2009, supplying structures principally to the Airbus single-aisle aircraft.

It is hard to identify any region in Europe or North America that has concentrated so heavily on a single manufacturing sector such as composite structures, to the exclusion of almost every other subsector.

Asian centers

Japanese companies, meanwhile, have begun an aerospace manufacturing cluster in Hanoi, Vietnam, with both Mitsubishi Heavy Industries and Nikkiso recently setting up manufacturing plants in the capital.

China's aerospace manufacturing industries are distributed throughout the country, with major civil aircraft clusters in Harbin and Shanghai. In late 2008 the Chinese government announced the remerger of AVIC I and AVIC II, which had separated in 1999.

Under the new structure, civil aircraft manufacturing has been centralized in Shanghai with the development of Commercial Aircraft Corporation of China to manage the C919 190-seat airliner and ARJ-21 regional jet. An AVIC helicopter company has been set up in Tianjin.

But most of the other aerospace activities have been brought back to Beijing. A defense branch has been set up in the capital to develop new capabilities in areas such as unmanned air systems and to export J-10, JF-15 and L-15 Falcon military jets. A new engine company has been established in an aerospace cluster zone near Beijing Capital International Airport, and an airborne systems division has been set up in the Zhongguancun Aviation Science Park of Haidian district, in northwest Beijing.

This reformation of aerospace clusters suggests that companies based in Shanghai and Tianjin will be fully integrated within the global supply chain, while the Beijing-based defense, airborne systems and engine companies will oversee the development of primarily indigenous capabilities.

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It is clear that the dynamics of aerospace cluster developments in both Europe and North America are changing. The process will most probably accelerate as companies seek to become increasingly more efficient at accessing new sources of innovative technologies in their domestic markets—and low-labor wage rates elsewhere.

Philip Butterworth-Hayes
phayes@mistral.co.uk

Events Calendar

FEB. 2-4 U.S. Air Force T&E Days, Nashville, Tennessee
Contact: 703/264-7500

FEB. 10-11
Thirteenth Annual FAA Commercial Space Transportation Conference, Arlington, Virginia
Contact: 703/264-7500

FEB. 14-18
Twentieth AAS/AIAA Space Flight Mechanics Meeting, San Diego, California
Contact: A. Trask, trask@apogeeintegration.com

FEB. 23-26
Space, Propulsion & Energy Sciences International Forum, Laurel, Maryland
Contact: Glen Robertson, 256/694-7941; gar@ias-spes.org

MARCH 6-13
2010 IEEE Aerospace Conference, Big Sky, Montana
Contact: David Woerner, 818/726-8228

MARCH 16-17
Congressional Visits Day, Washington, D.C.
Contact: 703/264-7500

MARCH 22-24
Eighth U.S. Missile Defense Conference and Exhibit, Washington, D.C.
Contact: 703/264-7500

MARCH 22-24
Forty-fifth 3AF Symposium of Applied Aerodynamics, Marseilles, France
Contact: Anne Venables, secr.exec@aaaf.asso.fr

APRIL 12-15
Fifty-first AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference; 18th AIAA/ASME/AHS Adaptive Structures Conference; 12th AIAA Nondeterministic Approaches Conference; 11th AIAA Gossamer Systems Forum; Sixth AIAA Multidisciplinary Design Optimization Specialist Conference. Orlando, Florida
Contact: 703/264-7500

APRIL 20-22
AIAA Infotech@Aerospace 2010, Atlanta, Georgia
Contact: 703/264-7500

APRIL 25-30
SpaceOps 2010 Conference: Delivering on the Dream (hosted by NASA Marshall and organized by AIAA), Huntsville, Alabama
Contact: 703/264-7500

Some answers, but still some questions

As winter arrived in Washington, the defense appropriations bill was signed, while questions about NASA's future human spaceflight program remained unanswered, and divergent plans for a new light combat aircraft began to emerge.

Defense budget ayes and nays

Largely unnoticed by press and public, on December 19 the Senate approved and President Barack Obama later signed the $636.3-billion FY10 defense appropriations law.

Almost three months late—Congress is rarely punctual in fulfilling this core responsibility—the bill contains provisions the administration wanted—and some it did not. The legislation is a success for Defense Secretary Robert Gates' effort to halt production of the F-22 Raptor superfighter at 187 airframes, to kill a combat search and rescue helicopter for the Air Force and to postpone developmental work on the next-generation bomber.

Because it puts an end to, or postpones, several big-ticket acquisition programs, critics say the bill is gutting the Air Force and widening a "fighter gap" that looms as a handicap to U.S. airpower in the coming decade. Yet when adjusted for inflation and added to expected supplemental legislation to cover an increase of 30,000 troops in Afghanistan, U.S. defense spending in FY10 rises to a level not reached since WW II. And it is rising at a time when a $1.4-trillion federal deficit is predicted for FY10 alone.

Among items the administration did not want are 10 C-17 Globemaster III airlifters for the Air Force. Gates says the

The defense bill will enable the Marines to operate five VH-71s.

The defense budget calls for 10 C-17s, which the Air Force, the DOD and the administration do not want.

Air Force does not need more C-17s, as does Air Force chief of staff Gen. Norton Schwartz. The administration did not request the aircraft and says it does not want them. But supporters say the order will keep alive Boeing's Long Beach, California, assembly plant, which produces no other product. The planemaker has also sold a handful of additional copies overseas, including a new (seventh) C-17 for Britain's Royal Air Force.

Also in the defense bill is limited funding for the Lockheed Martin VH-71 Kestrel presidential helicopter, based on the triple-engine AgustaWestland EH-101. Back on May 15, Gates announced he was terminating the VH-71, which was to become the future Marine One, after delays and cost overruns caused by retroactive requirements for additional equipment. The bill will enable the Marines to operate five of the 23 VH-71s once planned although it is unclear whether, or how, they will fit into a presidential fleet. Ashton Carter, the Pentagon's acquisitions boss, says he hopes to start another presidential helicopter program by this spring.

The bill prohibits the Air Force from carrying out its plan to retire 248 F-15 Eagle and F-16 Fighting Falcon legacy fighters pending an April 1 report by a federally funded research and development center. The bill also requires the service to conduct a cost-benefit analysis of its plan to shift F-15 training from Tyndall AFB in Florida to the Oregon Air National Guard's Kingsley Field. The bill temporarily halts a shutdown of F-15 operations at Tyndall even though the unit no longer has a mission to perform.

The spending bill contained 1,720 earmarks—those pesky add-ons sought by individual lawmakers for their districts, seen as democracy at its purest by supporters and as pork by critics. Many support museums and cultural centers in lawmakers' home districts, viewed by some as luxuries given the federal deficit.

A shutdown of F-15 operations at Tyndall has been temporarily halted.

Light combat aircraft

The Air Force and Navy are pursuing separate programs for small, light combat warplanes meant to be effective in counterinsurgency and special operations. The services are searching for a combat version of a turboprop training aircraft, like the Brazilian Embraer EMB-314 Super Tucano or the U.S. Hawker Beechcraft T-6 Texan II. A dark-horse candidate is a resurrected version of the Vietnam-era OV-10 Bronco, which would be assembled by Boeing at a facility yet to be named.

Some on Capitol Hill believe the dis-

Combat versions of the Super Tucano (left), T-6 (bottom) and OV-10 are all LAAR program candidates.

parate programs should be merged into a single effort. Others wonder if investing in a lightweight combat aircraft is a good idea at all, since it would entail significant start-up costs and have little applicability to large-scale "peer" conflicts between nation states. To complicate the situation, legislators from Kansas, where the T-6 is assembled in Wichita, object to the Pentagon considering a Brazilian aircraft under any circumstances.

Last November, Sen. Sam Brownback (R-Kan.) and Rep. Todd Tiahrt (R-Kan.) sent a letter to House of Representatives leaders requesting an investigation into reports that the U.S. and Brazil are negotiating an agreement for U.S. acquisition of at least 100 Super Tucanos. The two, strong defenders of the T-6, argued that such an agreement would "demean the integrity of the federal acquisition process" and result in the loss of thousands of American jobs. Tiahrt sent a similar letter to Gates.

Analysts in Washington, including some who follow acquisition closely, are less concerned about the prospect that the Pentagon might purchase a Brazilian aircraft and more worried that the small-warplane idea is a fad that is being pursued in several directions without adequate planning, procedures or oversight.

The Air Force program, which was known as OA-X until recently and is now called LAAR (for light attack armed reconnaissance aircraft) calls for a small plane with an advanced sensor suite; hardpoints to carry light missiles, bombs and rockets; and the independent capability to find and engage targets at night. The LAAR would also function as a forward air control aircraft, directing gunfire and ordnance from other platforms. The aircraft will need to operate from austere forward operating bases, including crude airstrips of grass or gravel. It needs to be largely self-sustaining, since it will operate in locations where maintenance support is all but nonexistent.

Some of the requirements, including those for high-altitude capability and for an on-board oxygen generation system, seem tailored to the war in Afghanistan.

"If you've got three or four Seals or Green Berets stuck on a mountain and the enemy is engaging them, this is a reasonable answer," former Pentagon analyst Pierre Sprey says. "All they need are some really accurate airborne .50-caliber machine guns or light cannons assigned to them and guaranteed available within 10 minutes."

Sprey says a purchase of 50-100 LAARs would be a reasonable expenditure, but would not substitute for "a real close air support [CAS] aircraft," meaning a replacement for the venerable A-10 Thunderbolt II. He says the Air Force and Navy have both ignored the CAS mission for years, making do with warplanes that were not designed for direct contact with troops.

The LAAR program is being run by the Air Force's Air Combat Command, which is responsible for traditional warfare, rather than Air Force Special Operations Command, which handles unorthodox fighting. Details of the program, including the amount allocated to it in the FY10 budget, have not been disclosed. Supporters believe the program will produce a low-cost, highly effective battlefield asset suitable for today's conflicts; critics say LAAR is in effect a cop-out, a way of avoiding a stronger and deeper commitment to CAS.

If the Air Force has been quiet about LAAR, the Navy has been silent about Imminent Fury, the demonstrator program that involves a Super Tucano—Kansas legislators notwith-standing—that appeared at three bases in the western U.S. last November. The aircraft is equipped with an electrooptical sensor in the nose turret and satellite and secure communications systems.

According to the British magazine *Air International*, the Navy leased the aircraft from EP Aviation, a subsidiary of contractor Xe Security, formerly named Blackwater International. The service is expected to eventually lease four Super Tucanos, designated A-29B, to evaluate their capabilities.

NASA and human spaceflight

A meeting between Obama and new NASA boss Charles Bolden at the White House on December 16 did not produce the usual public statement afterward and resulted in no decision on the agency's human spaceflight future. Spokesmen for the president and the administrator say they have no new information to impart while acknowledging that a policy must be set forth in public soon. The administration is scheduled to announce its FY11 budget request this month.

On the agenda for the Obama-Bolden meeting was the work of a blue ribbon panel headed by former aerospace executive Norman Augustine. Last October, the Augustine panel listed eight options for the future of the Constellation program. But the committee stopped short of telling the administration or NASA what to do.

According to the online edition of *Science* magazine, Obama intends to seek a $1-billion increase in the NASA budget for FY11. The funds, according to the report, will be used in part to fund a new heavy-lift launcher, replacing the Constellation program's Ares V, which has not yet been built or tested, to take astronauts to the Moon, asteroids, and the moons of Mars, as well as for cargo. The initial Ares I launcher that is part of the Constellation program and that has completed a test flight is reportedly suffering cost and technical issues and was excluded from several of the Augustine panel's recommendations. The *Science* article suggests that the White House is convinced that scarce NASA funds would be better spent on a simpler heavy-lift vehicle that could be ready to fly as early as 2018.

Whether the report is accurate or not, it appears that NASA engineers are more satisfied with the Constellation program's Orion crew exploration vehicle (CEV) than with efforts to construct a booster for it. When we went to press, however, the administration had not yet


Charles F. Bolden

made a policy announcement on human spaceflight.

A White House statement following the Obama-Bolden meeting said: "The president confirmed his commitment to human space exploration and the goal of ensuring that the nation is on a sustainable path to achieving our aspirations in space. Against a backdrop of serious challenges with the existing program, the Augustine committee has offered several key findings and a range of options for how the nation might improve its future human spaceflight activities. The two spoke about the administrator's work at NASA and discussed the Augustine committee's analysis."

Some critics have asked whether Bolden—an experienced astronaut and Vietnam combat pilot who was not the president's first choice for the NASA portfolio—is pushing hard enough for Constellation. One Washington wag pointed to the stark contrast between Gates' Pentagon and Bolden's NASA: Gates is widely viewed as willing to take unpopular positions and to make difficult decisions. Bolden is respected and admired but is not known to have taken a controversial position on Constellation. Many believe Bolden would like to push harder for the next-generation human spaceflight program but feels constrained by his, and his agency's, relative lack of clout in the administration.

As currently planned and funded, NASA has five shuttle missions remaining, all scheduled to launch this year, to complete the international space station. After the last flight, the shuttle's 134th, the agency is scheduled to ground its orbiter fleet, and the nation will have no way to put astronauts into space until, or unless, NASA proceeds with the Constellation program.

If Constellation matures as originally planned, the Ares rocket and Orion CEV will be ready for launch sometime between NASA's official estimate of 2014 and the Augustine panel's 2017 date. In the interim, U.S. astronauts will hitch rides on Russia's Soyuz, launched from the Baikonur cosmodrome in Kazakhstan, even though some U.S. sources believe Soyuz has its own safety and reliability issues.

Their experience may be like that of NASA astronaut Timothy Creamer, who, together with Russia's Oleg Kotov and Japan's Soichi Noguchi, docked with the ISS aboard a Soyuz on December 22. The three joined spacefarers already aboard, station commander Jeff Williams and cosmonaut Maxim Suraev, who is station flight engineer. Williams and Suraev will return to Earth in late March aboard another Soyuz, but three more astronauts are scheduled for launch in early April to boost the ISS crew to six.

The final year of space shuttle operations was scheduled to begin with the February 7 launch of Endeavour on STS-130 to deliver the Tranquility node and cupola, the last remaining segments of the station. The STS-130 crew is commanded by Marine Corps Col. George D. Zamka and will carry six astronauts. The cupola is a robotic control station with six windows around its sides and another in the center that provides a 360-deg view around the station. Also scheduled this month: the arrival of a Progress unmanned resupply ship. **Robert F. Dorr**

robert.f.dorr@cox.net

Graham Lake

How, globally, are ANSPs [air navigation service providers] managing the current airline recession—what have been some of the consequences of traffic decline, and has this fed into service provision?

