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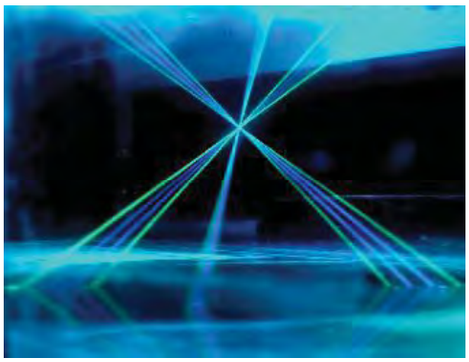
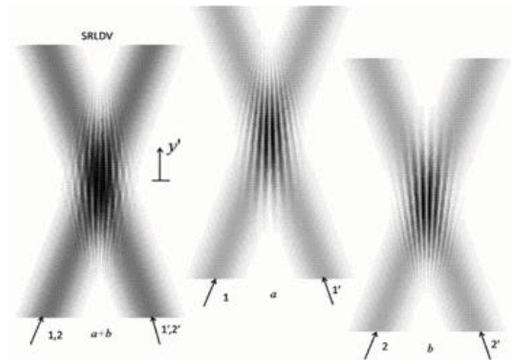
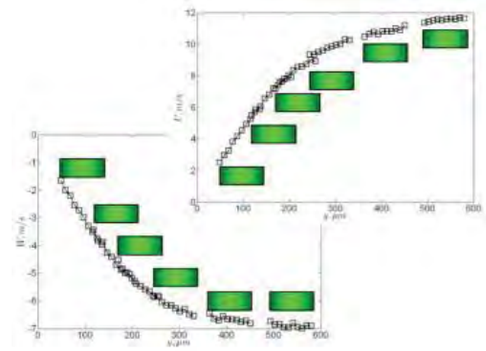


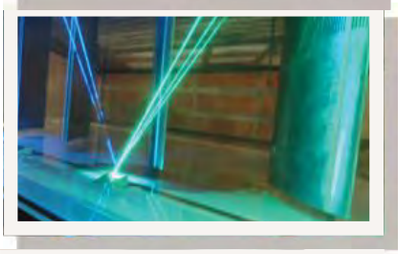
CompLDV measurement volume

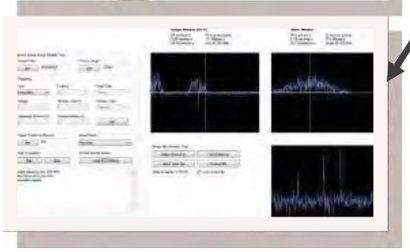


<u>How it works: Overlapping fringe sets determine particle position and velocity</u>



A green box is a y range measured by one stationary measurement volume





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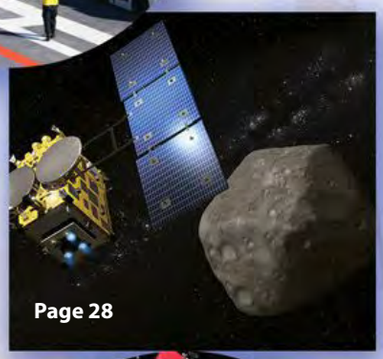

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COVER
A Falcon 9 rocket leaves the hangar at Cape Canaveral, prior to lofting a Dragon capsule toward the ISS. Read all about the Falcon's remarkable record by turning to page 12. Photo courtesy SpaceX.

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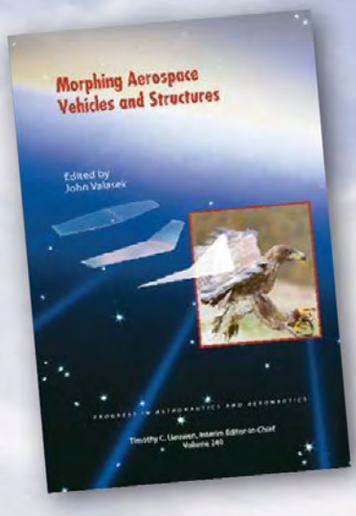

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Fitzgerald Art & Design
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Michael Griffin, *President*
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Craig Byl, *Manufacturing and Distribution*

Send materials to Craig Byl, AIAA, 1801 Alexander Bell Drive, Suite 500, Reston, VA 20191-4344. Changes of address should be sent by e-mail at custserv@aiaa.org, or by fax at 703.264.7606.
Send correspondence to elainec@aiaa.org.

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Commentary

Russian rocket engines forever?

Toward the end of the last century, U.S. development of large liquid-propellant rocket engines had come to a complete standstill. As pointed out by then-NASA Administrator Dan Goldin, the only such engine developed by the U.S. in the previous three decades had been the space shuttle main engine (SSME).

Thus was the stage set for the introduction of Russian rocket technology. In April 1992, the president of Russian engine developer Energomash visited General Dynamics Space Systems Division (GDSSD), builder of the venerable Atlas vehicle that had launched our first astronauts into orbit. He told division president Mike Wynne that for $100,000 Energomash would design and develop for the Atlas a half-scale derivative of the RD-170, which was a 1.7-million-lb-thrust liquid oxygen (Lox)-kerosene first-stage engine for Zenit and Energia. Since Atlas 2's three Rocketdyne MA-5A engines, with a combined thrust of only 490,000 lb, were barely able to get the Atlas-2 off the pad, Wynne understandably jumped at the chance to obtain access at such low cost to Russia's proven oxygen-rich closed-cycle technology in an engine that would deliver 860,000 lb of thrust at 15-20% higher efficiency than the MA-5A. Thus was born the RD-180, which first flew on an Atlas 3 in 2000. In 1997 GDSSD successor Lockheed Martin (LM) ordered 101 RD-180s from Energomash for about $1 billion and negotiated an exclusive agreement for U.S. sales.

But LM's biggest customer for the subsequent Atlas 5 was the USAF, which was not happy with relying on a Russian-built engine for half its Evolved Expendable Launch Vehicle fleet. So Energomash teamed with Pratt & Whitney to create a U.S. company, RD Amross, to duplicate RD-180 production.

However, Amross had great difficulty getting the detailed specifications for materials and machining processes, because although the Russian documentation was truly meticulous (each part had a 'passport' that accompanied it through every step in manufacture), it was very different from U.S. practice. Moreover, much of the detailed materials information and 'tricks' of the machining processes were in the heads of the skilled Russian workmen, to which Amross did not have access.

So although Amross remains the U.S. marketing agent for Energomash-produced RD-180s, it never achieved the desired U.S. manufacturing capability. Nevertheless, the RD-180's great success (43 flawless launches on Atlas 3 and 5) stimulated Orbital Sciences to file suit last June against United Launch Alliance, which had inherited parent LM's exclusivity agreement for RD-180s. Orbital would like the RD-180 for its new Antares launcher, which currently uses a derivative of the other mainstream Russian Lox-kerosene engine, the NK-33, modified and currently being sold by Aerojet-Rocketdyne as the AJ-26.

But where are the U.S. engines in this now highly restricted field of opportunity? The only current candidates are Rocketdyne's remodeled SSMEs slated for the new Space Launch System and the RS-68s currently used on Boeing's Delta 4. But both these are fueled by liquid hydrogen, which has operational limitations compared with kerosene. The only new Lox-kerosene prospects on the horizon are the current attempt by Aerojet Rocketdyne and Dynetics to resurrect the half-century-old Apollo-era F-1, and the far-future million-lb-thrust AJ-1E6 engine concept being promoted by Aerojet Rocketdyne for the eventual upgrade of the yet-to-be-born SLS.

Not much of a heritage for a once-dominant U.S. technology. Could it be because there's only one U.S. liquid-propellant rocket company left?

Jerry Grey
Editor-at-Large

Business aviation: Contraction, then recovery

THE EUROPEAN BUSINESS AVIATION market will return to growth in 2014, with demand for new aircraft and flights led by customers wanting to travel long distances from countries on the periphery of the continent. Meanwhile, for the rest of this year, the market will contract further.

That appears to be the consensus among manufacturers, operators, and other industry stakeholders as they analyze the traffic figures and trends for the year so far. The core business aviation market within the EU is still battling against stagnant or weak economic growth and prolonged austerity programs. Outside the Eurozone economies, however, the demand for business jet services is growing stronger.

"Among those countries reporting more than 3,000 business jet movements per year, Turkey, Ireland, and Sweden have shown the most year-over-year growth in the first four months of 2013," says Swedish-based market consultancy Avinode. "On the other end of the scale the Czech Republic, Greece, and Poland have reported the largest declines."

According to Fabio Gamba, CEO of the European Business Aviation Association (EBAA), "This year is going to be another year of contraction." The degree of decline, he says, will be the same as last year's, "between 3% and 4% fewer business aviation movements than the year before. But we believe that 2014 will be a positive year. We're seeing general improvements in gross domestic product figures from EU member states, and countries on the periphery of the continent, such as Turkey and Ukraine, are proving to be the real locomotives for growth….Longer haul aircraft services—such as those provided by Dassault Falcon 2000s and Gulfstream models—are now responsible for one-third of all movements, and this is growing a percentage while the lower end of the market continues to suffer."

Counterintuitive trend

The increased demand for larger aircraft appears somewhat counterintuitive, given the fragile nature of the continent's economy. Gamba suggests that one reason is the need for long-haul performance to connect Europe's corporations to the stronger performing global markets in Latin America, South Africa, and the Far East. There are other factors as well. According to Julian Burrell of business jet charter company Vertis Aviation (U.K.), there is also a burgeoning market for long-haul business jet travel from entrepreneurs in Russia and the Middle East.

This trend is supported by industry data. According to Avinode, "The entry-level, light, superlight, and midsize jet categories have shown minor declines in the first four months of 2013, while the super midsize and heavy jet categories have shown some growth. The one persistent standout is the ultralong-range jet category, which has shown a 10% increase in actual flight movements during the period."

And according to an analysis of business aviation movements collected by Brussels-based air traffic management agency Eurocontrol, the first few months of this year saw a 4.3% decline in intra-European business jet movements over 2012, while flights from European destinations to the rest of the world rose 3.8% over last year.

Driving forces

The key driver for business aviation demand is the performance of the European economy, which points in a positive direction for 2014. According to the EC: "After the recession that marked the year 2012, the EU economy is forecast to stabilize slowly in the course of the first half of 2013. A noticeable expansion in GDP is expected to set in only in the second half of the year, but growth should pick up at moderate speed in 2014. On the back of a global economic recovery, external demand is set to remain the predominant growth driver, while multiple headwinds continue to weigh on domestic demand. As a result, annual GDP in 2013 is projected to decrease marginally in the EU and contract by 0.5% in the euro area. For 2014, GDP growth is forecast at 1.5% in the EU and 1.25% in the euro area."

The good news is that recovery looks likely not just in the core area of the continent—business aviation activity in Europe is centered around Germany, France, the U.K., Italy, and Spain—but also in the southern part of the continent, where leisure routes are particularly important during the summer months. Portugal's GDP expanded 1.1% in the second quarter of this year over the same period in 2012.