Well first, it's important we acknowledge that ANSPs have recognized that the airlines are struggling; they have reacted positively and have taken steps to help. That in itself is somewhat of a change from past decades. Within the constraints of their regulatory structure, ANSPs have been working hard to cut costs where possible. But as CANSO [Civil Air Navigation Services Organization] has already said publicly, we do not want to imperil long-term investment plans, nor of course does anyone want to see any cuts to front-line services. So the room for our members to reduce costs faster than the decline in traffic is understandably limited.

Where is CANSO now in its development curve—how will the organization and the industry evolve in the next few years?

To borrow a Churchillian quote, CANSO is at the "end of the beginning." The secretariat and the members have performed outstanding work to bring the association from a standing start to where it is today in less than 15 years. The CANSO brand is strong and the organization is respected throughout the industry. The challenge now is for us to continue to deliver and to meet or exceed raised expectations.

In terms of the evolution of the association and the industry, we are seeing clear trends towards convergence and harmonization technologically, operationally and institutionally. CANSO will continue to support this industry evolution, by working closely with members and partner associations to provide the appropriate support necessary to facilitate these trends.

In December 2009 Graham Lake was appointed director general of CANSO, the Civil Air Navigation Services Organization, based in Amsterdam.

He began his career as an air traffic controller with U.K. NATS (National Air Traffic Services) in 1976 before moving to SITA as assistant vice president international relations in 1988, focusing on CNS/ATM (communications, navigation, surveillance/air traffic management) implementation in Europe and (for oceanic use) in the Atlantic and Pacific regions.

In 1997 he became a vice president at ARINC in Annapolis, Md., responsible for the aviation services division. He then moved to the U.K. as managing director of the ARINC EMEA (Europe, the Middle East, and Africa) region. In that capacity he led teams providing passenger systems at more than 20 major international airports, as well as aircraft datalink and IT services for airline and ATC (air traffic control) use.

Lake was also the founding president of AeroMobile, a joint venture company of ARINC and Telenor Norway, launched to develop and operate mobile communications services on aircraft for passenger and crew use. In 2006 Graham set up his own aviation technical services consultancy, AMSS, and was appointed nonexecutive chairman of Micro Nav, an ATC simulation systems company.

"The industry needs to look at the total value chain from the moment the passenger walks into the airport until he leaves at the other end of the journey."

Given the wide oscillations in traffic (and income) and the requirement for long-term investment, is there an economic model emerging for ANSPs that offers a clear blueprint that balances the needs of aircraft operators with long-term investment plans?

I don't accept that there are "wide" oscillations in traffic and income. If we take a step back and look over an extended period into the past and project traffic trends into the future, we can certainly say that we are experiencing a significant but temporary downturn. Our industry has lost about two years' worth of traffic growth. Don't forget that this also has to be balanced in context with what might be termed the years of "excess" before 2008. I firmly believe the traffic trend will soon be upwards again; we must plan accordingly and prudently.

All industries suffer from variations in income, and I don't believe aviation is unduly susceptible. The lesson to remember for me is that it is better to "mend the roof when the sun is shining," because it is much harder to be obliged to do so in an economic rainstorm.

Interview by Philip Butterworth-Hayes

If we look at what aircraft operators really need, it is of course a safe, reliable, environmentally sound and cost-efficient service. I believe they get that from ANSPs. We can debate the level of cost efficiency here and there, but ultimately real efficiencies will only come from harmonization across all stakeholder interests. Systemic change is going to be more important to achieve than charges reform, for example.

"If we look at what aircraft operators really need, it is of course a safe, reliable, environmentally sound and cost-efficient service."

The industry needs to look at the total value chain from the moment the passenger walks into the airport until he leaves at the other end of the journey. The whole industry needs a path to follow, a "vector," if you will: Historically there has been a tendency for each sector and organization to focus on its own challenges in isolation. The trend today is collaboration, interoperability and harmonization. This has to be a good thing.

Will the recession lead to more ANSP corporatization moves, or fewer?

We have to remember that this period is not the only recession in the history of aviation. Remember the oil shock in 1973-1974, and the deep recessions in the early 1980s and '90s. So many unforeseen events have the potential to seriously affect aviation—9/11 of course, or the trauma of the postcrash grounding of the DC10 fleet—the industry has to be strong enough to withstand and weather these shocks.

Whether ANSPs choose to "corporatize" themselves is not really the issue. It is much more about the collective organized strength of the industry to withstand times of difficulty.

There continues to be a mismatch between the technical capabilities of onboard systems to optimize flight profiles—especially in terms of taking the shortest route—and the ground-based systems managing the overall traffic flow. What role will CANSO play in bringing these two closer together?

I agree that there is a mismatch between the technical capabilities of some onboard systems and some ground-based systems in terms of traffic flow. However, I don't think that the systems themselves are the problem. Obviously, there is little point in having a shorter route between two airports using flex tracks if there is going to be unexpected or unavoidable holding at either end of the flight. Solving those sorts of aspects is a bigger challenge. CANSO will nevertheless continue to bring stakeholders together with the objective of achieving system-wide efficiencies.

With the advent of global ATM [air traffic management] we will need global, transnational management systems to implement a seamless system. Yet states, for reasons of national sovereignty, are notoriously slow at embracing these concepts. What can CANSO do to accelerate the process?

It is true that with the advent of a global ATM system we will need *transnational* management systems, but I don't think we will need completely *global* systems per se. We already have regional and subregional systems in place, and the first objectives should be and are to get them functioning effectively together. CANSO contributes to that effort by identifying key areas of action and applying focused workgroups to develop optimal approaches to the challenge.

"So many unforeseen events have the potential to seriously affect aviation—9/11 of course, or the trauma of the postcrash grounding of the DC10 fleet—the industry has to be strong enough to withstand and weather these shocks."

Airport managers—especially those responsible for optimizing taxiway and runway operations—need to be engaged more fully in strategic ATM capacity and safety planning, otherwise all we will be doing with NextGen and SESAR [Single European Sky ATM Research] is moving traffic more swiftly between bottlenecks. Do you agree, and if so, how can this be done?

I do agree that the ground infrastructure issues need to be comprehensively addressed. As I mentioned before, there is no point spending resources to shorten a route if there are going to be bigger delays at the end of the flight because the airport operations are not adequately optimized—no parking gate available at the arrival airport, for example. Ultimately, it is important that we recognize that ATM is part of a system that reflects the needs of airlines, airports, and ANSPs. We all need to work together to adapt and adopt solutions that offer real benefits.

What new technologies and procedures do you think offer the most promising solutions to the safety, capacity, efficiency and environmental challenges of the future?

It is essential to understand that a common approach to these challenges is likely to deliver the most success. I personally am a "technology agnostic"—I don't believe that it is a technology debate; it's a solutions debate. For example, CANSO will not be entering into technological evaluations but will be seeking to identify and facilitate the implementation of well-thought-through approaches to each of the key operational areas of focus.

How close are we to developing clear metrics that can objectively measure service performance?

Actually I think tremendous progress has been made on ATM indicators in recent years. You can see that in the work of the CANSO global benchmarking group and our human resources and environment work groups. CANSO will continue to encourage the development, refinement and adoption of robust, publicly available and accountable metrics. The aim will be to provide appropriate measures and indicators that can be effectively used as a "dashboard" by CEOs and managers throughout the industry.

"I personally am a 'technology agnostic' —I don't believe that it is a technology debate; it's a solutions debate."

But in your performance gathering work, which areas of ANSP performance can we now measure accurately and compare? Can you point to areas where this work has led or will lead to actual improvements?

Both the FAA and Eurocontrol have done some excellent work in this area, which we have built on with our own CANSO Global Benchmarking Report. Our fifth report is just about to be published, and it builds on the FAA and European metrics with additional contributions from ANSPs in the Asia Pacific, Africa and Middle East [regions], so it's a truly global perspective.

The report encompasses productivity, cost-effectiveness, pricing, profitability and quality of service. Plus we also include benchmarks on HR, environment and safety issues. The whole point about all performance measurement work—whether you are developing metrics for salaries, environmental performance, capital equipment costs—is that the dashboard can be used by the people who manage air navigation services and the systems' users.

It allows them to make comparisons. If you are measuring operations, day in day out, you can actually understand very clearly where performance is remaining stable, improving or deteriorating. And if it is deteriorating you can use the base metrics to take the appropriate actions to bring it back on track. We are already seeing ANSP CEOs acknowledge that the Benchmarking Report is helping them to improve the performance of their organizations, and this is obviously something we want to focus on in years to come.

I am absolutely in favor of performance metrics being used as a framework for a global vision. It's all about interdependency—benchmarking staffing levels, the environment…there are so many areas you can now take a critical look at and monitor. It allows us to look too at strategic trends, so when we are asked about ANSP performance we have clear evidence of what is happening.

ANSPs are coming under increasing pressure to mitigate commercial aviation's impact on the environment—one of the goals of SESAR, for example, is to cut CO_2 emissions per flight in Europe by 10%. But aren't some of these targets unrealistic, given that there always has to be a balance between emissions, safety, noise and airspace architecture?

I am a firm believer in interdependency, and I believe ANSPs, airports, airlines or other industry stakeholders will find it harder to act alone than with other stakeholders. We need to find a harmonized approach to the problem. It is unreasonable to expect ANSPs in isolation to find ways to meet these objectives.

SESAR is an example of a regional approach to a global challenge. While I would applaud the role that SESAR is playing, I would like to examine some of the ways we can go beyond that.

Are you worried that, when we compare the work of developing next-generation ATM systems—via SESAR and NextGen, for example—and then look at the level of research funding that is available to states in other parts of the world, particularly Africa, we are in danger of developing a two-track global ATM system? What can be done about it?

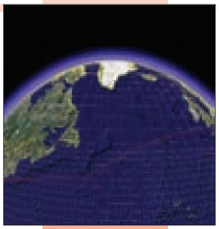
The reality of the world is that it is a large and complicated environment, and the solutions to its problems therefore must also be large and complicated. If you use the analogy of a large multinational supermarket chain then the operational technologies they employ to maximize their revenues include loyalty programs, automated checkout technologies, and complex retail and stocking systems. But they are also operating in the same business as the local corner shop. The market is the same—but we have to create a situation where the high-tech business area does not shut out the low-tech players.

"The reality of the world is that it is a large and complicated environment, and the solutions to its problems therefore must also be large and complicated."

So the issue is to make sure that all the systems are harmonized. This is particularly important for aircraft operators—we have to make sure all the systems are synchronized and that the whole ATM system becomes more efficient. And that means not looking exclusively at shorter flight times or optimal flight profiles but at the harmonized interdependency of the whole system.

And I recognise that CANSO is in a privileged position to help with that. I also believe that there is strength in diversity. The more stakeholders that we can involve in constructively working to a converging vision, the better for the industry as a whole.

Homeland security goes transatlantic



U.S. AND EUROPEAN DEFENSE AND AEROSPACE companies are working to build up their homeland security business to tap into an increasingly important market and build a transatlantic business base.

Flurry of purchases

At a time when acquisitions have slowed considerably, homeland security has become one of the hottest areas for mergers related to defense and aerospace. Two of the seven largest defense and aerospace acquisitions in 2009 were companies purchased, at least in part, for their homeland security business. France's Safran purchased an 81% stake in General Electric's Homeland Protection business in a $580-million transaction, the largest pure-play homeland security acquisition, in September 2009. That same month General Dynamics paid $643 million for Aysys Technologies, a manufacturer of high-performance electrooptical and infrared sensors and systems and of multiaxis stabilized cameras.

This came after a string of similar purchases made the previous year. Of the five largest acquisitions in 2008, three were related to homeland security. BAE Systems purchased Detica Group for £531 million in the fall of 2008. Detica's expertise is in software that can manage and analyze databases for antiterrorist and antifraud applications.

The two largest acquisitions that year were predominantly defense, but also involved important homeland security business. Finmeccanica's $3.9-billion acquisition of DRS Technologies in October 2008 provided the Italian national champion with important new capabilities in border security and UAVs. The $2.5-billion leveraged buyout of Booz Allen Hamilton's U.S. government business provided the Carlyle Group with a company whose expertise includes intelligence analysis, operational support, strategy and emergency management. Booz Allen plays a key role in assisting Boeing on the SBI net, a virtual border fence for the U.S. that links radar, cameras and communications.

In one case, the market became so heated that a U.S. and a European company engaged in an acquisition bidding war. Ultimately New York-based L-1 Identity Solutions beat off a challenge by Safran to win Digimarc's identification systems business for $310 million.

Cyber security and other hot areas

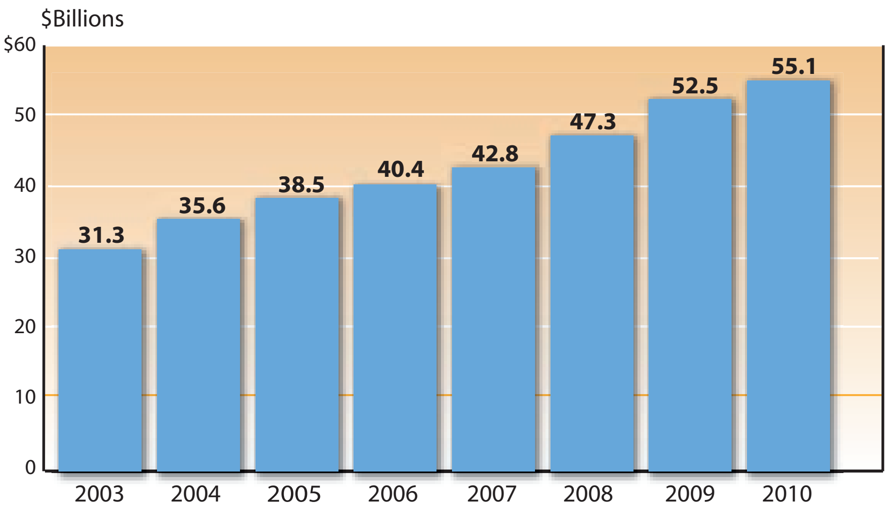
Cyber security in particular has become an extremely hot acquisition area, with Raytheon making four acquisitions over the past four years and Harris making one. In April 2009 Harris purchased Crucial Security, a company that identifies network vulnerabilities. Raytheon purchased BBN Technologies, another company involved in cyber security, for approximately $350 million in October.