"Even in the south the trends are positive," says Gamba. "Greece's economy looks to be much better in 2013 than in 2012. Italy is coming to terms with the recession; Spain remains difficult with the unemployment rate, but even there, in terms of movements, we are now seeing [that] Spain and Italy are almost back to the European norm. That is why we think 2014, unless there is a major unforeseen event, will be a positive year."

Although modest, these are welcome trends in the right direction for Europe's economies, where austerity measures have had a direct impact on the market. For example, the Italian government committed to reducing the number of business aviation hours flown by state employees by 5,000 hours a year from pre-austerity levels to this year, an equivalent of 1% of the country's total annual movements, says Gamba.

This means the lag between GDP recovery and a rise in business aviation movements is likely to be longer in Europe than in North America. This is especially true given the difficult image the industry has in Europe, which has caused European companies to be

far more conservative in their use of business jet travel. For the period of January to April this year, European business jet departures have declined 6.4% from 2011, according Avinode. While Europe has faced two consecutive years of decline, the U.S. market has enjoyed two years of growth.

Breaking it down

For the moment, however, Europe remains the second-largest business aviation market in the world, behind that of the U.S. At the May European Business Aviation Convention and Exhibition in Geneva, Hawker Beechcraft issued a study of this market. It suggested that there are 3,773 business aircraft (turboprops and jets) in Europe, with Germany hosting the biggest fleet—621 aircraft, a 16% share—followed by the U.K., with 503 aircraft (13%), then France, with 344 (9%).

Another forecast produced at the event, by JetNet iQ, predicted that over the next 10 years up to 1,741 jets (19% of the global market) will go to European customers, increasing the continent's business jet fleet to about 4,300 aircraft by 2022, a 56% rise from the current fleet.

According to Bombardier's latest forecasts, Europe will remain the world's second-largest market for business jets, with 1,700 aircraft deliveries between 2012 and 2021, and 2,220 deliveries between 2022 and 2031. The fleet will increase at a compound annual growth rate (CAGR) of 5% from 1,890 aircraft in 2011 to 5,125 aircraft by the end of 2031.

This is one of the anomalies in the European business jet market—deliveries seem to bear only a passing relationship to movements. According to EBAA's own figures, the continent's business aviation fleet grew from just under 2,500 aircraft in 2008 to 3,078 aircraft by the end of 2012, at a time when the industry—as measured by movements—was undergoing a severe contraction. It will be 2017, according to EBAA's most recent estimates, before business aviation movements climb back to their 2008 levels.

"Much of the apparent resilience shown by local operators in the face of eroding economic conditions is actually just the result of geographical definition," says an October 2012 business aviation market survey by Honeywell. "Russia, with strong local purchasing ambitions, is included in this region, as are the Central and Eastern European states, which are generally more economically robust. Ancillary data from the Western European portion of the region conjure an environment of slowing activity and demand, strongly influenced by complex problems such as higher unemployment, high government debt, and negligible growth."

But from 2014 Europe should be back to a prolonged period of growth in the current economically challenged EU segment of the market as well as the vibrant periphery. According to EBAA and Eurocontrol forecasts, European CAGR business aviation traffic growth will range between 3% and 5% between 2014 and 2018. This compares to an average monthly 4.4% decline in traffic movements measured between August 2012 and July of this year.

✈✈✈

Given the depth and longevity of the recession in Europe, these seem like modest increases. But as the demand for new aircraft in Europe will fall heavily within the high-value, long-range sector of the market, these new purchases will account for an important share, by value, of the global market. There may well be another round of consolidation in the European business jet operator market before the recovery finally takes hold, but for the moment, at least, all signs point to a sustained recovery beginning in 2014.

Philip Butterworth-Hayes
Brighton, U.K.
phayes@mistral.co.uk

Events Calendar

OCT. 14-17
Thirty-first AIAA International Communications Satellite Systems Conference and 19th Ka and Broadband Communications, Navigation, and Earth Observations Conference. Florence, Italy.
Contact: www.icssc2013.org

OCT. 16-17
International Symposium for Personal and Commercial Spaceflight. Las Cruces, New Mexico.
Contact: 575-646-6414; nmsgc@nmsu.edu

OCT. 21-24
International Telemetering Conference. Las Vegas, Nevada.
Contact: Lena Moran, 575/415-5172; www.telemetry.org

OCT. 24-25
Satellite Communications. Fukuoka, Japan.
Contact: Fumihiro Yamashita, yamashita.fumihiro@lab.ntt.co.jp; www.leice.org/cs/sat/jpn/purpose_e.html

NOV. 3-7
Twenty-second International Congress of Mechanical Engineering. Ribeirao Preto, Brazil.
Contact: Joao Luiz F. Azevedo, joaoluiz.azevedo@gmail.com; www.abcm.org.br/cobem2013

NOV. 5-7
2013 Aircraft Survivability Technical Forum. Monterey, California.
Contact: Laura Yuska, 703/247-2596; www.ndia.org/meetings/4940

Governing in spite of gridlock

WITH MEMBERS OF CONGRESS WRAPping up their five-week recess, few lawmakers were in the nation's capital as the end of summer approached.

Many legislators spent their break on privately funded travels around the globe—'fact finding' trips, their offices say, 'boondoggles' critics call them. As of late August, some 1,363 trips had cost their hosts $3.2 million, according to LegiStorm, a nonpartisan watchdog group. Neither during recess nor after returning to Washington was Congress expected to pass a budget for the fiscal year that began October 1. Observers say functioning without a budget has become the 'new normal,' making it difficult for federal agencies to operate programs or make plans.

Amid what CBS News' Stephanie Condon described as "gridlock and acrimony," lawmakers passed just 23 laws this year—including one to name a bridge—while key issues such as affordable health care and immigration reform remain stalled. The legislature owes 12 spending bills to keep the federal government in operation, and none has been enacted. "It's clear that we're not going to have appropriations bills finished by September 30," House Speaker John Boehner (R-Ohio) told reporters August 1.

With or without a government shutdown in the interim, the feds were expected to be operating under a continuing resolution in lieu of a traditional budget after October 1. The budget-cutting measure known as sequestration would thus remain in effect, and federal agencies, especially the Dept. of Defense, would remain under strong pressure to cut costs. According to a report by Tony Capaccio of Bloomberg News, under an "execution plan," DOD would fire 6,272 of its career civilian employees if, as expected, sequestration cuts $52 billion from the Pentagon's FY14 funding. The plan indicates that layoffs would be most painful among senior executives, whose ranks include many engineers and scientists, and says they would bring "degradation in morale."

In responding to the budget crisis, leaders in Washington uttered warnings. At the height of the summer/autumn wildfire season, with more than 50 blazes burning throughout the West, Forest Service chief Thomas Tidwell told reporters that some C-130 Hercules and CH-54 Skycrane firefighting aircraft might have to be grounded because the service is running out of money.

Gen. Mark Welsh, Air Force chief of staff, told U.S. airmen they should not spend too much time worrying about budget and planning uncertainties in Washington. His having spoken to troops about it confirms that it is a morale issue, but Welsh also cautioned that the Air Force, now at its lowest strength since it became an independent service branch in 1947, will get even smaller.

Going and going

Budget crisis or not, the government keeps going and going. While DOD employees are being furloughed as an economy move, other agencies—among them NASA, the FAA, and the National Transportation Safety Board—are keeping workers on duty full time. Most everyday activities of government, including air traffic control, space launches, and firefights in Afghanistan, are continuing as usual. As this issue went to press, the executive and legislative branches were debating what to do about upheaval and violence in Egypt and chemical warfare in Syria. Whatever foreign policy decisions are made, they will be implemented without deference to the budget situation.

The Dept. of Justice under Attorney General Eric Holder on August 13 took the unusual step of suing to block a planned $11-billion merger of American Airlines' parent company, AMR, and US Airways Group. Together the two would become the world's largest airline. The carriers had hoped to merge in August, but the antitrust suit puts their betrothal on hold, with the court trial expected to begin November 12.

Former American chairman and CEO Robert Crandall—loathed and loved for inventing frequent flyer miles, which evolved into today's retail rewards programs—says the proposed merger is "pro-competitive" and will produce a viable airline able to serve the largest number of people at the lowest prices. Crandall calls the lawsuit a "mistake." Others say the merger is needed to provide competition to behemoths Delta and United.

Also on the 'up' side: The merger would allow the airlines to cut costs by eliminating redundant departments and by being able to invest in new fuel-efficient planes that are more comfortable for consumers.

Workers for three American Airlines unions representing 55,000 employees favor the merger. American is

The Justice Dept. is suing to block a planned merger of American Airlines' parent company, AMR, and US Airways Group.

in bankruptcy and announced in February that it was cutting 13,000 jobs. The company showed a net loss of $1.7 billion for the first quarter of this calendar year. Management and workers agree that only the merger can bring American out of bankruptcy.

But DOJ charges that the move would reduce competition on key routes. The GAO found that 1,665 routes between cities would lose one competitor as a result of the merger, affecting 53 million passengers. There is also the simple fact that consolidation of routes costs jobs and affects communities' surrounding airports. Douglas Kidd of the Washington-based National Association of Airline Passengers tells *Aerospace America* the merger would be "especially troubling" at Ronald Reagan Washington National Airport—a favorite of members of Congress—because the newly formed airline would then own 55% of all departures from that location.

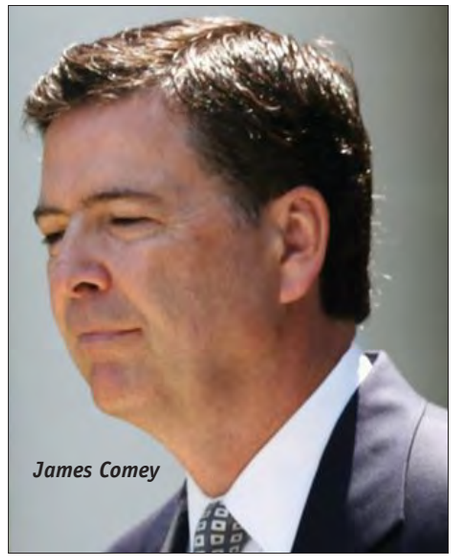
DOJ did not oppose the 2008 merger of Delta and Northwest, creating today's Delta. Nor did Justice intervene when United and Continental came together in 2010, forming today's United. Critics say the department has changed its standards. Only a judge's ruling, around the end of the year, will determine what happens to the biggest airline merger in history.

New appointments

On July 26, the Senate voted 93-1 to confirm James Comey as director of the FBI and was sworn into office on September 4. Comey was a deputy attorney general in the George W. Bush administration.

The lone dissent—and a brief, symbolic hold on the nomination—came from Sen. Rand Paul (R-Ky.) who has concerns about FBI use of surveillance drones in the U.S.

The law enforcement agency told Paul it would seek a warrant before using a drone in a situation where a suspect in a crime has a reasonable expectation of privacy. Paul said he was unsatisfied but would let the nomination move ahead. Currently,


James Comey

drones can be used only at certain altitudes and in certain locations allowed by the FAA.

Outgoing FBI boss Robert Mueller, who is remarkably well liked—a distinction not everyone in the capital enjoys—was unusually candid in warning about dangers from terrorism. Mueller told reporters, "My biggest worry is an attack on a plane."

Mueller, who took office a week before the attacks of September 11, 2001, said both the nation's aviation system and its cyber facilities are vulnerable. He warned of likely attacks from lone actors like those in the Fort Hood massacre and in the Boston Marathon bombings. Mueller's leadership is credited with foiling a 2010 plot to bomb cargo planes heading for the U.S. using explosives hidden inside transistor devices.

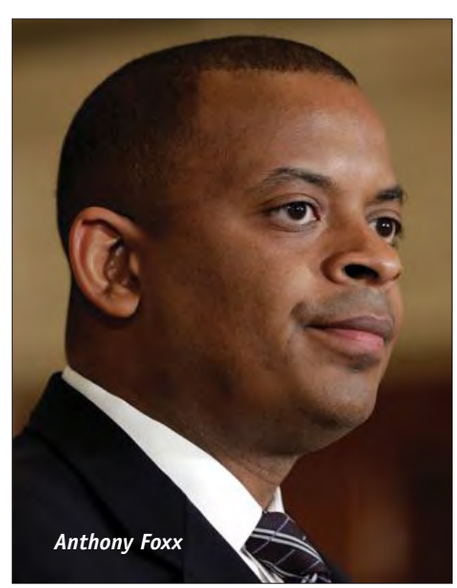
Another recent change in Washington made Anthony Foxx, former mayor of Charlotte, North Carolina, the secretary of transportation after his 100-0 Senate confirmation vote on June 27. In this era of budget austerity, Foxx will be asked to produce new solutions for the nation's aging airports, highways, bridges, and overall infrastructure. One of his first actions was to announce limited introduction of the FAA's NextGen navigation system at a handful of airports in the U.S.

NextGen, long plagued by scheduling delays, cost overruns, and technical glitches—as well as "organizational weaknesses," says the Dept. of Transportation inspector general's office—is making its debut in stages between now and 2025. The system is beginning to bring U.S. air navigation up to the standard of that in Europe. By shifting from navigation based on ground radars to one that relies on satellites, NextGen is expected eventually to provide U.S. airlines with fuel savings of $2.3 billion per year.

The FAA and its administrator, Michael Huerta, belong to Foxx's department and added a new face to help get NextGen on the right flight path. Retired Air Force Maj. Gen. Edward L. Bolton Jr. became the FAA's assistant administrator for NextGen on August 24. Bolton is known in Pentagon circles as a strong taskmaster and is expected to improve management.

Using NextGen, aircraft no longer have to fly indirect routes to stay within range of ground radar stations. Aircraft can continually broadcast exact GPS readings, providing data for cockpit displays showing a plane's relative position to other planes and those planes' flight paths. Being used in fledgling stages at locations as disparate as Seattle, Memphis, and Newark, NextGen is clearly providing savings and efficiency.

(Continued on page 13)


Anthony Foxx

Loren Thompson

How do you view our current national security situation amid sequestration and emerging threats?

Over the long term I am pessimistic about our security situation, because there is such a proliferation of new technologies—digital, biological, or whatever—that it seems to me something is going to happen that significantly impairs the progress of civilization. I have a suspicion that it will happen sooner rather than later.

Will we be able to handle whatever may happen?

In the near term, we have two basic problems. There is a profusion of new threats that we aren't postured to meet, and that weren't even considered 20 years ago, and it is hard to know what the national security organizational construct should be to cope with all that. And we have constructed a welfare state that runs the danger of soaking up all the available resources that might have been used for other purposes—defense or science or infrastructure or whatever—that are needed to counter the threats.

Is our national security establishment fully aware of the threats and structured to meet them?

The national security structure and the Pentagon in particular are in a perpetual state of reorganization, but I have the impression that they are not sufficiently committed to change so that they can deal with all the likely challenges that the global threat environment will pose. For example, we all know that cyber threats are potentially devastating to our society, but when I look at the responses the Pentagon has mounted, I feel as though they are not being sufficiently urgent or creative about how they are approaching this threat.

Elaborate on that.

We are way, way out on a limb here in terms of creating a society that is utterly dependent on the Internet and on being able to communicate electronically through networks. We basically have made ourselves vulnerable to adversaries who don't need bombers and aircraft carriers to take us down. I think most people in the business know this in the abstract, but we are not exhibiting the urgency that we would expect from a society in danger.

Do you advocate a radical restructuring of the nation's national security establishment?

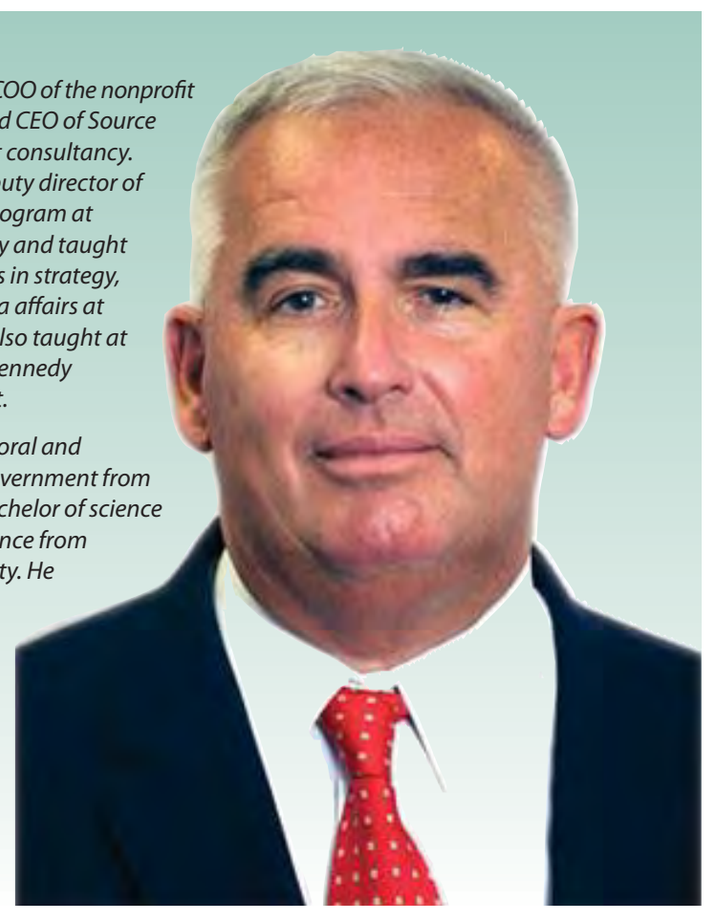
Our armed services were conceived for another time. We still need many of the competencies that they bring to the table, but they are not postured for dealing with things like biological or cyber threats. So I think we need a different kind of organizational construct here to avoid getting overwhelmed by some future asymmetric threat. We're trying to make everything fit into the framework that we've already built, and our current multiservices military department/defense agency structure will not be able to cope with a really ambitious cyber challenge.

Do we draw from the past too much? Does that prevent us from taking a clear look at the future?

In general, I think that we as a society, as a civilization, are exhibiting many of the symptoms of decay that are often associated with republics. The big problem with republics is that they tend to decay, as the Roman re-

Loren B. Thompson is COO of the nonprofit Lexington Institute and CEO of Source Associates, a for-profit consultancy. Previously, he was deputy director of the Security Studies Program at Georgetown University and taught graduate-level courses in strategy, technology, and media affairs at Georgetown. He has also taught at Harvard University's Kennedy School of Government.

Thompson holds doctoral and master's degrees in government from Georgetown and a bachelor of science degree in political science from Northeastern University. He was born in 1951 and currently resides in McLean, Virginia, and Plymouth, Massachusetts.



public did. Republics seem incapable of reforming themselves. In our case, we now have a system that seems to be mired in an accumulation of rules and customs that are not very well suited to maintaining the vitality of our civilization. We have a tax structure that's ridiculously complicated, a legal structure that's acceptable only to those with wealth, and a military that's focused on its signature combat systems and not on what's really needed for the future.

Where does the defense industry fit into that context? Or the aerospace industry?

The defense industry is a relatively recent phenomenon in American history. Before the Cold War, we did not have a large, dedicated, private-sector defense industry. What we had was a mobilization model for General Motors and the rest of the commercial sector, which served us well only if we went to war every generation or so.

Now we need a dedicated, full-time defense industry, but we have to reorganize how industrial America works today. It is not driven by the general good or by patriotism, it is driven by the assessment of shareholders as to whether they are getting the returns that they seek. It is about making money, just like every other industry is. You can't stay in control of these companies unless you deliver shareholder value, and that limits the industry leadership's influence outside the investment community.

Does the defense industry need better leadership in adjusting to change?

I think the leadership of the defense industry is as good as I've ever seen it. But again, that leadership is defined by its ability to meet the expectations of shareholders. That's what it does. Its focus is not on investing sufficiently in making the right weapons. We can't rely on market incentives and market forces to buy the kind of defense for the future that we will need to have.

Just look at what has happened in my lifetime—jet engines, computers, the Internet, lasers all originated in government research. They would not have come out of the private sector if the government had not intervened in providing the money to develop them. There is a lot of unjustified optimism among believers in free markets that if we just organized ourselves correctly, issues like investment and infrastructure would automatically be dealt with.

I don't believe that's the case. I do not believe there is an automatic market mechanism that could ever meet our many needs. We are always going to require government intervention to make it happen, to have the right kind of economy and the right kind of defense structure for dealing with the challenges we face.

"We can't rely on market incentives and market forces to buy the kind of defense for the future that we will need to have."

Well then, do you think we need a government-based defense industrial policy?

The problem with a defense industrial policy is that it tends to degenerate into an entitlement program, a jobs program for people in the defense sector who develop constituencies in Congress. My feeling is that the best kind of defense industrial policy is just maintaining a reasonable level of demand for the most important combat systems. If we have that, industry will take care of itself. If we do not have it, then we may not be able to sustain a defense industrial base.

Insufficient demand would make the industrial base wither and maybe fade away?

That's right. The United States did not have a defense industry through most of its history, because the level of demand was too low. We got a defense industry when the Cold War came along and there was an unusually elevated level of demand for weapons through two generations. If we revert to the historic pattern prior to the Cold War of low levels of demand between wars, then we will not be able to sustain a sufficiently large defense industry.

How would you describe the trend?

The future of demand for defense products will be driven first and foremost by the kinds of threats we face and how we react to them. I haven't decided whether 9-11 was a detour from a downward trend or a turning point in defense demand. But it was pretty obvious for the first 10 years after the Cold War ended that this system was reverting back to what it had been before the Cold War started.