The flurry of acquisitions is indicative of increased interest by defense and aerospace companies, which have taken notice of the market's rapid growth. Little-noticed European corporations have become transatlantic leaders in several key areas of the market, from detection to biometrics to public sector radios.

With a string of about 10 acquisitions

Border inspection requirements have led to mergers and corporate realignments.

DHS OBLIGATIONAL AUTHORITY



in the past decade on both sides of the Atlantic, U.K.-based Smiths Group has created the world's largest detection business, with customers in airports and ports around the world.

France's Safran, a world leader in biometrics, expanded that core work with the acquisition of U.S.-based Motorola's biometrics business in 2008. Safran then broadened into detection with its purchase of the 81% stake in General Electric's homeland security detection business.

BAE Systems' purchase of U.K.-based Detica was based on its belief that Detica's security capabilities in risk mitigation can be brought to the U.S. market. It follows a decision by BAE Systems' management to establish homeland security growth as a top strategic goal of the company. Earlier acquisitions of United Defense and Armor Holdings gave the company a portfolio of businesses that provide state and local police forces with mobile and protection systems such as armor, vests and helmets.

Finmeccanica's purchase of DRS Technologies was based in part on its interest in combining the border security capabilities associated with DRS' contracts in Egypt and Jordan, and its own capabilities involving Italian and Libyan contracts.

EADS, the Franco-German-Spanish aerospace giant, purchased PlantCML, which provides call management and radio dispatch products for emergency call centers. The move is an effort to overtake market leader Motorola in the U.S. public safety mobile radio market.

Congress has mandated that all maritime cargo containers entering the U.S. be scanned.

U.S. companies also are increasing their homeland security business lines, through acquisitions, international pursuits, and R&D breakthroughs. The focus here is more on building up a U.S. business base and using that to export to other countries. It tends to be a less transatlantic approach, and instead one more geared to satisfying the strong U.S. market and making exports to the Middle East, Asia, South America and other emerging markets.

Growth and goals on the rise

The reason for this heightened interest in homeland security by leading firms in both Europe and the U.S. is clear. As companies grow more nervous about the outlook for defense budgets on both sides of the Atlantic, homeland security is becoming an increasingly attractive business opportunity with growth continuing for the foreseeable future.

Total U.S. homeland security funding is up more than 160% since FY01, and it continues to grow. That is particularly attractive at a time when the commercial aerospace market is already under pressure and the U.S. and European defense budgets expect to feel more.

Not only has the size of the market grown but so too have potential business opportunities. For years after the 2001 terrorist attacks, the homeland security sector was relatively sluggish as the U.S. and other countries sought to decide what to do to protect their homeland. The Dept. of Homeland Security (DHS), created in the wake of the attacks, sought to meld 22 agencies into one. It needed to create a procurement infrastructure, and much of the initial funding increase went into hiring personnel to provide improved protection. The result was that for years there were relatively few programs, and those programs that moved forward were often troubled.

Since then new opportunities are increasing. In December the Coast Guard received its first UAV, a maritime variant of the General Atomics Aeronautical Systems' Predator B; the service is also studying the possibility of using Northrop Grumman's Fire Scout for its unmanned vertical lift requirement. American Eurocopter LLC, a subsidiary of EADS North America, won a U.S. Customs and Border Protection contract in July 2008 for 17 AS350B3 helicopters. With options, the contract could be worth more than $150 million to deliver 50 AS350BE helicopters over five years.

Now ambitious goals also have been put in place. In 2007 Congress imposed a requirement that DHS achieve 100% scanning of U.S.-bound maritime cargo containers by 2012. While that requirement is unlikely to be met by then, it is indicative of national efforts to devote resources to reshaping homeland security.

This market area is not only large and growing but also relatively open. In the U.S., the "buy America" provisions that restrict foreign competitors' ability to participate in many areas of the defense market are lacking in homeland security. That gives foreign companies considerable potential to penetrate the market.

Europe's defense and aerospace prime contractors have also seen the success of their efforts to penetrate the U.S. defense market. BAE Systems kicked off the process with a series of acquisitions that began in 2000. Other U.K. companies followed a similar acquisition strategy with the result that many U.K. defense companies, such as BAE Systems, Cobham and Ultra, derive substantially more income from the U.S. defense market than from their home U.K. market. Continental European manufacturers such as Finmeccanica have recently begun following a similar strategy.

European contractors are building on the experience they acquired in developing their market position in aerospace and defense. They are applying those same techniques to build a domestic presence in homeland security. For U.S. and European contractors, this area has the added appeal of being closely related to core defense companies' core skills in dealing with a government customer and in doing systems integration.

Other international markets

The attractiveness of the homeland security market is not limited to the U.S. International markets are growing rapidly in areas that include airport and port security as well as critical infrastructure protection.

Border security is booming as a business opportunity. The European Union is helping to pay for improved security along its expanded Eastern European borders. Poland and Romania, which have long borders with the former Soviet Union, have offered attractive opportunities. The Middle East has become a particularly active area, with Jordan, Libya, Egypt, Qatar and Saudi Arabia awarding contracts for border security over the past several years.

Immigration management is another strong international growth area. Raytheon won the U.K.'s e-Borders contract in November 2007. Under this program it received a £650-million contract to put in place a system to track travelers to the U.K., including examining possible links to high-risk individuals or those already on terrorist watch lists. Raytheon is holding discussions with other governments on putting a similar system in place.

Specialty areas

With the opportunities now in homeland security, virtually all major defense and aerospace prime contractors have established their areas of specific expertise. Raytheon, which does about $1 billion annually in this business, half of it international, has a broad portfolio in the area. Its international business, which also includes critical infrastructure protection, is growing more rapidly than its domestic business, accounting for most of its estimated $1.3 billion in homeland security contract bookings in 2009.

SBInet is a virtual U.S. border fence.

Generally the U.S. prime contractors have focused on the U.S. market. For Lockheed Martin, the world's largest defense contractor, the focus is on information technology, aircraft and biometrics. The company has been developing a state-of-the-art biometrics system for the FBI's Next Generation Identification System under a 10-year, $1-billion contract. The program increases the size of the bureau's database and includes facial, iris and palm print recognition.

Northrop Grumman is involved in the homeland security areas of information technology, patrol ships, and technical services. In addition, its Remotec subsidiary is a major provider of robotic products for bomb disposal and SWAT (special weapons and tactics) teams.

General Dynamics is building the multibillion-dollar, 15-year Integrated Wireless Network to implement interoperable wireless communications services to support the Departments of Justice, Homeland Security and Treasury. It is also developing and maintaining the Homeland Security Information Network Next Generation, a national information sharing platform for sensitive information.

Boeing, whose footprint is among the most limited, is focusing on its work as prime contractor for the SBInet, a U.S. border security program.

Many European prime contractors are developing their own niches. BAE Systems, the largest European defense contractor, has established growth in homeland security as a strategic goal. Thus the company has built up strong positions in counterthreat management, information technology, and mobility and protection systems for police forces.

EADS, Europe's largest aerospace contractor, showed the importance it is placing on the sector by making its only major acquisition in the U.S., purchasing homeland security contractor Plant CML. That follows three acquisitions in Europe in professional mobile radio and maritime security since 2006. Through its Eurocopter subsidiary, EADS also provides helicopters to the DHS. The company now estimates it has approximately €900 million of homeland security business, triple its level in 2000.

Philip Finnegan
Teal Group

Hearts in free fall

WE HAVE ALL SEEN VIDEO OF ASTRONAUTS drifting and gliding gracefully around inside the ISS like fish in an aquarium. It looks so relaxing. Enjoyable as it appears, however, there is a down side to all that freefalling.

"When astronauts land back on Earth after a long time in space, not only is their vestibular system mixed up and their kinesthetic sense thrown off," says Benjamin Levine of the University of Texas Southwestern Medical Center, "but also their bones and muscles have deteriorated."

Critical mass?

In space, even more than on Earth, the phrase "use it or lose it" applies. The human body and all its parts need to work to remain vital. Bones must bear weight to keep their density and strength. Muscles need to push or pull against resistance to stay in shape; without work they waste away.

Is this also true of our most critical muscle, the human heart? To find out, NASA is launching a new study known as Integrated Cardiovascular.

Astronaut Clay Anderson floats through the Unity node of the ISS.

We know that astronauts lose heart mass and exercise capacity when they are in microgravity for a long time," says NASA Johnson's Julie Robinson, ISS program scientist. "We suspect that this could lead to impaired heart function, which could cause low blood pressure and even fainting when astronauts get back to gravity. But we need detailed information. In the future, astronauts will spend longer and longer [times] in space, and even live and work on the Moon and Mars. We want to know exactly how space living will affect their hearts and heart function."

Levine is a principal investigator for the experiment, along with Michael Bungo of the University of Texas Health Science Center at Houston. The two have enlisted the support of several other cardiovascular experts to conduct this research—the most comprehensive and advanced study of its kind to date.

"We are investigating how, how much, and how fast deterioration occurs in the heart during long-duration space travel," says Levine.

The space station crew, which has recently increased to six, will help Levine and his team find answers by serving as subjects for Integrated Cardiovascular. The experiment will last for over two years—long enough to gather plenty of data on 12 different astronauts before, during, and after their stints in space.

"We are incorporating the most sophisticated tools ever used in such an experiment to look at the heart and its chambers and valves," Levine notes. "This is the first investigation ever to use advanced echo-Doppler techniques to follow the structure and function of the heart during long periods in space and confirm findings by using advanced magnetic resonance imaging tools on the ground. For example, we are using an echocardiogram to determine how heart muscle atrophy influences the way the heart relaxes and fills, and an MRI to quantify this atrophy precisely and determine whether [the heart] scars or gets infiltrated by fat."

Echocardiograms use high-pitched sound waves that are picked up as they reflect off different parts of the heart. These echoes are turned into a moving picture, allowing researchers to watch a movie of the heart in action as blood flows through it. By looking at such movies before, during and after spaceflight, the team can discern mechanical changes that happen in a person's heart after he or she is away from Earth's gravity for a long time. With the MRI, they can look at detailed computer images of the heart tissues to pinpoint exactly what kind of atrophy occurs.

The researchers will also try to determine whether the heart's deterioration is simply a matter of size—as with weightlifters who lose muscle mass if they stop lifting weights—or if the heart scars and cells die.

In addition, the team is studying the effects of heart atrophy on crewmembers' ability to exercise and on the likelihood of their developing unusual heart rhythms, both on the station and after they return to Earth. The researchers will also look closely at other cardiovascular issues, such as how blood pressure responds to the reintroduction of gravity at the levels experienced on Earth, the Moon and Mars.

"All of the results will help us fine-tune exercise protocols for the space station crew," Robinson says. "We will also learn what to look at in astronauts' hearts before we send them to, say, Mars. We will identify a set of risk factors that can help flight surgeons determine the best candidates for long missions."

Levine adds, "We may, however, show that the heart does just fine in space, and that the strategies now used to keep astronauts in shape are adequate to keep the heart functioning normally and in good health. If so, flight surgeons can turn their attention instead to other potentially critical problems, such as bone loss or radiation exposure."

Atrophy and arrhythmia

The study's results will also have the important benefit of helping researchers develop preventive and rehabilitative regimens for people on Earth.

"The information we get from these experiments will be relevant for patients after long-term bed rest or other physical activity restrictions, as well as for patients with congestive heart failure, heart disease and even normal aging."

Cardiac atrophy, a decrease in the size of the heart muscle, appears to develop during spaceflight or its ground-based analog (bed rest), leading to diastolic dysfunction (abnormal left ventricular function in the heart) and orthostatic hypotension (a drop in blood pressure upon standing). Such atrophy also may be a potential mechanism for the cardiac arrhythmias (irregular heart rhythms) identified in some crewmembers after long-duration exposure to microgravity aboard the Mir space station.

Recent investigations have suggested that cardiac atrophy may be progressive, without a clear plateau over at least 12 weeks of bed rest, and thus may be a significant limiting factor for extended-duration space exploration missions. This study will quantify the extent, time course and clinical significance of cardiac atrophy and identify its mechanisms. The functional consequences of this atrophy also will be determined for cardiac filling dynamics, orthostatic tolerance under both normal (Earth) gravity and fractional gravity (Mars and the Moon) conditions, exercise tolerance and arrhythmia susceptibility, both on the station and following return to Earth.

Astronaut Cady Coleman performs a remotely guided echocardiogram on a test subject using Integrated Cardiovascular protocols, while Betty Chen, a training coordinator, observes.

Using MRI, the Integrated Cardiovascular study will determine the magnitude of left and right ventricular atrophy associated with long-duration spaceflight and will then relate this atrophy to measures of physical activity and cardiac work in flight. In addition, it will use ultrasound to determine the time course and pattern of the progression of cardiac atrophy in flight. The study will also determine the functional importance of cardiac atrophy for cardiac diastolic function and the regulation of stroke volume (the volume of blood pumped by the heart in one contraction) during gravitational transitions and will identify changes in ventricular conduction, depolarization and repolarization during and after long-duration spaceflight. It will then relate these to changes in heart mass and morphology (shape and form).

NASA connection

This experiment is supported entirely through NASA funding mechanisms using grants to the University of Texas Southwestern Medical Center and the University of Texas Health Science Center at Houston, with on-site civil service and contractor support at NASA Johnson. The study's full name is Cardiac Atrophy and Diastolic Dysfunction During and After Long Duration Spaceflight: Functional Consequences for Orthostatic Intolerance, Exercise Capability and Risk for Cardiac Arrhythmias (Integrated Cardiovascular). The payload developer is the NASA Johnson Human Research Program.

Taking measurements

The researchers will use echocardiography before, during and after spaceflight, and MRI before and after. In addition, they will use a special imaging technique called magnetic resonance spectroscopy to quantify the amount of fat in the subjects' hearts.

Before and after flight, they will tilt the subjects on a table at angles to approximate various levels of gravity—from lunar levels to those experienced on Earth. During the tests, they will monitor each subject's heart rate and blood pressure and measure blood flow from the heart with an echocardiogram. All these functions will be monitored and measured during exercise as well, both before and after flight, to determine the subjects' reaction to the stress.

Electrocardiograms will be taken on several occasions during the study and will last up to 48 hr at a time. These recordings will be concurrent with continuous measurements of blood pressure and activity (using Actiwatches worn at the waist and ankle) to estimate the amount of work the heart is doing daily on Earth and in space.

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Astronauts as a group are perhaps as healthy and fit as is humanly possible. But to the risks of bone loss and muscle weakness from prolonged spaceflight are now added concerns about potential risks to the heart.