If that is indeed the case, then we are headed for a world in which America's defense industry is not all that robust. The one thing that can save the industry during periods of prolonged peace is that it is so concentrated in Washington and so good at getting what it wants from Congress.

Is the DOD cutting back as best it can under sequestration? Talk about specific weapon systems in that context.

We've already been cutting weapons for the last half-dozen years. We killed the Air Force's F-22 fighter, the Navy's next-generation missile defense cruiser, the Army's family of networked combat vehicles, the Marine Corps' expeditionary fighting vehicle. So whether we should have been cutting weapons or not, we have already

"We need to focus on what really contributes to our warfighters, rather than on what contributes to somebody's reelection campaign."

done it, and now we need to look at other areas where we can save money.

I think the most important area covers all of the overhead functions that don't contribute value to the warfighter and yet soak up huge amounts of money, including excessive operational testing, unnecessary rules and regulations, personnel levels in terms of manning and compensation that are obviously excessive—all of the areas in which we have just allowed the system to grow and grow and grow to the point where it is now in danger of strangling itself.

Will the spending cuts weaken us in the air, detract from our air power? Any specific concerns? What about unmanned aircraft in that context?

I have always thought that unmanned aircraft have been oversold as a technology. They are uniquely well suited to dealing with nontraditional threats like insurgents who don't have air defenses or air forces. But they wouldn't be much use in dealing with countries like China.

More broadly, the obvious problem we have right now with the future of air power is our failure to fund a robust modernization program. We have fallen behind in most of the key categories of air power: sensor aircraft, tactical aircraft, including fighters, and bombers. They all need to be modernized at the same time, and of course we can't afford to do that. We haven't even managed to buy a new trainer aircraft. So that's our most immediate problem. We just haven't run an adequate aircraft modernization program.

What are the longer term air power modernization issues?

There are specific things I worry about. I worry about enemies fielding directed energy weapons, or maybe undirected energy weapons like electromagnetic pulse [EMP]. And I worry about what this may mean for the future of U.S. air power, because those weapons essentially provide a cheap air defense, which we currently could not counter.

Do you think we somehow need to find the political will and a way to come up with the money to modernize our tactical air force and our bombers?

I think we could cover the cost of a robust aircraft and aerospace modernization program without increasing the defense budget by drastically cutting overhead. But no one is talking seriously about cutting those unnecessary costs. Instead, we are stuck with awful ideas like sequestration, where we're cutting the sinews of our warfighting capability while leaving hundreds of thousands of bureaucrats in locations where their value is highly questionable.

We need to focus on what really contributes to our warfighters, rather than on what contributes to somebody's reelection campaign.

You said you are very concerned about cyber security. Do we need to spend more on that?

At the moment, our spending on cyber security in the federal government is trivial compared to what we spend on weapons, both in gross amounts and as a percentage of the federal budget.

Cyber expenditures are the best bargain we can get, because of all the damage that is prevented just by having a cyber program. In deciding how we should spend money on cyber, I think we will have to rely to some degree on the threats that emerge. However, I am fairly certain that we're not spending enough right now on cyber preparedness.

How worried are you about that?

Even if the Chinese were not engaging in cyber espionage to steal billions of dollars in intellectual property from us every year, I would worry about their ability—or Iran's ability, or anybody else's ability—to simply collapse our whole system so that we could no longer function as an economy or a society. Considering how dependent we are on the Internet, we are just not adequately protected.

You have noted a cyber threat to the international space station—about hackers trying to take over its guidance and control functions.

Yes, and that is pretty amazing. We have many, many, many examples of situations in which information that should not have been accessible to outsiders was easily hacked. Most of our smartphones, iPads, and Internet connections are not sufficiently secure. We don't know what the Chinese or other foreign adversaries have already put into our system that could turn it off in an instant if they needed to do that during a war. I do not think it is all that hard to interfere with our electrical grid, with our financial system, with our medical records, and with other networks that are now the foundation of our civilization.

What would you recommend doing about all these national security problems? Where would you start? Does the DOD need to be revamped?

Our headquarters operation at the Pentagon has become so large and self serving that it is now largely disconnected from the warfighting enterprise. Bureaucracies have proliferated and become inward looking. If I were the president, I would start thinking about how to run all DOD operations with half the current staff. I'm sure it could be done. A lot of functions are not really necessary; but beyond that, there is huge duplication, huge redundancy in paralleling the civilian side and the military side of the establishment, and at the command levels in the services.

What else needs to be done?

I think we could make the Pentagon a world-class organization with its current structure if we had the right people running it. By the same token, I think we could optimize the structure and still have a bureaucratic disaster if we have the wrong people running it.

I think some of our defense secretaries have not been very capable, but more importantly, the quality of

the people who have been under them has been quite uneven. For every top-notch person like [deputy defense secretary] Ash[ton] Carter, there are a lot of political hacks or neophytes who really should not be in control of billions of dollars of activity. There are some very capable people at the Pentagon, but there are many who are pretty mediocre—so the system itself is pretty mediocre.

How would you remedy all that?

I would begin by removing all the restrictions and barriers to high-quality people serving in top positions. Right now, asking such people to serve in the Defense Dept. as senior political appointees is like an invitation to torture. They face losing a lot of money, being charged with conflicts of interest, being attacked by Congress, and not getting enough support from the White House. If we had half a dozen Ash Carters with the backing of the White House to change this system, it would get changed and be much better than it is.

What's wrong overall?

Fundamentally, the problem with our society today is that it's a paralyzed political system. The only way under the Constitution that we can get past that is to put one political party in full control. The fact that we have two contending ideologies in the electorate that are evenly balanced explains why the system is paralyzed. If in the midterm elections we either took the House away from the Republicans or the Senate away from the Democrats, creating something approaching a partisan consensus on Capitol Hill, then we might be able to make some progress on solving our problems.

But as long as we have a system that is divided along partisan lines, and with deep ideological cleavages, I don't see how we can solve our problems. If we're going to have a welfare state, let's have one that works well. If we're not going to have a welfare state, let's have a party in power that can actually implement a plan to create an alternative. What we cannot afford to do is just sit here for another generation wasting money without getting anything done.

Sounds like you would overhaul our entire electoral process, our political system.

No, what I'm looking for is to have the voters make a decision every two years—instead of splitting their tickets every two years—to have either the Democrats or the Republicans in control in the White House and in Congress to implement their ideologies and get things done. Right now we can't even pass the budget. Unless we get beyond our political paralysis, we will never fix anything—our national security problems, our highways, the way we educate our kids, everything.

SpaceX's expanding launch manifest

IT IS HARD TO FIND ANOTHER SPACE launch services company with as diverse a customer base as Space Exploration Technologies (SpaceX), because there simply is none. No other company even comes close. Founded only a dozen years ago by Elon Musk, SpaceX has managed to win launch contracts from agencies, companies, consortiums, laboratories, and universities in the U.S., Argentina, Brazil, Canada, China, Germany, Malaysia, Mexico, Peru, Taiwan, Thailand, Turkmenistan, and the Netherlands in a relatively short period. Moreover, it has done so within four completely different markets—civil, commercial, military, and university/nonprofit.

SpaceX has used two different rocket models thus far—Falcon 1 and Falcon 9 v.1.0—and at press time was preparing for the maiden launch of its Falcon 9 v.1.1 in September. That mission is for the Canadian Space Agency and several universities in the U.S., including Cornell, Drexel, Stanford, the University of Colorado at Boulder, and Utah State.

The company is also completing development of Falcon Heavy, which may become the nation's most powerful rocket since Apollo's Saturn V when it is ready for its first launch, sometime in 2015.

So far the company has launched satellites only to LEO. However, it was planning to send its first commercial communications spacecraft, the SES-8 for SES World Skies, to geostationary orbit in September, and its second to GEO, the Thaicom 6 for Shin Satellite, aboard a Falcon 9 v.1.1 this month.

At least seven more GEO comsats are scheduled to go up on v.1.1s during the next two years, including ABS 2A and 3A for Asia Broadcast Satellite of China, Asiasat 6 and 8 for Asia Satellite Telecommunications of China, Satmex 7 and 9 for Satelites Mexicanos of Mexico, the Star One C5 for Star One of Brazil, and the Turkmensat 1 for the Ministry of Communications of Turkmenistan.

A new market

The move to begin launching to GEO is significant, because it opens up an entirely new and potentially lucrative market for SpaceX. It also puts the company into direct competition with commercial launch heavy hitters Arianespace of Europe with its Ariane 5ECA, U.S.-Russian joint venture International Launch Services with its Proton M, and Sea Launch of Russia with its Zenit 3SL and 3SLB.

Still, SpaceX does not seem to be giving up its LEO market. If anything, it is expanding it. Its manifest is packed with more than two dozen micro, nano, pico, and femto (under 1 kg) satellites, but it is also filled with over 100 small spacecraft, including 16 Orbcomm-NG mobile comsats for Orbcomm of Rochelle Park, New Jersey, and 70 Iridium-NEXT mobile comsats for Iridium Communications.

Most launch companies would be ecstatic with just the Iridium and Orbcomm business, or either. These programs not only contain an awful lot of satellites but are also the kind that just keep on giving, because of the need for replacement spacecraft every few years. But keep in mind that this is in *addition* to an already healthy number of GEO comsat launch orders.

Ending the myth

Perhaps the most intriguing thing about SpaceX's satellite launch activities is that they are not even its 'core' business. The company has made a name for itself not primarily for launching satellites, but rather for being the first private company to launch resupply capsules to the ISS. Before SpaceX's unmanned Dragon capsule maneuvered in LEO and successfully linked up with the ISS on May 25, 2012, the space docking feat had been performed only by governments—the U.S., Russia, and China.

The SpaceX docking debunked the myth that has prevailed since the launch of Sputnik in 1957, that space travel can be undertaken only by national governments because of the prohibitive costs and technological challenges involved.

Teal Group believes it is that mythology that has helped discourage more private investment in commercial spaceflight and the more robust growth and development of the space market. We sense this is now changing.

SpaceX has hauled supplies—food, water, equipment, and experiments—to ISS twice since the initial docking, and its next resupply mission is scheduled for January 15, 2014. It has created a new commercial space resupply service that could eventually evolve to become an industry. For now, the company is merely providing a little competition for the Russians and their Soyuz and Progress capsules, fulfilling its obligations under its commercial resupply services (CRS) contract to NASA.

Soon SpaceX will be joined by Orbital Sciences and its Cygnus capsule, which it has been developing under a commercial orbital transportation services contract to NASA. Orbital is preparing to start launching Cygnus aboard Antares rockets in December under an eight-mission CRS contract.

SpaceX has 10 more Dragon ISS resupply missions remaining on its CRS contract with NASA. It is proceeding with development of a human-rated capsule known as DragonRider, capable of transporting a crew of up to seven astronauts. Plans call for launching the first crewed DragonRider by 2015, although we suspect it will be closer to 2017. This work is being done under NASA's Commercial Crew Development 2 program.