Astronauts take medication and perform exercises to counter the effects of weightlessness. This study will try to determine the extent of the effects of weightlessness on their hearts and discover what steps are needed to prevent damage. And studies like this may also result one day in better cardiac health for those of us here on Earth as well.

Edward D. Flinn
edflinn@pipeline.com

China's short march to

JF-17

China's aerospace industry has some way to go before it can match the technical capabilities and manufacturing capacity of North America or Europe. But it is catching up fast.

In November 2009 the deputy commander of the Chinese PLAAF (People's Liberation Army Air Force), Ho Weirong, announced in a television interview that the air force would be operating a fifth-generation fighter within eight to 10 years.

This was the fifth new Chinese aerospace program to emerge last year. The COMAC C919 190-seat airliner was launched in March 2009, with an in-service date of 2020. The KJ-2000 AWACS aircraft and Xi'an ASN-207 tactical unmanned air system were officially unveiled at the October military parade in Beijing to celebrate the 60th anniversary of the founding of the People's Republic. A 200-tonne-class military airlifter was also due to make its first appearance before the end of the year. Meanwhile, the China Satellite Navigation Project Center planned to launch four BeiDou-2 (Compass) satellites during 2009, as part of a program to develop a 12-satellite regional capability by 2012 and a full global capability of 30 medium Earth orbit and five geosynchronous Earth orbit satellites by 2020 at the latest.

China's headlong rush into the global aerospace market is unprecedented. Within 20 years it will have transformed itself from a customer to a competitor in almost every area of the market—from front-line fighters to helicopters, unmanned air vehicles to missiles, military transport aircraft to airliners. But as the capability gap narrows, will China really be able to compete on equal terms with the U.S. and Europe, in both the

With activities ranging from new military and commercial aircraft programs to satellite and other space projects, China is on its way to becoming a significant player in the aerospace arena, where it has long trailed the West. The growing number of alliances it is forming with Western companies is accelerating the trend and enabling faster advancement of its technologies.

by **Philip Butterworth-Hayes**
Contributing writer

aerospace autonomy

civil and military sectors? And how should Western companies respond to an emerging new aerospace power that offers as many threats as opportunities?


J-10

More than technology

Building a competitive aerospace industry almost from scratch requires more than technical know-how. It takes a profound understanding of market demand and an industrial base that encompasses lean manufacturing and Six Sigma principles, a knowledge of the global supply chain (for both manufacturing and support), and an ability to integrate complex structures and systems via a global network of niche suppliers. There are some holes in China's aerospace business portfolio, especially in areas such as competitive engine, avionics, and aircraft system design capabilities. And in some areas, such as business jets, there is hardly a Chinese presence at all. But China has proved adept at attracting Western suppliers to set up joint ventures that provide Chinese manufacturers with enough knowledge to kick-start an indigenous capability very quickly.

Having acquired the basic knowledge base to produce aircraft such as the Chengdu J-10 and the JF-17—with performances reputedly on a par with an early-generation F-16—and the Airbus A320, produced under license by the Harbin Aircraft Industry Group (HAIG), China's aerospace industry is now gearing up to manufacture products that it hopes will soon outperform those in the West.

"The Chinese are a generation behind in aircraft technology, but they are catching up very quickly," says London-based aerospace analyst Paul Beaver. "They have the capability to evolve their electronics technology at a far faster rate than anywhere else in the world, helped by the 300,000 new engineers coming into the market every year. The JF-17 is exceptionally interesting—the Pakistani version has Western avionics and weapon systems, and this makes it a very exportable product for countries wanting an aircraft with an F-16 Block 30 performance."

Realigning with markets

Over the past 18 months China has been restructuring its aerospace sector to align more closely its specialist manufacturing industries with the markets they serve.

In late 2008 the Chinese government announced the remerger of AVIC I and AVIC II, the two Aviation Industries of China organizations separated in 1999. AVIC I, comprising 47 manufacturing companies, 31 research institutes, and 22 other aviation support companies, made larger aircraft and engines—including fighter aircraft, turbofan engines, air-to-air missiles, the ARJ 21, and the 50-seater turboprop MA60 airliner. AVIC II made military and commercial helicopters along with the 50-seater ERJ 145.


KJ-2000

C919

In 2009 AVIC set up a number of semi-independent subsidiaries to build and market the new generation of aircraft under development. The defense branch was set up in Beijing, with reported assets of around $7.3 billion, to develop new capabilities in areas such as unmanned air systems (UAS) and to market fast jets such as the J-10 and JF-15 alongside trainers like the L-15 Falcon. The division manages 10 assembly plants and research institutes across China.

Civil aircraft manufacturing has been devolved to the Commercial Aircraft Corporation of China (COMAC), based in Shanghai, to manage development of the C919 190-seat airliner and the C regional jet. COMAC businesses include AVIC I Commercial Aircraft, Shanghai Aircraft, and First Aircraft Institute.

An AVIC helicopter company has been set up in Tianjin Binhai New Area, with the Tianjin municipal government holding a 31% stake in the company. A new aviation engine company, also producing composite materials, also has been started in an aerospace cluster zone near Beijing Capital International Airport. An AVIC airborne systems company has been established in the Zhongguancun Aviation Science Park of Haidian district in northwest Beijing. Other AVIC specialist companies have been developed to support general aviation and military transporter businesses.

ARJ-21

Funding sources and airliner profits

Part of the funding for the new enterprises has come from a 176-billion-yuan ($25.8-billion) credit agreement signed in January 2009 with 10 Chinese banks, including Industrial and Commercial Bank of China, China Construction Bank, and China CITIC (China International Trust and Investment) Bank. Chinese banks are playing an increasingly important role in funding major global aerospace deals. In November 2009, for example, Boeing signed aircraft leasing agreements with China Construction Bank and CDB Leasing for up to 25 billion yuan ($3.7 billion) in financing and leasing for Boeing aircraft.

In terms of turnover, by the far the largest aerospace sector Chinese companies have targeted is the airliner market. It has taken China just 25 years to reach a stage where its indigenous products are in the market, competing with Western companies. It has achieved this extraordinary rate of growth through a three-pronged strategy of licensed assembly of increasingly complex Western aircraft, competitive bids for structures and component contracts on Boeing and Airbus aircraft and, finally, strategic alliances with Western manufacturers, leading to joint ventures in China.

The first licensed assembly deal was the 1985 agreement with McDonnell Douglas to assemble MD-80s in Shanghai. The aircraft were assembled from kits, and 35 were produced between 1985 and 1994. A follow-on contract that substantially increased Chinese content was signed in 1992 to produce 40 MD-80/MD-90s, but this was amended in 1994 to produce 40 MD-90s, and again in 1998 when McDonnell Douglas merged with Boeing, which reduced the number of MD-90s produced in China to just two. Then, in 2002, AVIC II and Brazil's Embraer formed a joint venture to build 50-seat Embraer EMB-145 regional jets in Harbin. At the end of 2009 it was reported that the Harbin plant might also assemble 106-seat EMB-190 jets. Harbin is the center of an Airbus narrowbody

Joint ventures in China

There have been significant joint ventures established in China over the past few years with aerospace companies in Europe, Canada, Brazil, and the U.S.

***Airbus China** opened its Beijing office in 1990. The Airbus Beijing training center was set up jointly with China Aviation Supplies Import & Export in 1998, while nearby Airbus has set up a customer support center that stocks some 25,000 spare parts. The Airbus Tianjin assembly line opened on September 28, 2008, producing A320 aircraft. It is a joint venture between Airbus and a Chinese consortium of Tianjin Free Trade Zone and AVIC. ABEC, the Airbus (Beijing) Engineering Center, opened in early 2006 and is a joint venture between Airbus and AVIC, designing A350 XWB systems. In addition, Airbus signed a contract in January 2009 with Chinese partners, creating a joint venture to make carbon composite parts for its A350 XWB and A320 aircraft. Airbus' Chinese business will hold a 20% stake in the joint venture, based in Harbin, and China's Harbin Aircraft Industry Group will hold a further 50% stake, while other local players HAI, AviChina, and HELI will each own 10%. The new plant was ready for operations by in late 2009. Airbus said the value of its partnership with the Chinese aviation industry is expected to be near $200 million a year this year and $450 million in 2015.*

*In June 2007 **Boeing** contracted a package of work for its range of Boeing 737NG, Boeing 747-8, and Boeing 787 aircraft valued at about $500 million. Chinese companies, for the first time, are building flaps, ailerons, and spoilers for Boeing aircraft. According to the company, "Boeing supplier partners have active supplier contracts with China aviation industry valued at well over US$2.5 billion." Boeing is one of the main partners, with Hexcel and AVIC, in BHA Aero Composites in Tianjin, producing secondary composite structures and interior parts. First deliveries started in 2002. BHA customers include Boeing, Hexcel, Fisher, and Goodrich. It has over 570 employees.*

***Fokker-Elmo**, working with Boeing Electrical System Responsibility Center, delivers 99 part numbers to the Boeing 737-600, -700, -800, and -900 programs via a new plant in Langfang, Hebei Province, where it has 504 employees working on Boeing, Pratt & Whitney, and other companies' electrical products.*

***Messier-Dowty** set up a plant at Suzhou for landing gear components.*

***Bombardier's** new CSeries regional jet is being developed in conjunction with Shenyang Aircraft, which will supply the fuselage, center wing box, and doors. During the 2007 Paris Air Show the former AVIC I signed a risk- and revenue-sharing deal with Bombardier to develop the ARJ21-900, a 105-seat regional jet. The former AVIC I and Bombardier Aerospace have a long-standing strategic agreement that includes AVIC I's Xian unit manufacturing components for the Bombardier 415 and SAC unit supplying components for the Q-Series aircraft.*

*In October 2004 the French and Chinese presidents attended the signing of a Cooperation Framework Agreement between AVIC II and **Eurocopter** for a joint helicopter venture. Eurocopter and the former AVIC II have been cooperating for more than 25 years, in particular with the Z9, a Dauphin made in China, and the EC120, also manufactured in China, by Harbin Aircraft Industries.*

*In 2003, **EADS**, Eurocopter's parent company, took a 5% share in the AviChina enterprise.*

*The former AVIC II, through its subsidiaries Changhe Aircraft Industries and Shanghai Xinshen Aviation Industry Investment and Development, recently joined Shanghai Sikorsky as a shareholder. The company was established in 2003 by **Sikorsky** and Shanghai Little Eagle to build civil helicopter sales and support in China.*

*The Harbin aerospace cluster houses the only assembly plant for the Embraer ERJ-145; **Embraer** moved ERJ-145 production to Harbin as part of a joint venture with AVIC II in 2004.*

*During the September 2009 Asian Aerospace show Safran signed a framework agreement with AVIC for work on the aircraft, as did Nexcelle—a joint venture company created by **GE's Middle River Aircraft Systems** and Aircelle, a Safran group company to supply nacelles.*

*In November 2009 **Honeywell** opened its China Aerospace Academy in Shanghai to train aerospace engineers. The academy is located at Honeywell's Shanghai Learning Center in Pudong.*

***Alcoa** and COMAC have set up a joint venture technology cooperation agreement to examine the use of advanced aluminium structural concepts, designs, and alloys for the 190-seat aircraft.*

***General Electric** recently reached an agreement with AVIC to set up a joint venture to provide avionics systems for the global airliner market; both GE and AVIC will each hold 50% of the venture. According to Boeing, its suppliers' Chinese aerospace business includes the following activities:*

•General Electric procurement from Harbin, Shanghai, Xi'an, Sichuan, Suzhou, Guizhou, and Shenyang. The General Electric Suzhou plant makes engine parts and flight controls.

•Goodrich contracted the CF34 fan cowl in 2008 to BHA. Hongdu Aviation in Nanchang builds 787 part kits for the 787 nacelle.

•Parker Hannifin has a machining joint venture with Jincheng, Shanghai Qi Yi Automotive, and Sichuan Golden Dragon Machine.

•Pratt & Whitney sources engine components from Xi'an and Chengdu.

•Primus International has built an aircraft components factory in Suzhou.

•Rolls-Royce procures from several locations in China, including Xi'an, Shenyang.

•Snecma has a CFM56 engine blade joint venture in Guiyang.

assembly plant as well; the first Harbin-assembled A320 flew on May 18, 2009.

Growth of joint ventures

In parallel with the license assembly program, Chinese companies have been gradually building up their work share on Airbus and Boeing programs. Led by Chengdu Aircraft, HAIG, Shanghai Aviation Industries Group, Shenyang Commercial Aircraft, and X'ian Aircraft, Chinese firms have evolved their product range from relatively simple structures through to doors and, most recently, complex composite parts. The new BHA plant operated by Chinese companies with Hexcel and Boeing, for example, produces complex composite panels and parts for interior and exte-