SpaceX envisions eventually mating an unmanned Dragon with its Falcon Heavy and sending missions to orbit the Moon. It then hopes ultimately to launch a manned DragonRider to land on the lunar surface by 2020. The company would like to send a series of relatively low-cost Red Dragon landers (based on the Dragon capsule) to Mars, launching them on Falcon Heavies. Yes, the ultimate goal is to send humans to Mars—not astronauts to plant the flag, but settlers to establish a colony.

Against all odds

It sounds like pie in the sky. But this has been heard so often when it comes to SpaceX, and consistently the company has overcome tremendous obstacles and proven the mainstream space establishment wrong. SpaceX failed on its first three launch attempts with its Falcon 1, and it simply persisted until it got it right. After the third failure on August 2, 2008, there was strong speculation that the company would have to call it quits. Musk had deep pockets, but he could not endlessly keep financing what appeared to be a losing venture. It was thought that in six months to a year he would either try another launch or announce that he was closing shop.

SpaceX became the first private company to launch resupply capsules to the ISS, with its unmanned Dragon capsule.

What was not expected was that SpaceX would attempt another launch within less than two months. On September 28, 2008, the company completed its first successful Falcon 1 mission, carrying the 165-kg Ratsat demonstration satellite.

In many ways, SpaceX is reminiscent of the U.S. government during the late 1950s and the early 1960s, when so many of its rockets kept blowing up, and it just kept trying until it managed to launch its astronauts to the Moon. The Russians still operate that way. Whenever one of their Proton rockets fails, they launch again within a few months. It is an aggressiveness that some in the space industry may feel is irresponsible. However, it is an attitude that is probably required if you plan to be doing things like sending humans to the Moon and Mars in timeframes of 10 years or less.

Falcon 9 was scheduled to begin launches to GEO in September.

SPACEX MANIFEST *(to LEO unless noted)*

Date Launched	Launcher	Customer	Country	Payload	Mass (kg)
03/24/06	Falcon 1*	Air Force Academy	U.S.	FalconSat 2	19.5
03/20/07	Falcon 1*	NASA/DARPA	U.S.	LCT2/AFSS	150
08/02/08	Falcon 1*	MDA	U.S.	Trailblazer	83.5
		NASA ARC	U.S.	Nanosail-D	4
		NASA ARC	U.S.	PREsat	4
		Space Services	U.S.	Celestis 7	1
09/28/08	Falcon 1	SpaceX	U.S.	Ratsat	165
07/14/09	Falcon 1	Astronautic Technology	Malaysia	RazakSAT	180
06/04/10	Falcon 9 v.1.0	SpaceX	U.S.	Dragon (qual)	< 4,200
08/12/10	Falcon 9 v.1.0	SpaceX	U.S.	Dragon C1	< 4,900
		Northrop Grumman/USC	U.S.	Mayflower-Caerus	5
		NRO	U.S.	QbX 1, 2	5
		Army SMDC	U.S.	SMDC-ONE 1	4
		Los Alamos National Lab	U.S.	Perseus 000 - 003	1.5
05/22/12	Falcon 9 v.1.0	SpaceX	U.S.	Dragon C2	6,650
08/10/12	Falcon 9 v.1.0	NASA	U.S.	Dragon CRS-1	6,650
		Orbcomm	U.S.	Orbcomm-NG 1	142
01/13/13	Falcon 9 v.1.0	NASA	U.S.	Dragon CRS-2	6,650
Planned					
09/13	Falcon 9 v.1.1	SES World Skies	Netherlands	SES-8**	3,200
09/13	Falcon 9 v.1.1	Canadian Space Agency	Canada	Cassiope 1***	375
		University of Colorado	U.S.	DANDE	50
		Cornell University	U.S.	CUSat 1, 2	1
		Drexel (and other univs.)	U.S.	POPACS 1	1
		Drexel (and other univs.)	U.S.	POPACS 2	1.5
		Drexel (and other univs.)	U.S.	POPACS 3	2
		Stanford University	U.S.	SNAPS	0.5
10/13	Falcon 9 v.1.1	Shin Satellite	Thailand	Thaicom 6**	3,325
11/13	Falcon 9 v.1.1	Orbcomm	U.S.	Orbcomm-NG 2 - 9	142
01/15/14	Falcon 9 v.1.1	NASA	U.S.	Dragon CRS-3	–
		University of Hawaii	U.S.	Ho'oponopono 2	3.5
		NASA Goddard	U.S.	TechCube 1	3
		Montana Space Grant Consortium	U.S.	FIREBIRD A	2
		California Inst. of Technology	U.S.	LMRSat	2
		Colorado Space Grant Consortium	U.S.	ALL-STAR/THEIA	1
		Colorado Space Grant Consortium	U.S.	Hermes 2	1
		City University of New York	U.S.	CUNYSAT 1	1
04/06/14	Falcon 9 v.1.1	NASA	U.S.	Dragon CRS-4	–
		NRL	U.S.	Spinsat	55
2014	Falcon 9 v.1.1	Asia Satellite Telecommunications	China	Asiasat 6**	3,813
2014	Falcon 9 v.1.1	Asia Satellite Telecommunications	China	Asiasat 8**	3,813
2014	Falcon 9 v.1.1	NASA	U.S.	Dragon CRS-5	–
2014	Falcon 9 v.1.1	Army SMDC	U.S.	Kestrel Eye 1	14
		NASA JPL	U.S.	IPEX	1

Otherwise, people and investors lose interest, and the costs of such programs grow out of control, thereby decreasing their odds of completion.

In spite of Musk's bold, seemingly outrageous ideas and predictions, it is getting harder and harder to bet against SpaceX. Just look at the company's launch manifest. It is impressive in terms of both length and diversity, not to mention that it was built up within a few short years. The company has not been around very long. Founded in 2002, it has been launching since only 2006. Its first successful launch did not occur until late 2008, yet it has something on the order of 30-40 flights scheduled over the next five years—depending on how payloads are configured. It certainly sounds like a serious business venture.

The only mildly weak area in SpaceX's manifest is the military side. Falcon rockets have launched only six satellites for the Dept. of Defense, including two for the NRO; one for the Air Force Academy; one for the Army Space and Missile Defense Command (SMDC); one for DARPA; and one for the Missile Defense Agency. All of these spacecraft have been small or tiny, and none could be called critical to national security. They were all technology development satellites—the Pentagon was searching for a cheap ride to space, and SpaceX was glad to provide it.

There are only nine military satellites in the manifest. They include the DSCOVR Earth observation STP-2 ISAT technology satellites for the Air Force, the DSX technology satellite for the

Date Launched	Launcher	Customer	Country	Payload	Mass (kg)
2014	Falcon 9 v.1.1	Orbcomm	U.S.	Orbcomm-NG 10 - 18	142
2014	Falcon 9 v.1.1	Satelites Mexicanos	Mexico	Satmex 7**	5,600
		Asia Broadcast Satellite	China	ABS 3A**	1,800
10/20/14	Falcon 9 v.1.1	Ministry of Communications	Turkmenistan	Turkmensat 1**	4,500
11/15/14	Falcon 9 v.1.1	Air Force	U.S.	DSCOVR	440****
		SpaceX	U.S.	SHERPA (demo)	–
		NASA	U.S.	Sunjammer	< 50
12/05/14	Falcon 9 v.1.1	NASA	U.S.	Dragon CRS-6	–
		NASA	U.S.	SAGE III	76
12/30/14	Falcon 9 v.1.1	Star One	Brazil	Star One C5**	4,680
03/01/15		NASA	U.S.	Jason 3	553
03/03/15	Falcon 9 v.1.1	NASA	U.S.	Dragon CRS-7	–
06/01/15	Falcon 9 v.1.1	NASA	U.S.	Dragon CRS-8	–
		Bigelow Aerospace	U.S.	BEAM	1,360
2015	Falcon 9 v.1.1	Satelites Mexicanos	Mexico	Satmex 9**	5,600
		Asia Broadcast Satellite	China	ABS 2A**	1,800
2015	Falcon 9 v.1.1	CONAE	Argentina	SAOCOM 1A	900
		Astronautic Technology	Malaysia	D-Sat	< 25
		Alas Peruanas University	Peru	UAPSat	1
2015	Falcon 9 v.1.1	NASA	U.S.	Dragon CRS-9	–
			U.S.	IDA 2	–
2015	Falcon Heavy	AFRL	U.S.	DSX	600
		NRO	Taiwan	Formosat-7A – 7L	217
2015	Falcon 9 v.1.1	Iridium Satellite	U.S.	Iridium-NEXT 3 - 22	800
2015	Falcon 9 v.1.1	Air Force	U.S.	STP-2 ISAT	5,000
2015	Falcon 1e	NRL	U.S.	TacSat-1A	110
12/15	Falcon 9 v.1.1	SpaceX	U.S.	SHERPA 1	–
01/05/16	Falcon 9 v.1.1	NASA	U.S.	Dragon CRS-10	–
04/05/16	Falcon 9 v.1.1	NASA	U.S.	Dragon CRS-11	–
			U.S.	OCO 3	550
2016	Falcon 1e	GeoOptics	U.S.	Cicero 1 - 6	30
2016	Falcon 9 v.1.1	SpaceX	U.S.	DragonLab 1	–
2016	Falcon 9 v.1.1	Iridium Satellite	U.S.	Iridium-NEXT 23 - 62	800
08/08/16	Falcon 9 v.1.1	NASA	U.S.	Dragon CRS-12	–
2016	Falcon 9 v.1.1	SpaceX	U.S.	DragonLab 2	–
2016	Falcon 9 v.1.1	CONAE	Argentina	SAOCOM 1B	900
2016	Falcon 9 v.1.1	SpaceX	U.S.	SHERPA 2	–
2017	Falcon 9 v.1.1	SpaceX	U.S.	DragonRider	–
2017	Falcon 9 v.1.1	Iridium Satellite	U.S.	Iridium-NEXT 63 - 72	800
2017	Falcon 9 v.1.1	SpaceX	U.S.	SHERPA 3	–
2018	Falcon 9 v.1.1	CSA	Canada	RCM 1 - 3	1,300
2018	Falcon 9 v.1.1	Bundeswehr	Germany	SARah Aktiv 1	2,200
2018	Falcon 9 v.1.1	B612 Foundation	U.S.	Sentinel Telescope	1,500
2019	Falcon 9 v.1.1	Bundeswehr	Germany	SARah Passiv 1, 2	1,800

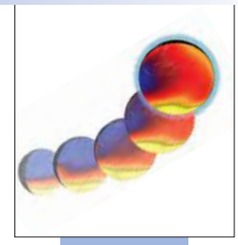
*Launch failure. **GEO. ***Elliptical. ****Lagrange point 1 (L_1).

AFRL, the Kestrel Eye 1 tactical imaging satellite for the Army SMDC, three SARah radar imaging satellites for the German Armed Forces (Bundeswehr), and the Spinsat technology demonstration and TacSat-1A maritime surveillance experimental satellites for the Naval Research Laboratory.

Within a few years, though, SpaceX may be winning its share of launches under the Air Force's Evolved Expendable Launch Vehicle program, which has been the exclusive domain of United Launch Alliance, a Boeing/Lockheed Martin joint venture, for several years. Once SpaceX's Falcon Heavy is certified by the Air Force, it is likely to be selected for at least 14 of the next 50 EELV missions contracted. The prices for Falcon 9 v.1.1 and Falcon Heavy, estimated at nearly half the price of the Atlas Vs and Delta IVs, are going to be attractive to the Air Force, which has long been seeking to reduce its launch costs dramatically—ever since the days of the $350-million-per-mission Titan IV rocket.

Next to cargo resupply work for NASA, Musk views competing head to head with Boeing and Lockheed Martin for EELV contracts as his top priority. Last year the Air Force awarded SpaceX two EELV-class payloads—DSCOVR and STP-2 ISAT. That was the first time a company besides Boeing or Lockheed Martin was allowed into EELV. SpaceX has opened another door for itself, and one that is sure to add noticeably to its manifest.

Marco Cáceres
Teal Group
mcaceres@tealgroup.com



Space science GOLD: A payload trend?

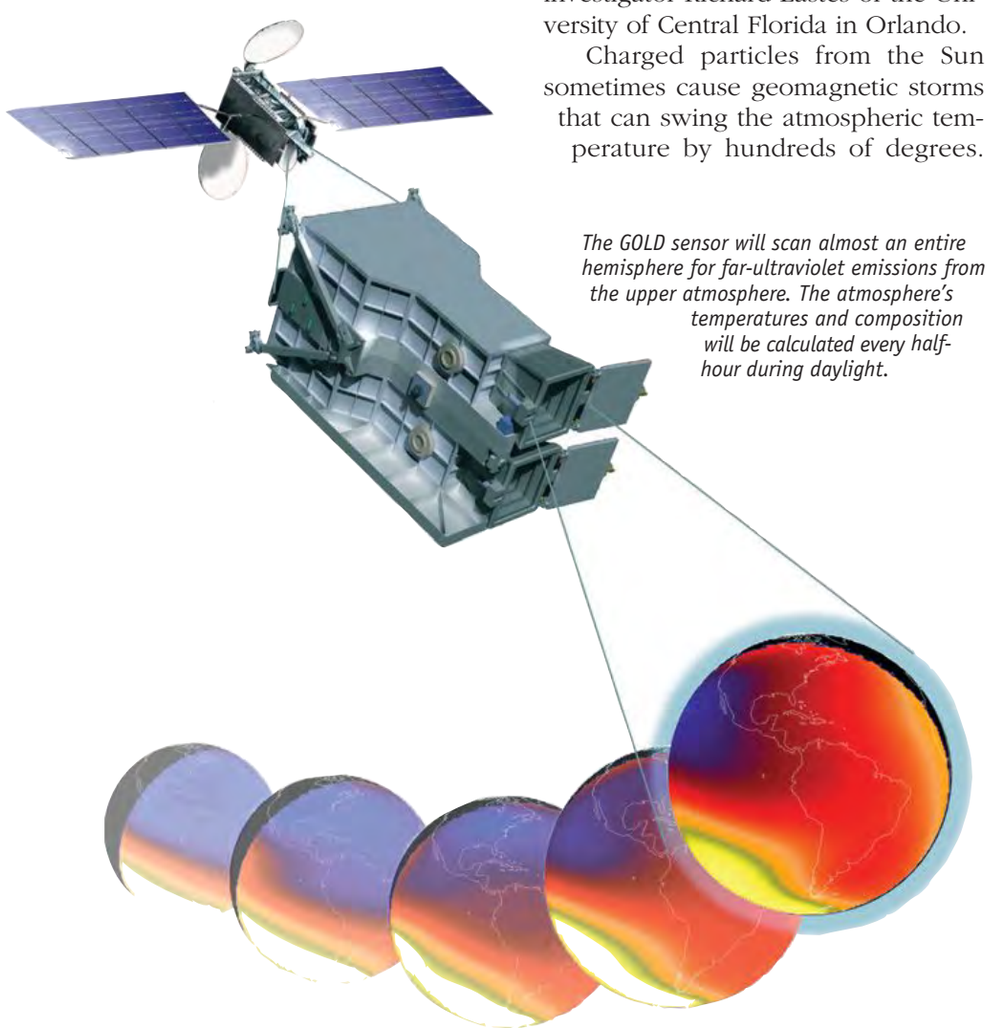
NASA'S GOLD (GLOBAL-SCALE OBSERvations of the limb and disk) instrument is a space weather sensor scheduled for launch in 2017 as a hosted payload on a commercial communications satellite.

From its perch in geosynchronous orbit, the 26-kg GOLD sensor will scan almost an entire hemisphere of Earth—175 degrees, to be exact—for far-ultraviolet emissions from the upper atmosphere at an altitude of 160 km. From these spectral readings, the temperatures and composition of the atmosphere will be calculated every half-hour during daylight. At night, GOLD will search the ionosphere for irregularities that can disrupt signals traveling between space and Earth, especially GPS signals.

The ionosphere and thermosphere at 160 km are complicated places that scientists do not fully understand. Hurricanes, weather fronts, and solar energy produce gravity waves and tides that change the composition and temperature. The Sun is the primary source of the tides, because as Earth rotates, heat is deposited along 360 degrees of longitude.

"Beyond that, the pattern becomes more complex," says GOLD principal investigator Richard Eastes of the University of Central Florida in Orlando.

Charged particles from the Sun sometimes cause geomagnetic storms that can swing the atmospheric temperature by hundreds of degrees. GOLD will depict all these fluctuations with color-coded maps.



The GOLD sensor will scan almost an entire hemisphere for far-ultraviolet emissions from the upper atmosphere. The atmosphere's temperatures and composition will be calculated every half-hour during daylight.

The main engineering challenge will be to keep GOLD's optics clean during development, installation, and launch. On top of that, the team has little wiggle room in its development schedule. The instrument must be ready in time to catch a ride on the commercial satellite.

Over time, if all goes as planned, GOLD will chronicle changes more persistently from GEO than it could from low Earth orbit. LEO satellites pass by a particular location on Earth about once a day, but GOLD will stare at the same side of Earth continually from geosynchronous orbit. The sensor could in theory produce images as often as every 15 minutes, but the team plans to operate at a half-hour cadence.

Once GOLD is up, GPS operators are expected to use its data to improve the algorithms that correct for atmospheric signal distortions. The FAA might even be able to reduce false alarms about possible GPS outages during geomagnetic storms.

"This information should, we hope, decrease the chance of having unnecessary [flight] delays, and it would also improve the [GPS] accuracy at other times," says Eastes.

Eight-year effort

Winning a $55.6-million commitment from NASA in April was a big breakthrough for Eastes and his teammates. The sensor will be built at the University of Colorado's Laboratory for Atmospheric and Space Physics, or LASP. Communications satellite operator SES Government Solutions of McLean, Virginia, has reached a "rough order of magnitude" agreement on how much it should cost to host GOLD on one of its upcoming satellites.

Eastes and LASP have been trying to get GOLD funded since 2005 under

NASA's Explorer series but have never gotten beyond phase A research funding until now.

The attraction of a hosted satellite was that building a free-flying spacecraft and launching it to geosynchronous orbit would have been impossibly expensive. The hosted payload option was the only way to keep GOLD under the Explorer cost cap, which is currently $55.6 million.

When Eastes and his partners first broached their idea in 2005, flying a scientific instrument on a commercial satellite was a very new idea.

"There have been ancillary instruments, for instance radiation detectors, on other satellites in the past. However, when we first proposed GOLD there had been no remote sensing science instruments flown as hosted payloads," Eastes says.

The skeptical questions flowed from NASA during site visits and reviews. Could the construction schedule for a scientific instrument be synchronized with that of a commercial satellite? What about contamination on the ground or out in space? A little bit of vaporized goo can wreak havoc on scientific optics.

Not all the questions were from NASA to the physicists. SES Government Solutions had to reassure backers that GOLD would not pose an unacceptable risk to a valuable communications satellite.

"They've got to be able to convince everyone—not just a NASA review panel, but their investors and their insurance company—that this is a reasonable thing to do," Eastes says. Gradually, the concept lost its radical aura. "It became clear that the industry was behind us, that they felt this is something really beneficial for them," he adds.

Even so, the GOLD team needed three attempts to get a 'yes.' "This time, they finally found the money," says Eastes.

Payload pioneers

The selection of GOLD could arguably be considered the start of a payload trend. In November NASA announced selection of another scientific hosted payload, the $90-million TEMPO (tropospheric emissions: monitoring of pollution), scheduled to be built by 2017. That would be in time for launch on a commercial satellite yet to be named.

CHIRP (commercially hosted infrared payload) was installed on the SES-2 commercial satellite. Credit: SES Government Solutions.

Two missions are a good start, but the GOLD team cautions against overconfidence. "We're still in the pioneering phase of doing this," says Mark Lankton of LASP, the project manager.

GOLD scientists may have benefited from the success of an Air Force infrared missile warning instrument called CHIRP (commercially hosted infrared payload). Launched into geosynchronous orbit in September 2011 on an SES communications satellite, it is reportedly performing well. CHIRP is an experimental military instrument, but its challenges are largely similar to those of GOLD. It has a good view of the U.S., so it can watch missile tests at ranges in Arizona and New Mexico.

GOLD scientists are not sure yet on which satellite their instrument will be hosted, so they do not know where in orbit it will be positioned. Somewhere with a view of the U.S. would be optimal, because it would make downloading the data less complicated, and it would enhance opportunities for public outreach.

"If you say, 'This satellite basically is looking at the thermosphere and ionosphere over your house,' it brings the general interest in," Lankton says.

At the end of the day, the scientists do not really care where GOLD ends up. They can prove its effectiveness anywhere.

No 'goo' please

GOLD will have two separate baffles to let ultraviolet radiation in and keep stray light out. Mirrors and a grating corresponding to each baffle will direct the ultraviolet radiation to detectors. Those optics must be kept clean to keep the UV signal as strong as possible. Covering each baffle will be a spring-loaded hatch that will be commanded to pop open about a month after launch. The optics will produce identical UV channels. The readings will be combined to produce color-coded temperature maps about once every half-hour.

"There are times when we need the two channels to get as much signal-to-noise [ratio] as we want and as we need to satisfy the requirements," Eastes explains.

The GOLD team spends lots of time worrying about contamination from glues or lubricants that might be used in construction of the host satellite and instrument.

"Any sort of goo on your optics—you know, something that evaporates from one part of the spacecraft and lands on your mirrors, for instance—just kills the signal," says Lankton.

Controlling contamination is especially important for instruments like GOLD that must be sensitive to short UV wavelengths. "Basically the shorter the wavelength you're looking at, the cleaner you need to be, just as a rule of thumb," Lankton explains.