MA-600

CHINESE SUPPLIERS TO MAJOR NEW AIRLINER PROGRAMS

Supplier	*Work package*	*Aircraft type*	*Comments*
BHA Aero Composites	Composite panels and parts	Boeing 737-600, -700, -800, -900	Flight deck, close out panels, dorsal fin, wing-to-body fairing, cover panels, wing fixed trailing edge, wing fixed leading edge, interior panels
	Composite panels, door liners, fixed trailing edge	Boeing 747-8	
	Wing fixed trailing edges and dry bay barriers, empennage panels	Boeing 767	
	Wing fixed trailing edges and dry bay barriers, empennage panels, flight deck interior panels	Boeing 777	
Chengdu Aircraft Corporation	Rear passenger door and nose section parts	Airbus A318/A319/ A319CJ/A320/A321	
	Rear passenger door and nose section parts	Airbus A330/A340	
	Forward entry doors, over wing exit doors	Boeing 737-600, -700, -800, -900	Contracted in 2005. From 2008 the contract is with Spirit.
	Aileron and spoilers	Boeing 747-8	Contracted in 2007. First delivery 2009.
	Horizontal stabilizer and subassemblies	Boeing 747-8	Contracted in 2007
	Composite rudder	Boeing 787	Part of a $600-million contract announced in June 2005 by Boeing to a group of Chinese suppliers
Harbin Aircraft Industry Group	Composite material parts and components	Airbus A350 XWB	The two companies have established a manufacturing center, now in operation, that is an equity joint venture enterprise, with HAIG holding an 80% stake and Airbus owning a 20% stake. According to the contract, the center will manufacture composite materials parts and components for the Airbus A320 family and participate in the industrialization and serial production of Airbus A350 XWB work packages.
Hafei Company	Wing-to-body fairing panels	Boeing 787	The company is affiliated to the Chengdu Aircraft Industrial Group based in Sichuan Province, China. Hafei's capabilities include composite and sheet metal manufacturing, numerically controlled machining, tooling design and production, and complex structure assembly and integration. Contract signed 2005.
Hong Yuan Aviation Forging & Casting (HYFC)	Titanium forging parts to mount engines onto wings	Airbus A318/A319/ A319CJ/A320/A321	
	Titanium forgings	Boeing 747-8	There are 12 forgings for each Boeing 747. Deliveries began in 1984. Contract signed in 1995.
Shanghai Aviation Industries Group (SAIC)	Horizontal stabilizers	Boeing 737-600, -700, -800, -900	
	Parts for vertical fin, horizontal stabilizer	Boeing 737-600, -700, -800, -900	SAIC, XAC, and BHA are cooperating on this contract.
Shenyang Commercial Aircraft	Aft fuselage subassemblies	Boeing 737-600, -700, -800, -900	Originally contracted for 1996/2001, expanded to include "Texas Star" (November 2004), contracted with Spirit, expanded to full aft section 48 (2007)
	See comment	Bombardier C Series	SAC is a risk-sharing partner in the design, manufacture, assembling, and testing of the aircraft's fuselage. The contract follows a June 2007 memorandum of understanding on the C Series. Just over 10% of the C Series aircraft will be manufactured in China by Shenyang Aircraft. Shenyang also supplies the empennage, as well as the aft and forward fuselage sections for Bombardier's Q400 turboprop airliner.
	Various components	Bombardier Dash 8 Q400	Shenyang Aircraft (part of AVIC-I) and Stork Aerospace signed a contract in 2005 for the machining of components for the Gulfstream G450, the G500, and the G550. The order relates to components for the aircraft that were formerly produced elsewhere.
X'ian Aircraft	Access doors	Airbus A318/A319/ A319CJ/A320/A321	
	Electronic bay doors, wing fixed trailing edges	Airbus A330/A340	
	Fuselage section 16 Vertical fin	ATR 42-500/72-500/600 Boeing 737-600, -700, -800, -900	
	Fixed trailing edge wing ribs	Boeing 747-8	Contract signed in 2007, first delivery 2008, and inboard flaps contracted in 2007, first delivery in 2009

A-320

A tale of two helicopters

The EC175 program was launched on December 5, 2005. The helicopter was developed in cooperation with Chinese industry in just four years, thanks to innovative new computing tools that offer major time savings. The work teams, separated by some 10,000 km, have been working together under the aegis of the French and Chinese governments. Their cooperation has been exemplary, and has benefitted from 30 years of close ties between the partners, first through the Dauphin and then through the EC120. During the development phase, an average of 50 Chinese employees joined their Eurocopter colleagues in France to define the helicopter's characteristics.

Now it's the turn of Eurocopter's employees to reciprocate, and a staff of 30 is currently on permanent assignment in China to assist the teams with design, quality, production and procurement work.

The development and industrialization work has been equally split between Eurocopter and AVIC according to the specialties of each company. Two different helicopters will result from the common platform: The EC175, manufactured, sold and maintained by Eurocopter in Marignane, and the Z15, manufactured, sold and maintained by the AVIC Group.

Z-15

rior structures. This expertise has allowed Chinese concerns to widen their customer base from airframers such as Airbus, Boeing, Bombardier, and Sikorsky to prime contractors like Spirit and Fokker-Elmo.

At the same time, the number of joint ventures between Western companies and Chinese concerns, based in China, has mushroomed over the past two years.

It is not hard to see why. According to Airbus' September 2009 Global Market Forecast, China's aviation market will see an annual increase of 7.9% in the next 20 years, becoming the world's second fastest growing market after India. The Asia Pacific market, including China and India, is forecast to account for 31% of all global demand by 2027. AVIC is predicting that in the next 20 years China will need 3,815 airliners, comprising 2,822 aircraft of 100 seats or more and 993 regional jets.

According to the Center for Asia Pacific Aviation, passenger numbers have been growing at over 10% a year in China (2009 measured against 2008) at a time when most areas of the world have seen a decline.

COMAC's progress

In the civil market, the litmus test for whether China's aerospace capabilities really have reached those of the West will be the success of the COMAC 919. According to the current schedule, the 190-seat aircraft will be on the market by 2020; concept design and research will be completed in 2010, and production will start in 2014.

The C919 is being developed as a competitor to the Airbus A320 and Boeing 737s and their successor programs. It is the most ambitious Chinese civil aviation program to date; the aim is to produce an aircraft that is 15-20% cheaper to operate, in terms of direct operating costs, than the current A320s and 737s. While the aircraft is aimed primarily at the Chinese domestic market it will also be made available to a wider audience and will therefore be a direct competitor to Airbus and Boeing in the most lucrative area of the market. How will it fare?

"Given that both Boeing and Airbus are improving the efficiency rate of their current models by around 1% a year—in terms of fuel burn—Chinese companies have a tough task," says Ian Lowden, managing director of U.K. aviation consultants RDG Solutions. "The current designs for the C919 look fairly conservative, and there is likely to be a high percentage of metal on the aircraft, rather than lighter composites. However, if timing of the launch can be managed so COMAC has access to new engine technology such as the geared turbofan—which could provide an immediate 10% minimum improvement in fuel burn over current designs—and Boeing and Airbus delay further their narrowbody replacement programs, it seems that there could well be a niche in the global market for this aircraft."

K-8 Trainer

Labor and raw material costs are lower in China than in the West, but others, such as transport and oil costs, are similar. COMAC will have cut its project management teeth on the ARJ-21, a 90-seat regional jet that took to the skies for the first time in November 2008. The ARJ-21 is very much a joint Chinese-North American effort. The core design is based on an MD-80 configuration. Canada's Bombardier is a lead partner, and most of the main systems have been sourced from U.S. companies—the flight deck comprises Rockwell Collins displays and avionics; Honeywell is providing the fly-by-wire flight control system, General Electric the CF34-10A engines, and Parker Aerospace the fuel systems.

At the end of 2009 COMAC reported 90 orders for the aircraft, mainly by domestic Chinese airlines. But there are also orders for two aircraft from Lao Airlines of Laos, and for five, with options for 20 more, from GE Commercial Aviation Services, the U.S./Irish leasing company.

New aircraft reflect military shift

Another recent export success for China has been the sale of Chengdu Aircraft Industries JF-17 and J-10 fighters to Pakistan. The agreement, announced in March 2009, will see 42 JF-17 aircraft jointly produced in Pakistan and China and exports of J-10s to Pakistan from China, probably starting in 2014. Pakistan could buy up to 150 JF-17s equipped with Western avionics and weapon systems.

AVIC is aiming the JF-17 and J-10 at other export markets. Also in the planning stages is the J-10B, an export version of the J-10 with upgraded avionics and weapon systems. Another new Chinese military export hope is the Hongdu Aviation Industry Group's advanced jet trainer, which was displayed for the first time publicly outside China at the November 2009 Dubai Air Show. Aimed at advanced training, lead-in training, and close air support markets, the aircraft features fly-by-wire and digital cockpit systems and two Ukrainian-built Ivchenko Progress AI-222K-25F turbojets, giving it a maximum speed of Mach 1.4. Other new export aircraft featured on the AVIC exhibition stand included the FTC-2000 supersonic trainer, the K-8 Karakorum jet trainer, the Z-11 multipurpose light helicopter, and the JF-17.

ASN-207

All of these aircraft are aimed at countries in Africa, the Middle East, South America, and Southeast Asia, which have difficulty accessing U.S. and European technologies.

But their development also reflects a fundamental change in direction for China's own military strategic thinking. China's military forces are undergoing a rapid transformation, from a manpower-intensive force set up primarily for defensive operations to a smaller, more flexible force with more offensive capabilities. For the PLAAF this has meant reducing reliance on large numbers of Soviet aircraft and developing a smaller air force based on indigenous technologies, capable of network-enabled operations.

So the last few years have seen the development of new AWACS, air-to-air refueling, and UAS. China has throttled back its reliance on Russian platforms—though it purchased 24 Sukhoi SU-30-MK2s in 2004 and still depends on Russian and Ukrainian engine technology for many of its military programs—investing instead in Chinese military technologies that do more than just mimic Western models.

The JF-17 and J-10 are entering the PLAAF in increasing numbers, the Shaanxi Y-9 medium-range military transport—a C-130J equivalent—is currently under development. In the helicopter sector the Zhi-15 (Z-15)—a 6,000-kg-class transport helicopter jointly developed by HAIG and Europe's Eurocopter—is due to enter military service around 2012—and the Z-10, an attack helicopter, is under development by Changhe Aircraft Industries. In June 2009 over 100 aircraft—including air-to-air refueling and AWACS aircraft—took part in an exercise to demonstrate new, long-range strike capabilities based on indigenously built platforms. The next phase of development will be to increase networking capabilities for air- and space-based operations, according to PLAAF Commander Xu Qiliang, speaking to the official Xinhua News Agency at the start of November 2009.

The sight of Xi'an ASN-207 tactical reconnaissance UAVs within the October 2009 Beijing parade of military vehicles suggests these assets are already being integrated within the PLA's operational structure—the next stage will be the development of Chinese-built high-altitude, long-endurance UAVs and unmanned combat air vehicles (UCAVs). The appearance of several concepts for both at the 2006 Zhuhai air show—including a stealthy Anjian UCAV Shenyang—suggests this is now an area of some priority for the nation's aerospace companies.

Space projects

To develop further a network-enabled military capability, China is also investing heavily in new space systems.

Its heavy-load launcher ChangZheng 5 (Long March 5) is due to be test flown in 2014, and its most capable form will be able to lift payloads of up to 25,000 kg to LEO or 14,000 kg to GTO. This year more satellites will be added to the BeiDou network until it provides a global satellite navigation capability between 2015 and 2020.

In 2003 China launched its first manned spacecraft, ShenZhou 5, followed by other manned spaceflight missions in 2005 and 2008; if the planned spacecraft docking systems work this year as intended, China will launch a space lab in 2012, around the time it plans to put an astronaut on the Moon. Other work is under way to develop more capable Earth observation assets—and, based on the remarks of PLAAF Commander Xu Qiliang in November, a greater military capability.

The speed with which China has acquired this broad range of aerospace capabilities is remarkable. At the current rate of progress it is likely that in most sectors China will be able to compete on broadly equal terms with the West by 2020, if not before. During the past 18 months it is China's banks and Chinese aircraft orders that have provided vital support to civil aviation industries of the U.S. and Europe; China is a market that can simply no longer be ignored. The real issue for aerospace concerns in the West now is to develop a framework in which competition, at least for civil aircraft orders, can develop along commonly agreed lines.

New capabilities for GPS II/III

GPS III (Increment A)

by J.R. Wilson
Contributing writer

While the Global Positioning System seems ubiquitous today, nearly two decades elapsed between the launch of the first experimental GPS satellite and the 1995 declaration of a fully operational system for military and civilian use. Since then, GPS satellites have been upgraded constantly, with each new generation providing greater power and precision. The system has grown from a minimum constellation of 24 spacecraft to the 30 in orbit today, and plans call for maintaining the current number.

In some ways, the evolution of GPS resembles that of the Internet. What began as an Air Force positioning, navigation, and timing (PNT) program for the military has expanded so widely that civilian applications now outnumber military, and the system is used more for timing than for navigation. From turn-by-turn driving directions to pinpointing individual whales at sea to time signals for bank ATM machines, GPS applications have seen a significant transformation, especially in the past decade.

"Unlike a lot of other satellite constellations, GPS affects a tremendous number of users, so there is a constant vigilance on the part of the Air Force to ensure any changes made do not disrupt those users," says Lockheed Martin GPS III program director David J. Podlesney. "They go through great pains to make sure they accommodate all end users worldwide.

"From originally looking at [military] navigation requirements, GPS today has transformed into a system where the primary use is the civil timing signal, and most navigation users are commercial. This new group, which was not originally imagined, is now the biggest component of the GPS user community, and the military is really the smallest user."

It remains a military system at heart, however, under control of the GPS Wing of the Air Force Space Command Space and Missile Systems Center (SMC). And although the U.S. government has repeatedly assured civilian and commercial users throughout the world the system will not be degraded to nonmilitary

Like the Internet, GPS has undergone a transformation never envisioned when it was created. Although more vital than ever to the military, the system now has more civil than military users. If glitches and potential delays can be averted, new satellites will soon provide even greater capabilities.

users (as it originally was), nor arbitrarily shut off for military reasons, this subject has remained an issue blocking full acceptance.

Importance of security

Given the critical importance of GPS to the military, which relies on it for close tracking of assets in an often confused battlespace, and for the viability of its growing arsenal of precision-guided munitions, the security of the constellation has never been of greater concern. As the civil world also looks to a future increasingly dominated by GPS, those concerns only broaden.

"GPS security features have evolved to safeguard U.S. and allied forces and protect authorized GPS operations," according to Col. Donald Wussler, who was deputy commander of the GPS wing before his promotion to director of development planning for SMC in May. "GPS security features enhance weapons delivery and, as a byproduct, minimize collateral damage."

The current GPS security architecture includes the selective-availability antispoofing module (SAASM) capability. Since selective availability was turned off in May 2000, SAASM's primary benefit has been for antispoofing based on unclassified National Security Agency "black" cryptographic keys, which enable flexible handling options such as over-the-air distribution of keys. SAASM keys also are uniquely associated with distinct user groups, each on a separate cryptographic network. There are more than 100,000 such SAASM receivers in use by U.S. and allied forces around the world.

"GPS Block II modernized satellites and Block III satellites will broadcast the military code [M-Code] signal, with added protection—including expanded cryptonets, secure acquisition, special messaging, and next-generation cryptography," Wussler tells *Aerospace America*, adding that the Block III security architecture beyond SAASM is called PRONAV (protection of navigation).

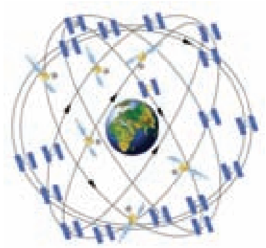
"The PRONAV security architecture will protect GPS mission effectiveness through application of defense-in-depth information assurance principles. PRONAV security relies on more than cryptography and uses additional technological methods and operational techniques to assure the integrity of GPS signals. PRONAV also allows innovation in tailoring a multitude of protection measures to different GPS applications, environments, and emerging threats. The end result is a fully modernized, robust security architecture that will protect U.S. and allied forces and GPS operations."