One precaution will be to pump pure nitrogen gas into the instrument, from the moment it is assembled at LASP until launch. The nitrogen will flow out of small gaps between the baffles and their protective covers to prevent any contaminants from flowing in.

In space, spring-loaded hatches will be popped open, and this is when a second anticontamination precaution will become apparent. The instrument will be positioned on the satellite's Earth-facing deck so that its mirrors are not in line with any potential contaminant sources, such as the satellite's solar arrays.

"If you've got some lubricant or glue or something that's giving off gas from somewhere on the spacecraft, or somewhere on your own instrument even, it tends to evaporate and just go out," Lankton says. He notes there are "no wind currents up there, so it doesn't turn corners."

Measuring cleanliness

These precautions are not the whole story. The GOLD team has spent time with commercial satellite manufacturers and noticed that they pay more attention to contaminants than some NASA scientists initially assumed.

"Part of the reason is that they have long-term contamination concerns of their own," Lankton says. Thermal control surfaces, for example, need to stay clean over what could be a 15-year communications mission.

The GOLD team visited manufacturers to find out what kinds of materials and practices they typically use. Commercial manufacturers place their spacecraft in thermal vacuum chambers equipped with sensitive scales called thermoelectric quartz crystal microbalances. These devices measure the weight of any contaminants that might outgas and accumulate on a satellite's surfaces.

"We worked with one commercial satellite builder to obtain the data from a representative spacecraft, and found that the overall outgassing numbers were acceptable, given that we plan to protect the cleanliness of the instrument in several different ways prior to launch," Lankton says.

Synchronizing schedules

The GOLD team also faces the challenge of meshing production schedules with a still-unspecified commercial communications satellite. "Typically, the science instruments are on a little bit different schedule—a little longer one, actually—than the commercial communications satellites," Eastes says.

The team does not think this will be a problem. The scientists have had a lot of extra time to refine their design over the years, and they were not starting from scratch. LASP built a similar ultraviolet instrument for the Cassini Saturn probe launched in 1997. The team has a baseline design in hand that will use the RS-232 connection interface. "Now we'll go back and decide the connectors that actually get used, and refine more closely the details of the interface, how that electrically will work," Eastes says.

To be ready to go once they learn which satellite will carry GOLD, the team has been looking at the designs of different candidate satellite frames. Whichever satellite that is, the commands will go up to GOLD via the same route as the commands to the satellite. The scientific data will come down to a ground station via a separate transponder.

If things go well with GOLD, scientists are hopeful the mission will prompt the U.S. to make such space weather readings a regular part of business. "Ideally, you'd have three of these [instruments], and you could see absolutely everything absolutely all the time. But we have one, and it'll be a big step forward," Lankton says.

Ben Iannotta
biannotta@deepdiveintel.com

(Continued from page 7)

It is also generating complaints, however, because every altered traffic pattern can mean increased noise over someone's house. Typical is the Forest Hill neighborhood association near Newark, which is bombarding the New Jersey congressional delegation with complaints that aircraft flyovers are now louder.

Secretary of the Air Force

Deborah Lee James is the president's choice to become secretary of the Air Force, the White House announced on August 1.

"Deborah's strong record of public service and leadership in the private sector makes her uniquely qualified to be my nominee," said President Obama in a statement. "I look forward to working with her to keep our Air Force the very best in the world and to keep faith with our extraordinary Air Force personnel and their families."

James is a former assistant defense secretary and House of Representatives staffer who comes from defense contractor Science Applications International Corporation (SAIC), where she was technical and engineering president. SAIC's chairman and CEO is retired Gen. John P. Jumper, former Air Force chief of staff. James, if confirmed by the Senate, will work with the current chief of staff, Gen. Mark Welsh.

James has held various positions during a 30-year career in government and the private sector. She serves on the Defense Dept. Advisory Committee on Women in the Services. She will replace Michael Donley, who announced his retirement on April 28 and left office June 30. Some Washington pundits wondered why it took Obama fully three months to choose a candidate. Eric Fanning has been serving as acting secretary.

At a time when the Air Force needs fuel, flying time, a new bomber, and a new focus on the Pacific region, some in Washington wonder whether James—who has worked on the military's legal and social issues in the past—was chosen because of the Air Force's ongoing scandal (and seeming preoccupation) over sexual assault in the ranks. The Air Force is the only service branch to have placed a two-star flag officer in charge of addressing the problem. That officer is Maj. Gen. Margaret Woodward, who earlier commanded U.S. air operations over Libya, in spring 2011.

Supporters of the James appointment point to a healthy relationship between the public and private sectors and note that she is well qualified for her new duties. Critics see a 'revolving door' between government and industry, with too much familiarity between the two sectors.

Lawmakers blasted the Air Force this spring after two incidents in which senior officers overturned guilty verdicts in sexual assault courts-martial. One of those senior officers was Lt. Gen. Susan Helms, a former shuttle astronaut nominated to be vice commander of Air Force Space Command. Sen. Claire McCaskill (D-Mo.) put a temporary hold on the Helms nomination—still in effect when Congress went into recess—as a way of protesting what she called "the inadequacy of the military justice system when dealing with assaults."

Under military law today, a commander can overturn a court-martial verdict just as Helms did, and the commander's decision becomes final, with neither the secretary of defense nor the president having any authority to intervene. Because of the severity of the sexual assault issue, a bipartisan group in the Senate wants to overhaul the military justice system. Sen. Barbara Boxer (D-Calif.) says, "immediate steps must be taken to prevent senior commanders from having the ability to unilaterally overturn a decision or sentence by a military court." McCaskill says she will introduce a bill to do exactly that.

Deborah Lee James

Lt. Gen. Susan Helms

Military experts believe the critics are on the wrong flight path. "It's no accident that military justice is different from what happens in the civilian courts," says Fred L. Borch, an attorney and historian on military law. "Military culture requires that we have confidence in our commanders. They are accountable for everything that happens under them, and they should retain the authority to act responsibly when they see a flaw in a court-martial finding."

At a time when the Air Force secretary probably should be answering questions about the F-35 Lightning II Joint Strike Fighter, an aging arsenal of atomic weapons, troop morale in the face of the fiscal sequester, and a host of other issues, nominee James can expect the Senate to grill her about the court-martial system and about assault in uniform. James has worked such issues in the past and is well qualified to deal with them, but her views on changing the military justice system are not known.

She will certainly be asked.

Robert F. Dorr
robert.f.dorr@cox.net

Robert F. Dorr's new book, Mission to Tokyo*, is a history of American bomber crews in WW II.*

China's new aircraft carrier conducted its first recovery of an aircraft—the J-15—last November.

Chinese military modernization remains robust and shows no signs of letup. A growing variety of advanced weapons is making the Chinese People's Liberation Army (PLA) ever more capable of waging war, both close to home and far away from its shores and borders. New weapons already deployed or far along in development include antiship and land-attack ballistic and cruise missiles, nuclear submarines, surface combatants, advanced aircraft, and an aircraft carrier. China is now a demonstrable military threat in space and in cyberspace.

The DOD set forth this assessment for 2012 in its annual report to Congress on Chinese military developments. Issued earlier this year, the report concludes that preparing for short-duration, high-intensity conflicts, and for potential conflict in the Taiwan Strait, is the main goal of Beijing's military investments. However, weapons and forces now being developed and produced "will enable the PLA to conduct a range of military operations in Asia well beyond Taiwan [and] in the South China Sea, western Pacific, and Indian Ocean," the report notes.

David Helvey, assistant secretary of defense for East Asia, addressed reporters at a Pentagon press briefing on the report. He said that although relations between China and Taiwan appear to have improved, preparation for possible armed conflict across the Taiwan Strait is still the "principal focus and primary driver" of China's military buildup. Sustained and robust annual increases in defense spending are financing this buildup, according the report.

China's military budget for this year

by James W. Canan
Contributing writer

China's growing military might

Continuing modernization is improving China's capabilities for waging war, both conventional and nuclear, at growing distances from its own shores, according to DOD's most recent findings. The country's defense plans emphasize new and expanding domains, including cyberspace, now an area of major activity and even aggression, notes the Pentagon. China's efforts to overcome remaining vulnerabilities in its defenses show no signs of abating.

stands at $114 billion, representing a 10.7% increase over the previous year, the DOD document says. It notes also that estimating China's actual defense expenditures presents difficulties "due to a lack of accounting transparency" and to "China's incomplete transition from a command economy to a market economy." Because publicized figures omit many categories of military expenditures, the actual spending total could be as high as $135 billion-$215 billion a year, the Pentagon believes.

The direction and priorities of China's military modernization dovetail with its growing influence on the international scene, the DOD document notes. Beijing "has become increasingly focused on investments in military capabilities to conduct a wider range of missions beyond the country's immediate territorial concerns, including counterpiracy, peacekeeping, humanitarian assistance/disaster relief, and regional military operations." The report also notes that one of the development priorities stated in China's 2008 Defense White Paper is "to increase the country's capabilities to maintain maritime, space, and electromagnetic space security."

Emphasis on cyberspace

The DOD document says Beijing "is investing in military programs and weapons designed to improve extended-range power projection and operations in emerging domains such as cyber, space, and electronic warfare." The report is explicit, for the first time, in accusing Chinese government and military establishments of having invaded military and private-sector computers and networks of the U.S. and of other nations.

"China continues to explore the role of military operations in cyberspace as a fea-

Completing the Beidou network will bring China closer to matching U.S. space capabilities.

ture of modern warfare, and continues to develop doctrine, training, and exercises that emphasize information technology and operations," Helvey told reporters. "In addition, in 2012, numerous computer systems around the world, including those owned by the U.S. government, continued to be targeted for intrusions, some of which appear to be attributable directly to the Chinese government and military."

The report asserts: "China is using its computer network exploitation (CNE) capability to support intelligence collection against the U.S. diplomatic, economic, and defense industrial base sectors that support U.S. national defense programs. The information targeted could potentially be used to benefit China's defense industry, high-technology industries, policymaker[s]…and military planners building a picture of U.S. defense networks, logistics, and related military capabilities that could be exploited during a crisis."

Cyberwarfare capabilities support Chinese military operations by enabling data collection for purposes of attacking the computer networks and intelligence networks of possible adversaries, the report notes. Such capabilities also help the military target network-based logistics, communications, and commercial activities, also serving as a force multiplier when used in conjunction with kinetic warfare attacks during armed conflict.

In the U.S., a Defense Science Board (DSB) report issued this year dramatized that assessment by noting that the designs of nearly 30 major U.S. weapon systems have been captured in cyberspace by foreign hackers. The DSB report did not name China as the culprit, but sources familiar with the document were unrestrained in doing so.