Evolving technologies

Last August, the Air Force launched the last of eight Block IIR-M replacement satellites and is now preparing to launch the first of 12 Block IIF satellites this year. Those are to be joined, beginning in 2014, by a substantially upgraded Block III generation, which itself will advance through three stages of evolution.

The IIR-M satellites added a new M-Code on both the L1 and L2 channels and a more robust civil signal (L2C) on the L2 channel in addition to the existing L1 C/A signal. The Boeing-built Block IIF satellites will have an extended design life of 12 years (the original satellites were designed for about 7.5 years in orbital operation), as well as more memory, faster processors, and a third (L5) new civil signal that will enable improved accuracy for many users.

"Civilian users, whether U.S. or international, will be unaffected by changes in the GPS security architecture. Instead, civilian users will have access to more civil signals from a more robust GPS constellation—four civil signals from Block III satellites—with un-



"GPS III is probably best characterized as being a third-generation system where the focus is on improvement and modernization; the only two second-generation global SatNav systems in operation today are GPS II and GLONASS."

Col. Donald Wussler, former deputy commander, GPS Wing
Air Force Space Command Space and Missile Systems Center

precedented timing performance delivered by improved satellite atomic clocks. As a result, user receivers that process two or more civil signals will achieve much better accuracy by removing the ionospheric error," Wussler says.

"In parallel, FAA is working to add L5-augmentation to their wide-area augmentation system to improve reliability and robustness for properly equipped users, especially safety-of-life applications for commercial aviation."

John Duddy, who was director of GPS programs at Boeing Space and Intelligence Systems before being put in charge of all Boeing programs in Australia, explains how the L5 signal will be used by aviation services, including, eventually, air traffic control (ATC).

The GPS Block IIF follow-on satellite design features increased signal strength.

"ATC is a ground-based system, but could someday go to a GPS-based system. Right now, it augments the existing system," he tells *Aerospace America*. "The FAA is looking forward to the L5, which is a long-term strategy for them and allows them to start testing out various future applications.

"In addition, the signal itself will allow for a more precise read, although that accuracy is still up to the Air Force. And it helps provide a more precise location fix. In some areas, such as city centers with tall buildings, where it is harder to get a good fix, the increased signal strength from Block IIF will help that."

GPS IIIA, being built by Lockheed Martin, will transmit another new civilian signal (L1C) and include a new M-Code antijam capability to enhance military security and capability. Three increments are planned for GPS III, each adding new capabilities as technologies mature.

"GPS IIIB satellites will enable a cross-linked command and control architecture, allowing the entire GPS constellation to be updated from a single ground station instead of waiting for each satellite to orbit in view of a ground antenna. GPS IIIC satellites will also deliver greater M-Code power for increased resistance to hostile jamming via a high-powered spot beam," Wussler says.

"All users, military and civil, will receive improved accuracy integrity and assured availability. GPS III satellites will also transmit a new civil signal, L1C, which is compatible with the civil E1 signal that will be broadcast by the European Galileo satellite navigation [SatNav] system. L1C is also compatible with signals planned for broadcast by Japan's Quasi-Zenith Satellite System."

Interoperability issue

Those other systems—including the Russian GLONASS satellites—are seen as complementary to GPS, one reason the new satellites have enhanced interoperability, Wussler says. Galileo and China's COMPASS are considered roughly equivalent to GPS I, which was a first-generation developmental system, while GPS II and GLONASS are recognized as the only second-generation (operational) global SatNav systems.

"Galileo sees [itself] as independent, but if you have a full constellation of Galileo satellites and a full constellation of GPS, interoperability becomes important in providing a better and more powerful signal strength for the world," Duddy says. "COMPASS is still working out the interoperability piece, from what I understand, but they apparently don't consider that as important. GLONASS is struggling along, but working cooperatively to assure compatibility."

Wussler says the GPS program will continue to work diligently with other SatNav systems as each evolves to the next generation, with a goal of achieving as much compatibility and interoperability as possible to provide civil users worldwide with the best possible combined PNT service.

"We see GPS II as being today's preeminent space-based PNT system. The deployment of GPS III will guide the world to a higher level of space-based PNT. While it's difficult to predict the course that other global SatNav systems, or even regional/local augmentation systems, will follow in the years to come, we hope that GPS III will be joined by interoperable and compatible space-based PNT services," he says.

"Increasing GPS security for military users should have no effect on the civil prospects for other SatNav systems since SAASM, M-Code, and PRONAV have no impact on GPS civil signals. Increasing GPS accuracy and integrity, along with new GPS civil signals, will boost the GPS prospects for working effectively with other SatNav systems. New GPS signals have been designed to work either individually or in concert with other systems."

Civilian perspective

From the civil user community perspective, having multiple systems available is a major plus, according to Basil Barimo, vice president of operations and safety for the Air Transport Association (ATA).

"We would love to see a redundant satellite network that, if one turns off, you can switch over to the other and keep going," he says. "We would like for airplanes to determine which satellite signal is right and step through, in priority order, to get what they need from wherever they can get it, without any interaction from the flight crew.

"ATA believes these should all be interoperable systems, so when an airline purchases an aircraft and equips it to operate, either domestically or internationally, they don't have to install multiple sets of equipment to operate in different parts of the world. We would like to see compatible systems so a single nav system can be put on the aircraft and do what it needs to do regardless of where it is in the world."

What the future actually holds for satellite-based ATC, however, remains an open question, adds Barimo.

"The alternatives today are to maintain some kind of ground network, which is fine for the U.S. And as we make this transition, that will be the case. We won't do anything abrupt or risky in the commercial aviation world," he says.

"So we will hang onto ground infrastructure for some time and will operate a system that relies on both and has the ground system as a backup. As we become more comfortable and confident with satellites and address some of these security issues—which are very real—we gradually will migrate away from the ground system, even as a backup, which is ultimately where we need to be. But that isn't anything that is going to happen in the near future."

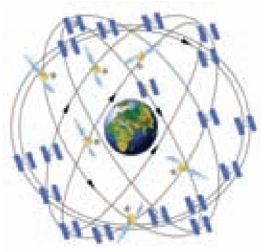
Warnings and responses

Last May, a Government Accountability Office (GAO) report caused a considerable stir in Congress and the international GPS user community with warnings of potential launch delays for GPS III and both space and ground-based problems with the latest GPS II satellites. The report had been requested in the wake of the Air Force's October 2008 biennial report to Congress, which restated previous concerns about the current constellation and the impact of any future delays.

"Of the 31 GPS satellites currently on orbit, 20 are past their design life and 19 are without redundancy in either the navigation mission equipment or the satellite bus or both," the USAF document stated. "Should GPS IIF launches be delayed, sustainment of the GPS constellation will be difficult and the [U.S. government] could fail to meet performance levels prescribed in published federal plans and standards."

The Air Force and Boeing both responded quickly to the GAO follow-up, which actually did little more than repeat USAF "worst case" scenarios that any significant delays or malfunctions in the GPS IIF or III programs could diminish the quality of service.

"We are working through some remaining challenges prior to the delivery of the first GPS IIF satellite and have made great progress while keeping the right focus on mission success. We are planning to launch the first of the 12 GPS IIF satellites in early 2010," said a July 7 statement from the GPS Wing. "SV2 will be scheduled based on constellation sustainment needs, but is not projected for sooner than 6-9 months after the first launch. We have ample satellites in the near term; we currently have 30 satellites on



"Under the original [GPS IIF] schedule, we were supposed to have launched some time ago, but we had some development issues; we still run into issues from day to day, which is typical on any program, but I believe all the technical issues are now behind us."

John Duddy, former director of GPS programs
Boeing Space and Intelligence Systems

The GPS Block IIR-M replenishment satellite design has modernized features.

orbit and operational today. Users can rely on GPS with confidence today and will continue to be able to do so in the future.

That sentiment was echoed in a simultaneous official statement from Boeing:

"Working very closely with the Air Force and its team, Boeing has taken aggressive steps to resolve the technical issues on IIF with a strong emphasis on mission assurance. Design changes were required to ensure performance over the satellite design life and have caused schedule delays, but these changes are in the final phase of implementation, and a fully integrated satellite (SV1) has already successfully completed the thermal-vacuum test program—the most stressing system level test. SV2 was shipped to the Cape on May 6 to perform system-level compatibility tests and serve as a risk reduction pathfinder for SV1 processing later this year."

Lockheed Martin Space Systems, meanwhile, was successfully completing a major GPS III milestone—the preliminary design review phase in May—and entering the follow-on critical design review (CDR) phase. That actually is a year-long series of 70 individual CDRs for key spacecraft subsystems, assemblies, and elements by Lockheed Martin and its industry partners, ITT and General Dynamics. Those are scheduled to conclude in the fall of 2010 with a final space vehicle CDR to validate the overall GPS III design for both military and civil requirements.

"The launch schedule for GPS III certainly will maintain the current numbers [of operational satellites in orbit], but the more vehicles there are in the constellation, the better coverage and accuracy users on the ground have," Podlesney told *Aerospace America* in mid-July. "Before we get through the development phase, the option rate is four per year. They can authorize two at a time, usually in January and July, although they can choose to exercise options earlier. It also depends on constellation health—these are planned more for launch-on-need rather than demand.

"They will support the existing constellation; part of the requirement is to be backward compatible, with all the signals of the current constellation, but also forward compatible. The uniqueness of the III contract is it is a three-phase approach, not biting off the IIIC requirements right up front, but doing an incremental approach with A and B. So A needs the hooks to make it forward compatible, that is, a big enough structure to accommodate the IIIC systems, with weight and space area so we don't need to change the basic satellite structure, change harnessing, or move components within the vehicle to make that happen."

Block III advances

In addition to some new signals and increased power, the Block III satellites eventually will bring significant advances to both civil and military capabilities.

"Ultimately, the IIIC will enable a regional spot beam, substantially increasing the military signal for areas of concern. To do that, you must be able to command the vehicle with a more robust crosslink across the constellation, which will be added in with the IIIB, giving us better telemetry," Podlesney explains, adding that the advanced IIIC capabilities eventually will become the GPS standard. "The vehicles eventually wear out and, although most have lasted well beyond their design life, they ultimately will fail, and replacements will be needed."

The current plan calls for up to 12 GPS IIIA launches, beginning in 2014, followed by eight GPS IIIB and 16 GPS IIIC satellites, eventually replacing all previous models and sustaining the system through 2030.

"From an overall perspective, what we now have is a logical progression toward a full constellation of GPS IIIC capabilities. It is the government's call, however—if they decide they prefer the newer capabilities, they may decide to launch on demand as opposed to on need," Podlesney concludes.

"The government's plan is not necessarily to exercise all 10 IIIA options (beyond the two now under contract) before switching over to the IIIB. They have structured the program with enough latitude to continue A, if they want, or, if we are finished with the development aspects, we can implement the B earlier. It all revolves around funding and performance levels, but the government has structured it with flexibility in terms of how they authorize things."

Forecasting turbulence over the seas

by J.R. Wilson
Contributing writer

Turbulence, the leading cause of injuries in commercial aviation, is a particular concern for transoceanic flights, in remote areas where the phenomenon is often worst and pilots have little information. NASA and NCAR (National Center for Atmospheric Research) are working to develop a prototype system to enhance the weather information available to pilots flying over these remote ocean regions.

GATDSSA, the Global Atmospheric Turbulence Decision Support System for Aviation, project will use computer weather models, satellite data, and state-of-the-art artificial intelligence techniques to create a picture of developing storms and other potential causes of turbulence.

"One of the goals of providing automated weather information is to make better planning decisions on where to route aircraft in the first place, then give everyone—pilots, air traffic controllers, dispatchers—a common view of weather." – JOHN WILLIAMS

When a cumulus cloud becomes vertically developed and dense enough to produce lightning, it is termed a cumulonimbus, or thunderstorm, cloud. The bulging, puffy, cauliflower shapes (left) and the well-developed anvil (right) indicate that this cloud has reached maturity. Copyright University Corporation for Atmospheric Research.

Researchers are developing techniques to give pilots earlier warnings of turbulence in remote areas on transoceanic flights. Until now, little information has been available in these regions, and pilots have had to rely on reports from other aircraft or on satellite data. NCAR is combining advanced technologies and computer modeling to develop clearer pictures of developing storms and other hazardous conditions.

"Oceanic weather is hard, because there isn't any weather radar over the ocean; all we have are pilot reports and satellites," notes John Murray, advanced satellite aviation-weather products (ASAP) project manager at NASA's Science Mission Directorate. "In the past five years, we have developed a lot of tools to improve convective weather and turbulence forecasting, primarily over CONUS [continental U.S.]. Now we are trying to integrate these tools to deal with the oceanic turbulence problem.

"We have given NCAR a number of grants in the past five years to develop and prove convective weather and turbulence products using satellite data. Many of those were joint with the University of Wisconsin, the University of Alabama-Huntsville, and MIT's Lincoln Laboratory. For example, the $912,000, three-year grant we issued to NCAR in July to study oceanic convection and turbulence is an effort to bring together all of the tools developed in the previous five years of ASAP studies."

Guidance for better decisions

The GATDSSA study is focused on improving turbulence decision support systems for pilots, using satellite data to address and improve information the U.S. provides to two world area forecast centers, in London and Washington, D.C. Those centers send out significant meteorological reports (SIGMETs) every four hours and significant weather charts every six hours for preflight briefings to pilots on overseas routes. The intent is to provide more rapid updates and enable pilots en route to request SIGMET updates.

"Sometimes we call it global GTG [graphical turbulence guidance], a play on the CONUS GTG," Murray says, referring to information currently derived from ground-based radars and satellites. "We are aligning this with the U.S. NextGen [Next Generation Air Transportation System] effort, part of which is to provide a 4D weather cube—time dimensions with diagnosis and forecast.

"Our forecast will run from 0 to 36 hr, including 0-3-hr 'nowcasts' that include thunderstorm locations and intensities we can use to derive a probability of convectively induced turbulence. That is one of three major sources of upper atmospheric turbulence—the other two being mountain wave turbulence and clear air turbulence, which is associated with jet stream upper level fronts and shears."

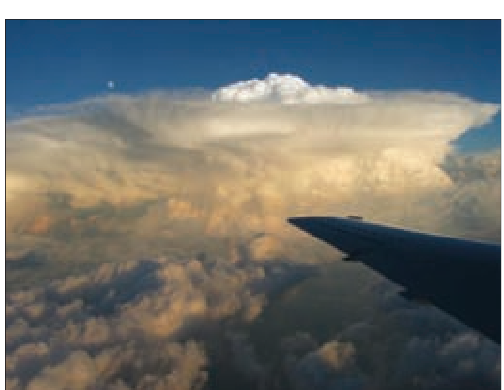
GTG is an "expert system" that combines information

"This new work to detect the likelihood of turbulence associated with oceanic storms using key space-based indicators is of crucial importance to pilots." – JOHN HAYNES
program manager, Earth Science Division's Applied Sciences Program, NASA

Studying developing thunderstorms on land will aid in predictive modeling capabilities. Image courtesy North Dakota State Climate Office.

from a variety of sources that is then weighted based on reliability, timeliness, and other factors. Satellite data can be the first indication of possible trouble in areas without radar coverage or regular traffic routes, filling in data gaps through examination of such things as gravity wave patterns in clouds; turbulence often is associated with breaking waves. Another technique called "random forests," first identified in 2001, also can be applied, according to John Williams, NCAR's GATDSSA project lead.

"The basic idea is to take a set of data in which you associate a number of predictors with a predictant—in our case, taking various environmental and observational features of a thunderstorm and associating that with an aircraft observation of turbulence. Then build an empirical model that maps the observables and models data to a prediction of the turbulence," he says.



Overshooting tops can provide strong evidence of turbulence.

"That works by taking a set of data and training an ensemble of decision trees, each on a random subset of the data and only allowed to use a certain number of predictors. You train up about 200 decision trees, each able to vote on the classification of a new situation and, based on the distribution of those votes, you can relate to a probability of where turbulence is likely to be. That seems to be working pretty well, although we haven't applied it yet to the global turbulence problem—just to predicting thunderstorms over the U.S. and convective turbulence."

Spotting clues

Another useful weather feature is called overshooting tops—cloud towers that have punched through the general cloud top, indicating the greatest area of strong updrafts and, if associated with precipitation, leading to strong downdrafts and so a good chance for severe turbulence. Other factors, such as features associated with the jet stream, also are considered, because turbulence itself is too small to be seen.

"The average area of turbulence is only about 10 to a few hundred meters, and satellites can only see [weather] features down to about 1 km in length or breadth—but we can see areas where turbulence is likely to occur," Murray explained. "So a main satellite function is actually to help us rule out areas least likely to have turbulence.

"Turbulence actually is most damaging when the area is about the same size as the aircraft itself. If you have an area that is very strong and only 100-1,000 ft long, all that energy is concentrated like a punch. And that's where people standing in the aisles hit the top of the cabin when the aircraft drops or rises abruptly."

Part of the current NCAR effort is to study more closely elements associated with thunderstorms over land, such as height, size, and intensity, and how they are likely to be related to turbulence, then apply those measurements to satellite data. Because ground-based radars and other measurements used in the forecasting methodology over land are not available over water, identifying commonalities that can be seen with both is crucial to enhancing oceanic forecasting.

Aid from advanced space systems

Advanced satellite technologies now coming online or due in the near future also will substantially improve weather-related data available to turbulence prediction and detection. For example, the MODIS (moderate resolution imaging spectroradiometer) imager now flying on NASA's Terra and Aqua Earth orbiting satellites can see down to 250 m, very close to the scale of turbulence.

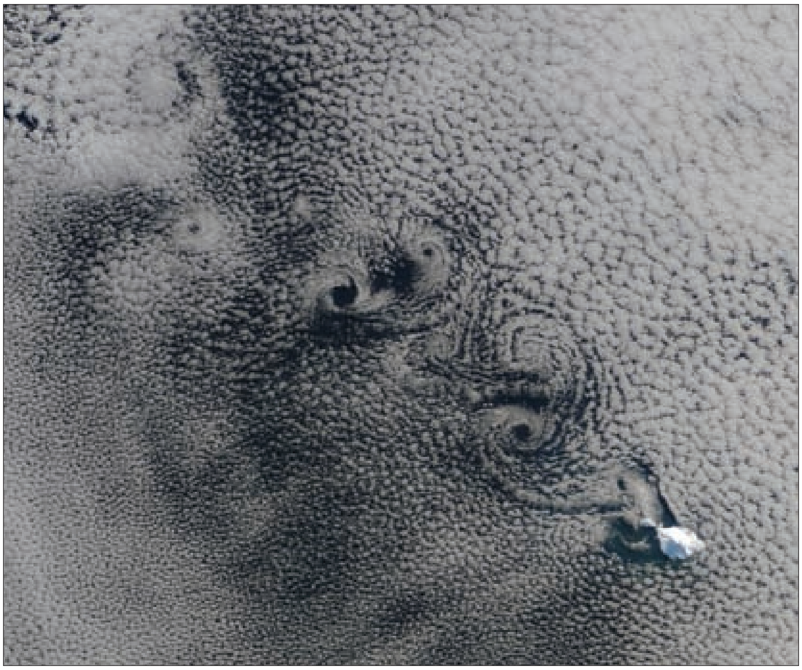
Higher resolution sensors coming online include imagers that look at visible light, providing not just pictures but energy measurements at different wavelengths. By looking at the differences in multiple data channels, researchers can tell if the cloud tops are cooling quickly, indicating rapid convection. Other sensors called sounders look at the infrared portion of the spectrum, providing information on relative humidity and temperature at different altitudes. Balloon sounders currently are used for that, along with some on satellites, but future satellite sensors will be much more sophisticated.

"In a few years, we will have even higher resolution imagers on the GOES series; around the midteens, the GOES-R satellite will have an advanced imager, and eventually these experimental sensors will become standard," Murray says. "GOES-R also will have a lightning sensor, and the polar orbiting satellites will have instruments measuring profiles of temperature and water vapor—the starting point for all weather forecasts.

"If you look at the GTG model, it starts out using information from NOAA's rapid update cycle," Murray continues. "The RUC tells the temperature and water vapor levels for the next 6 hours and is the finest resolution instrument we have for that. By looking at the RUC profiles, the GTG can tell what the stability of the atmosphere will be at a particular location."

While NASA satellites are being used in developing the system, Williams adds, they will serve primarily for verification and tuning, rather than data-gathering, in an operational system. "We are using primarily operational environmental satellites, such as NOAA's GOES, and hope to use the European MediaSat and Japanese 1R satellites. The NASA satellites are, by and large, polar orbiters and make occasional stripe measurements, so we really can't base a product on them," he says.

"But we can use some advanced NASA research satellites to verify the products we develop based on the others. For example, there is a satellite with a down-pointing radar that can really characterize what the storms look like as it flies over that strip; we can use that to verify that the information we have on that storm, based on the environmental satellites, is correct."



MODIS can see down to 250 m, very close to the scale of turbulence, and so aids in turbulence prediction.

The size factor

Because of the actual size of areas of turbulence, the impact varies greatly with the size of the aircraft—as does the best course of action for the pilot to take.

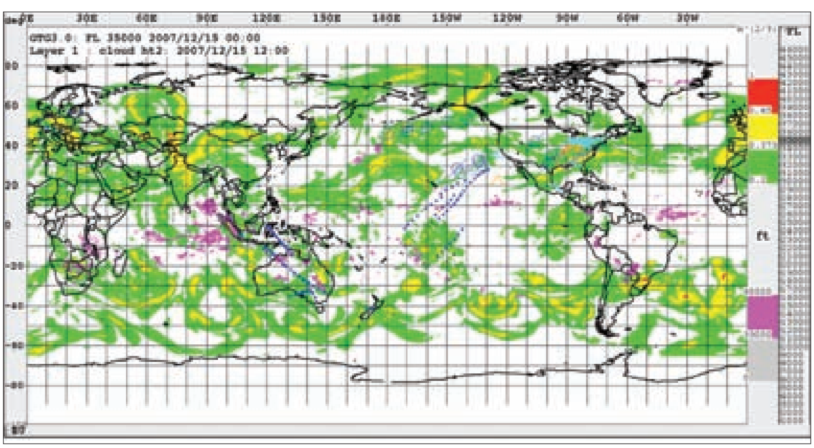
"Turbulence operates at the scale of the aircraft, so if the area of turbulence is smaller than the aircraft, it might be felt as just a little high-frequency chop, where an aircraft the same size as the turbulence would have a much higher level of problem," Murray explains. "The size of the aircraft and its configuration, amount of fuel, whether it has passengers or cargo, all change the loading. What a 747 might not even feel or a 737 might feel as light to moderate turbulence, someone in a smaller aircraft might experience as severe turbulence."

"For nonfatal accidents, turbulence is the number-one cause of injury to flight crews and passengers, especially flight attendants, who spend so much time on their feet." – JOHN MURRAY

Thus the cost of diverting may be significantly higher than the benefit of any evasive action for a "big heavy" than for a lighter aircraft. In addition, some new aircraft are designed with some measure of turbulence mitigation built in, so even if all other factors are identical, the pilot of a new model might make a different decision from the one made by the pilot of an older aircraft from the same family.

Researchers also are developing or enhancing other ways to measure encountered turbulence and determine the best approach for a variety of aircraft that may be on course to encounter it next.

"In-situ turbulence reporting is a system developed by NCAR to turn the airplane into a turbulence monitor," Williams says. "That uses the eddy dissipation rate [EDR]—measuring the rate at which energy flows from large-scale forcing mechanisms down to smaller scale eddies. The scaling from EDR to a particular aircraft depends on its speed, weight,



The GTG combines and assigns weight information from a variety of sources.

and wing area. We take the reporting aircraft's independent measurement and can scale it back to apply to any particular aircraft type and operating conditions.

"That gives us routine, objective measurements of turbulence, which are key to developing relationships of what can be measured by satellite, from the global forecast system model and the aircraft measured turbulence, using AI [artificial intelligence] techniques to sort through all this data and uncover those relationships, which we then will apply globally."

Communicating the results

Currently, the global forecast model run by the U.S. National Weather Service provides 3D forecasts of wind, temperature, stability, humidity, and other environmental features around the world. The data will be used to derive diagnostics of turbulence and combined to form an estimate of where it is likely to occur.

"So the various satellite systems, the AI methodology of random forests, etc., are put together, using some pretty fast computers to process it all with minimum latency to get information to decision-makers. In a year, we plan to demonstrate cockpit uplinks of customized maps of turbulence ahead of oceanic flights; for that, we send a text message to ARINC that will be downlinked via satellite to the ACARS [aircraft communications addressing and reporting system] printer, which is an enabler for that cockpit uplink," he says.

"We will have a Web link for pilots to review the messages they receive and provide feedback. We also will have a Web-accessible link, using Java, based on a system called the Aviation Digital Data Service, for dispatchers, air traffic controllers, and anyone else interested, but next year probably only visible to selected United Airlines dispatchers. It will be a few years before it would be FAA approved and publicly accessible."

The system is being designed to avoid the need for any additional cockpit hardware, Williams adds, although additional pilot training may be required down the line.

"We're doing our best to focus on the atmospheric science problems of predicting thunderstorms and turbulence, making use of available data feeds and technologies, such as uplinking a text graphics map to ACARS," he notes. "We would prefer a graphical color map, but we're focusing on the aviation weather problem, not the dissemination problem. So it will print out on the same strip printer as other ACARS messages in the cockpit, which is a new use of an existing product.

"We hope, in two years, we can make the system available to the FAA for evaluation as part of the NextGen operational capability in 2013, where it would be run routinely by the FAA Tech Center or National Weather Service. The grids would be made available for airlines or private vendors to use as they see fit. We hope that will mean inclusion in electronic flight bags currently under development to provide pilots with graphical displays of a variety of weather data in the cockpit—and that certainly will require some additional pilot training."

At the same time, any such system will have to avoid creating information overload for the pilot.

Managing the load

"One thing we studied under our last aviation weather program was how much of a pilot load, with respect to weather [information], can be managed effectively. We learned it is best to give a pilot only what he needs. He

"Our goal is to give pilots a regularly updated picture of the likely storms ahead as they fly over the ocean, so they can take action to minimize turbulence and keep their aircraft out of danger." – CATHY KESSINGER
NCAR project scientist

has too many other things to manage to be looking at weather maps in the cockpit, so any information you provide has to be very specific and tailored specifically to his need," Murray says.

"This is an evolutionary question. There is an ATC [air traffic controller] there now, because he has information the pilot doesn't. If the pilot has better information, it might be better to let him make decisions now made by others, especially if he can make a better decision. But until the information is better, the workload is divided to take advantage of the fact the ATC knows things the pilot doesn't.

"The whole purpose of NextGen is to use automated tools to help manage this vast amount of information without overwhelming the pilot," says Murray. "As the FAA and airlines examine the quality of information they get through NextGen, the question becomes 'When, and to what degree, do we give pilots more autonomy?' In a typical en route scenario, with aircraft spaced out every 5 mi. and 2,000 ft, if the pilot gets information that would avoid or reduce turbulence, there's no reason not to independently change altitude or heading. Right now, however, there are too many factors to make that determination."

The information now being developed under the NCAR program, together with other NASA, NOAA, FAA, and academic research, has been identified as critical for NextGen, Murray says, and especially for its 4D Network-Enabled Weather System. The long-term goal of that network-centric, Internet-based approach is for every system aboard an airplane to have an IP address, making the relationship between all aircraft, satellite, and ground systems similar to that of all the networked computers in an office.

"NextGen will use a standard database, and all ATM [air traffic management] will be based on a very strict data set, called the single authoritative source. And I tend to think weather information associated with that will be much higher quality and will have some probabilistic components, such as saying, 'Here's where we expect convection to be in 1 hr with 85% confidence and in 2 hr with 35% confidence,' and so on," Murray says.

"That information and those probabilities will be constantly updated and improved, because weather is nonlinear and chaotic, which is why weather forecasts are less reliable the farther out you try to go. If you get one observation just a little wrong, it can throw the whole forecast off."

Parallel efforts

NextGen and its weather component involve efforts by a wide range of government agencies, industry and industry organizations, and academia, including international collaboration. Those range from the FAA, NOAA, NASA, and NCAR to the American Meteorological Society's Aviation Range and Aerospace Meteorology Group and AIAA's Atmospheric and Space Environments Technical Committee to NASA's Aeronautical and Space Operations Subcommittee. Those and others work closely through an interagency/industry partnership program to coordinate their efforts.

That also applies to ongoing efforts in Europe and Asia to develop similar systems, including a global standard to deal with weather information. Thus while each effort is primarily designed to develop a new airspace system for a nation or region, each also must deal with aviation as a global enterprise. The same aircraft may fly through multiple jurisdictions on a single flight, but will need a coordinated set of rules and information provision to do so safely and efficiently.

"I think we can improve safety, efficiency, and passenger comfort by providing an automated system, with minimal latency, to help pilots, dispatchers, and air traffic controllers make better decisions on how to route the aircraft and when to divert or prepare for encounters with pockets of turbulence," Williams concludes.

"Our system will indicate something about storm height and intensity, which includes the hazard of turbulence, but also water temperature and the possibility of hail and lightning. So even though turbulence is the primary goal of our system, if you know where the storms are and their intensity, these other hazards also might be avoided."

Out of the

25 Years Ago, February 1985

Feb. 8 Arabsat 1, the Arab world's first communications satellite, is launched by an Ariane rocket. The satellite was developed by a French consortium. Also launched on the same mission is Brazil's first satellite, Brazilsat 1. However, on January 2, 1986, Arabsat 1 malfunctions and ceases to operate. NASA, *Astronautics and Aeronautics, 1985*, pp. 136, 455; NASA, *Astronautics and Aeronautics, 1986-90*, p. 3.

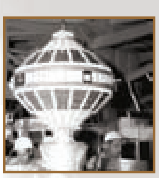
50 Years Ago, February 1960

Feb. 2 Paul Codos, the French flying pioneer, dies in Paris. With others, he set speed and endurance records for distance flights in the 1920s and 1930s. In January 1932 he flew the first flight from Paris to Hanoi and in May 1934, with copilot Maurice Rossi, flew the Atlantic from Paris to New York in a record 38 hr 27 min. *The Aeroplane*, Feb. 19, 1960, p. 215; Paul Codos file, NASM.

Feb. 2 The USAF two-stage Titan ICBM makes its launch from Cape Canaveral, Fla. Both stages ignite successfully and the second stage achieves separation. The first full-range flight of the Titan I is achieved on February 24. D. Baker, *Spaceflight and Rocketry—A Chronology*, p. 99.

Feb. 3 Duane E. Graveline, a doctor at the USAF Aerospace Medical Laboratory at Brooks AFB, Texas, undergoes simulated weightlessness as encountered in space when he is submerged in liquid in a centrifuge and placed in a 5-*g* spin, demonstrating muscle deterioration without exercise. E. Emme, ed., *Aeronautics and Astronautics, 1915-60*, p. 119.

Feb. 4 Scientists at Stanford University report the successful reflection of radar signals bounced off the Sun's corona on April 7, 10, and 12, 1959. E. Emme, ed., *Aeronautics and Astronautics, 1915-60*, p. 119.



Feb. 7 New data from Explorer VII reveals that the outer Van Allen radiation belt rim around the Earth moves as much as 500 mi. north and south in latitude and varies tenfold in intensity within a few hours. E. Emme, ed., *Aeronautics and Astronautics, 1915-60*, p. 119.

Feb. 9 Spacetrack, the National Space Surveillance Control Center, is dedicated at Bedford, Mass. The facility detects, tracks, catalogues, and identifies man-made objects orbiting Earth. These include active or inactive satellites, spent rocket parts, and fragmentation debris. E. Emme, ed., *Aeronautics and Astronautics, 1915-60*, p. 119.

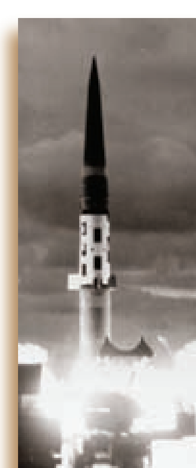
Feb. 11 The X-15 rocket research aircraft makes its third successful powered flight. Pilot Scott Crossfield flies it up to 88,116 ft and reaches a speed of 1,466 mph. D. Jenkins, *X-15: Extending the Frontiers of Flight*, p. 610.

Feb. 16 The Reaction Motors Div. of Thiokol Chemical successfully completes a series of 36 tests of the 59,000-lb-thrust throttlable XLR-99 Pioneer rocket engine

for the X-15 at the Arnold Engineering Development Center at Tullahoma, Tenn. Because of developmental delays with the XLR-99, the X-15 is using the "Interim Engine," consisting of two XLR-11 engines of 8,000 lb total thrust. The XLR-11s are upgraded versions of the engine used in the old Bell X-1 and other early X research aircraft. D. Jenkins, *X-15: Extending the Frontiers of Flight*, passim.

Feb. 16 Plans are announced in Washington, D.C., to use the British solid-fuel Skylark sounding rocket to send U.S.-built instruments 100 mi. into the atmosphere. The U.S. wishes to obtain comparative results of some experiments conducted in different latitudes such as Australia, at whose Woomera facility the rocket is usually launched. *The Aeroplane*, Feb. 26, 1960, p. 256.

Feb. 19 The Discoverer X is launched but does not reach orbit. E. Emme, ed., *Aeronautics and Astronautics, 1915-60*, p. 119.



Feb. 25 The sold-fuel Pershing two-stage medium-range ballistic missile, designed to replace the single-stage liquid-fuel Redstone missile as the Army's primary theater-level weapon, achieves its first test flight from Cape Canaveral, Fla. Named after WW I Gen. John J. Pershing, the missile serves for 30 years. E. Emme, ed., *Aeronautics and Astronautics, 1915-60*, p. 119.

Feb. 26 The newly developed Atlas-

Past

An Aerospace Chronology
by Frank H. Winter, Ret.
and Robert van der Linden
National Air and Space Museum

Agena B vehicle is launched in an attempt to orbit the first Midas satellite, designed to detect hostile ICBM launches. But the second stage Agena fails to separate and the satellite does not go into orbit. *The Aeroplane*, March 11, 1960, p. 328.

75 Years Ago, February 1935

Feb. 1 The annual RAF Middle East Command air display takes place at Heliopolis, Egypt. Prince Farouk, heir to the country's throne, is among the visitors. The flying is reportedly of a high standard, although sand churned up by stiff breezes prevents live parachute drops. Mock attacks on towed targets are made, and the event also features troop-carrying airplanes, aerial ambulances, formation flying, parachute drops of dummies, supply dropping, and other demonstrations. *The Aeroplane*, Feb. 13, 1935, p. 181.

Feb. 3 Hugo Junkers, the German airplane designer and pioneering manufacturer, dies on his 76th birthday in Munich. The son of a mill owner and gas engine manufacturer, Junkers started his own firm in 1895 to make water-heating machines for bathing spas. These were so-called Junkers electric geysers. In 1910 he patented an all-wing aircraft. In 1915 his company made its first all-metal airplane, of sheet steel, and in 1916 made an all-aluminum one. Junkers Aircraft was formally founded in 1919. Closed soon after because of the Versailles Treaty, the company later reopened and became one of the world's great airplane firms. Subsidiaries opened in 1920 in Moscow and Sweden soon after. In 1921, the company started a domestic air service that was later taken over by Lufthansa. Junkers retired in 1932 and devoted himself to scientific experiments and his family. His aircraft played a crucial role in supporting Hitler's ambitions in WW II, particularly the infamous Ju 87 "Stuka" dive bomber that swept before the advancing German armies in Western Europe and later Russia, and the superlative Ju 88 medium bomber. This despite the fact that Junkers himself was an ardent anti-Nazi. *The Aeroplane*, Feb. 6, 1935, p. 146.

Feb. 12 The Navy rigid airship USS Macon is destroyed in a storm a few miles off Point Sur, Calif., while returning from maneuvers. All but two of the crew survive. As soon as the captain, Lt. Cmdr. Herbert Wiley, realizes the ship is falling, he orders the crew to prepare to abandon ship. They inflate and jettison rubber lifeboats, and, as the airship's stern settles into the water, swim to them. Three ships later pick up the crew. The Macon was launched April 21, 1933, shortly after the loss of her sister ship, the Akron. *Flight*, Feb. 21, 1935, p. 198.

Feb. 21 A new transcontinental record is set by Leland S. Andrews and Henry Meyers in a Vultee standard transport machine flown in a gale from Los Angeles to New York in 11 hr 34 min at an average speed of 218 mph. The previous record for the 2,577-mi. route, set a month ago, was 11 hr 59 min. *The Aeroplane*, Feb, 27. 1935, p. 234.

Feb. 23 The first airplane of the fortnightly Sabena airmail service between Brussels and the Belgian Congo, a Fokker F. VIIb/3m called the Edmond Thieffry, leaves with 82 kg of mail. Pilot Prosper Cocquyt was invited to King Leopold's palace a few days earlier to explain the operating arrangements. Cocquyt has been Sabena's chief pilot since 1927. *The Aeroplane*, Feb. 27, 1935, p. 251.

And During February 1935

—The Segrave Trophy for 1935 goes to Kenneth Waller for his flights to and from Australia and the Belgian Congo. Named for Sir Henry Segrave, the trophy is bestowed upon the British subject who makes the year's most outstanding demonstration of locomotion by land, air, or water. *The Aeroplane*, Feb. 6, 1935, p. 146.

—Pacific Alaska Airways, a subsidiary of Pan American, receives its new Lockheed Electra twin-engine airliner at its Fairbanks headquarters. Previously, the airline flew single-engine Lockheed Vegas. The two main routes are from Fairbanks to Nome and Fairbanks to Bethel, each about 550 mi. *The Aeroplane*, Feb. 13, 1935, p. 192.

100 Years Ago, February 1910

Feb. 11 French pilot Julien Mamet completes the first flight of an airplane in Spain while piloting his Bleriot. A. van Hoorebeeck, *La Conquete de L'Air*, p. 82.

MECHANICAL AND AEROSPACE ENGINEERING DEPARTMENT
Department Chair (Ref #00050312)

The Mechanical and Aerospace Engineering Department at Missouri University of Science and Technology (formerly the University of Missouri-Rolla) is seeking applications and nominations for the position of Department Chair with an anticipated starting date of July 1, 2010.

The Department currently has about 800 undergraduate students, 150 graduate students and 34 faculty members, with $4.5M in funded research annually. A recent $29M construction and renovation project has provided the department with world-class office and laboratory facilities. The department is ABET/EAC accredited and confers B.S., M.S., and Ph.D. degrees in mechanical engineering and aerospace engineering. Areas of education and research include: energy conversion and utilization, heat and mass transfer, fluid mechanics, aerodynamics, CAD/CAM/CAE, manufacturing processes and systems, robotics, automatic control, acoustics, statics and dynamics of structures, vibrations, computational mechanics, fracture mechanics, composite materials, and micro- and nanotechnology. A graduate program is also available through Missouri S&T Distance and Continuing Education online and at the Missouri S&T Engineering Education Center on the campus of the University of Missouri-St. Louis.

Missouri S&T is one of the four campuses of the University of Missouri System. Enrollment on campus is approximately 6,100 students with a wide range of degrees offered. Rolla, located in the beautiful Ozark Mountain region of south central Missouri, is a small community surrounded by national scenic rivers and recreational lakes with easy access to metropolitan areas and transportation. It is about 100 miles southwest of St. Louis, a vibrant city with many recreational and cultural activities.

The department chair will be responsible for all administrative, budgetary and personnel decisions within the department and is expected to provide intellectual leadership to the department faculty. The candidate must have an earned Ph.D. in mechanical engineering, aerospace engineering or a closely related field, and have strong qualifications including a sustained record of scholarly achievement and recognition at the national and international level for appointment as a tenured full professor. The candidate must have demonstrated leadership and administrative abilities and a commitment to quality undergraduate and graduate education and research. The candidate should have a dynamic personality with interpersonal skills to effectively represent the department on campus and in interactions with the public and private sectors.

An application should include: (i) a letter of interest, (ii) a detailed current curriculum vitae, (iii) a 1-2 page statement of vision and leadership philosophy, and (iv) a list of names and contact information of at least three professional references. Questions regarding the position and application should be directed to the chair of the search committee, Professor Ming Leu, (573) 341-4482, mleu@mst.edu. Screening of applications will begin March 1, 2010 and applications will be accepted until the position is filled.

Applications must be submitted to:
Human Resource Services (hrsinfo@mst.edu)
Missouri University of Science and Technology
300 W. 12th Street
113 Centennial Hall
Rolla, Missouri 65409-1050

Missouri University of Science and Technology is an AA/EEO employer. Females, minorities, and persons with disabilities are encouraged to apply. Missouri University of Science and Technology participates in E-Verify. For more information on E-Verify, please contact DHS at: 1-800-464-3218.

SYRACUSE UNIVERSITY
Department Chair/Professor
Mechanical and Aerospace Engineering (025863)

Applications and nominations are sought for the position of Department Chair. Interviews will be held during the Spring semester of 2010 with the position being filled before the start of the Fall semester of 2010. The Department seeks candidates who have outstanding records of scholarship and teaching, and who have shown potential for academic leadership. The Department has a rich history of research in Mechanical and Aerospace Engineering, and has recently experienced substantial growth in its research portfolio in indoor environmental quality and energy systems.

Candidates should each present a vision and plan to build on these traditions of excellence while improving the national ranking of our programs. The Department offers programs leading to B.S. degrees in both Mechanical Engineering and Aerospace Engineering, and M.S. and Doctoral degrees in combined Mechanical & Aerospace Engineering. The Department enjoys a vibrant and rapidly growing research environment, combined with a dedication to teaching built on individualized attention to its students. The faculty members are research-active with a funding portfolio that balances major Federal agencies with industrial contracts and consulting. Applicants must have a Ph.D. in mechanical or aerospace engineering or in a related field, as well as a research record and teaching experience consistent with the rank of full professor, focused on the growing field of energy research, and committed to interdisciplinary scholarship.

The LC Smith College of Engineering and Computer Science is undergoing significant renewal under the leadership of our new Dean, Dr. Laura J. Steinberg, with outstanding opportunities for growth and reinvention across all departments. The new Department Chair will benefit from many substantive collaboration opportunities with such groups as The Syracuse Center of Excellence in Environmental and Energy Systems, Center for Advanced Systems Engineering, Syracuse Biomaterials Institute, SUNY College of Environmental Science and Forestry, and Enitiative, the Syracuse Campus-Community Entrepreneurship Initiative. Departments in the College are mutually supportive and the Department Chair will be in a position to foster synergies between departments and between colleges at the University level. The department has recently enjoyed significant growth of its student size, and anticipates continuation of growth in research under the leadership of the new chair and our Dean.

For full consideration applicants must complete an online Dean/Senior Executive/Faculty Application and attach, electronically, a cover letter, curriculum vita, and the names of five (5) references through **www.sujobopps.com** (025863). Review of applications will begin February 15, 2010 and continue until the position is filled.

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VP Member Services
AIAA
1801 Alexander Bell Drive
Suite 500
Reston, VA 20191-4344

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