According to the report, the compromised designs included those of the F-35 and F-18 fighters, the Navy V-22 Osprey tiltrotor aircraft, the C-17 airlifter, the Global Hawk surveillance and reconnaissance UAV, the Navy littoral combat ship and Mk54 lightweight torpedo, the Aegis ballistic missile defense system, and the Patriot surface-to-air missile system. Directed-energy, nano- and satellite communications technologies also were named by DSB as having been pilfered in cyber intrusions that other sources have attributed to China.

China's 2010 Defense White Paper stressed cybersecurity's importance to national defense and expressed concern over foreign cyberwarfare efforts, the DOD report notes. It also says an essential element of China's antiaccess, area-denial (A2/AD) planning is "the ability to control and dominate the information spectrum in all dimensions of the modern battlespace." This "information blockade" strategy is fundamental to gaining an "information advantage" early in a campaign to attain military superiority in the air, on land, at sea, in cyberspace, and in outer space, the DOD report proclaims.

A2/AD warfare

China's emphasis on girding for antiaccess and area-denial warfare shows up in its "sustained effort to develop the capability to attack, at long ranges, military forces that might deploy or operate in the western Pacific," says the Pentagon report:

"China is pursuing a variety of air, sea, undersea, space, and counterspace and information warfare systems, and operational concepts to achieve this capability…. China's current and projected force structure improvements will provide the PLA with systems that can engage adversary surface ships up to 1,000 n.mi. from China's coast." Beijing is intent on developing weapons that will enable its combat arms to project power even farther from home, against targets such as regional air bases, logistical facilities, and infrastructures, the report continues.

"China is fielding an array of conventionally armed ballistic missiles, ground- and air-launched land-attack cruise missiles, special operations forces, and cyberwarfare capabilities to hold targets at risk throughout the region," the report asserts. The introduction of China's first aircraft carrier has also strengthened the country's regional combat capability, as have advanced fighter aircraft, submarines, integrated air defenses, improved command and control, and more

sophisticated training and exercises across air, naval, and land forces.

The PLA Navy is at the forefront of China's A2/AD developments, because it has "the greatest range and staying power" to interdict enemy forces, says the report. "In conflict, PLA Navy operations would likely begin in the Chinese offshore and coastal areas with attacks by coastal defense cruise missiles, maritime strike aircraft, and smaller [surface] combatants, and extend as far as the second island chain and Strait of Malacca using large surface ships and submarines. As the Chinese navy gains experience and acquires larger numbers of more capable seagoing platforms, including those for long-range air defense, it will expand its operations farther into the western Pacific, and "it will develop a new capability with ship-based land-attack cruise missiles," the document predicts.

"China views long-range anti-ship cruise missiles as a key weapon and is developing multiple advanced types and the platforms to employ them," the report says. The platforms include four types of conventionally powered and nuclear-powered attack submarines, six types of surface combatants, and four models of maritime strike aircraft, it continues.

Currently, China would display several shortcomings in an A2/AD operation, the Pentagon document contends. "First, it has not developed a robust, deep-water antisubmarine warfare capability, in contrast to its strong capabilities in the air and surface domains. Second, it is not clear whether China has the ability to collect accurate targeting information and pass it to launch platforms in time for successful strikes in sea areas beyond the first island chain. However, China is working to overcome these shortcomings."

Helvey noted that the new aircraft carrier conducted its first recovery of an aircraft—the carrier-capable J-15 fighter—last November. China is expected to "spend the next three or four years on training and integration before achieving an operationally effective aircraft carrier capability" and "will likely build several indigenous aircraft carriers over the next 15 years," he said.

"In addition to Taiwan, China places a high priority on asserting its maritime territorial claims," said Helvey. "In recent years, China has begun to demonstrate a more routine and more capable presence in both the South and East China Seas, which has increased anxieties over China's intentions."

The space domain

The U.S. is closely monitoring Chinese military activities in space, Helvey declared. Last year, he noted, China conducted 18 space launches and expanded its constellations of space-based ISR (intelligence, surveillance, and reconnaissance), navigation, meteorological, and communications satellites, and continues to invest in a multidimensional program to deny others access to, and use of, space.

The Pentagon report contends that China sees space utilization, and the ability to deny adversaries access to space, as fundamental to waging modern, information-based warfare. Space operations would play a key role in the A2/AD operations of the PLA, which is "acquiring a range of technologies to improve China's space and counterspace capabilities," says the report. It notes that the Chinese demonstrated their counterspace, kinetic-kill capability by destroying a defunct Chinese weather satellite in early 2007, and have not acknowledged any additional antisatellite programs since.

According to the report, a PLA analysis of U.S. and allied-coalition military operations "reinforced the importance of operations in space to enable 'informatized' warfare" and concluded that "space is the commanding point for the information battlefield." The DOD report further notes that "PLA writings emphasize the necessity of 'destroying, damaging, and interfering with the enemy's reconnaissance and communications satellites,' suggesting that such systems, as well as navigation and early warning satellites, could be among the targets of [Chinese] attacks designed to 'blind and deafen the enemy.'"

The Pentagon report also quotes the PLA as having stated that 'destroying or capturing satellites and other sensors…will deprive an opponent of initiative on the

The J-11B is part of China's fleet of fourth-generation aircraft.

China continues to develop UAVs like the BZK-005 (image from Chinese Defense Website).

battlefield and [make it difficult] for them to bring their precision-guided weapons into full play.'"

New fighter, advanced SAMs

China continues to develop its fifth-generation air-superiority fighter, which "is not likely to be fielded before 2018," says the Pentagon report. That warplane is expected to be highly maneuverable and stealthy, with "lack of visibility on radar due to very low observable shaping, and an internal weapons bay." It will embody modern avionics and sensors to provide "more timely situational awareness for operations in network-centric environments, radars with advanced targeting capabilities and protection against enemy electronic countermeasures, and integrated electronic warfare systems with advanced communication and GPS navigation functions."

The new fighter should greatly improve the air power now vested in China's existing fleet of fourth-generation aircraft—the Russian-built Su-27/Su-30 and the indigenous J-10 and J-11B fighters—"by utilizing low-observable platforms to support regional air superiority and strike operations," says the Pentagon report. Moreover, it says, "China's continuing upgrades to its bomber fleet may provide the capability to carry new, longer range cruise missiles." In addition, its development and acquisition of "longer range unmanned aerial vehicles, including the BZK-005, and unmanned combat aerial vehicles, will increase China's ability to conduct long-range reconnaissance and strike operations."

Mainly to counter long-range airborne strike aircraft and low-flying cruise missiles, China's ground-based air defenses feature increasing numbers of advanced, long-range surface-to-air missiles (SAMs), including Chinese HQ-9 and Russian-built SA-10 and SA-20 SAMs. China wants to acquire the Russian S-400 SAMs, with a range of 400 km, and is expected to continue developing longer range variants of its home-produced HQ-9, 200-km SAM.

Longer range SAMs are fundamental to China's military modernization, the U.S. report contends. It depicts Beijing as trying to "go beyond defense from aircraft and cruise missiles to gain a ballistic missile defense capability" in protection of mainland and strategic assets. The report also notes that the SA-20, said to be the most advanced SAM that Russia offers for export, has the advertised capability to engage ballistic missiles at long range; China's domestic CSA-9 SAM system can engage them only at much shorter distances, it says.

China is expected to continue developing longer range variants of its HQ-9.

Missile defense and nuclear capabilities

More broadly, "China is proceeding with research and development of a missile defense umbrella consisting of kinetic-energy intercept at exoatmospheric altitudes (above 80 km), as well as intercepts of ballistic missiles and other aerospace vehicles within the upper atmosphere," says the report. It notes that in January 2010, and again in January of this year, China successfully intercepted ballistic missiles at midcourse, using ground-based SAMs.

At the same time, China is developing a range of technologies—for systems such as maneuverable reentry vehicles, chaff, decoys, jamming, thermal shielding, and antisatellite weapons—to counter the ballistic missile defenses of the U.S. and other nations. "China's official media also cite numerous Second Artillery training exercises featuring maneuver, camouflage, and launch operations under simulated combat condi-

A JL-2 missile is flight tested from a new Jin-class ballistic missile submarine on patrol in the Bohai Sea.

tions which are intended to increase survivability," the report adds. "Together with the increased mobility and survivability of the new generation of missiles, these technologies and training enhancements strengthen China's nuclear force and enhance its strategic capabilities."

The paper also notes that increases in the number of its mobile ICBMs and "the beginning of deterrence patrols" by its SSBN nuclear-armed submarines "will force the PLA to implement more sophisticated command and control systems and processes…for a larger, more dispersed [nuclear] force."

Production and deployment of China's Jin-class nuclear-armed ballistic missile submarines are on steady course, according to the report. It says that three of the Jin-class subs have been delivered and "as many as two more [are] in various stages of construction." These "will eventually carry the JL-2 submarine-launched ballistic missile with an estimated range of 7,400 km" and "will give the PLA Navy its first long-range, sea-based nuclear capability." After a round of successful testing in 2012, the JL-2 missile appears ready to reach operational capability this year, and Jin-class SSBNs based at Hainan Island in the South China Sea will then be capable of operational patrols, the report says.

China is fashioning its nuclear force to be capable of surviving any attack and of responding with enough power to inflict unacceptable damage on the attacker, says the DOD report. Beijing has consistently asserted that it adheres to a "no first use" nuclear policy, that it would resort to using nuclear weapons only in response to a nuclear strike against the homeland, and that it would never use or threaten to use nuclear weapons against any nonnuclear-weapon state or nuclear-free zone, it says.

The Chinese "will likely continue to invest considerable resources to maintain a limited, but survivable, nuclear force (sometimes described as 'sufficient and effective') to ensure [that] the PLA can deliver a damaging retaliatory nuclear strike," says the Pentagon report. It predicts that this nuclear force will consist of approximately 50-75 silo-based and road-mobile ICBMs complemented by intermediate-range ballistic missiles for "regional deterrence missions." By 2015, the force will include additional silo-based and road-mobile ICBMs, the paper predicts.

In keeping with its 'no first use' policy, China has assumed that it may need to absorb an initial nuclear strike while shielding its leadership and strategic assets, says the report. As a result, it says, China "maintains a technologically advanced underground facility program protecting all aspects of its military forces, including C2 (command and control), logistics, missile, and naval forces." China began updating and expanding its construction of underground facilities with greater urgency in the latter part of the last century, in reaction to the increased precision and penetrating power of modern weaponry, says the paper: "A new emphasis on 'winning high-tech battles' in the future precipitated research into advanced tunneling and construction methods."

The Pentagon report on China's military developments was prepared in cooperation with the departments of State, Homeland Security, Energy, and Commerce, and "reflects views that are broadly held across the United States government," Helvey told reporters. Noting that China is expanding its political and military outlook and has become increasingly concerned with international developments, U.S. policymakers, he said, see "an opportunity for China to partner with the international community to address the types of challenges that we all face in the 21st century."

HONORING ACHIEVEMENT

AIAA Hall of Fame

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Geoffrey Landis

R & D Engineer
NASA Glenn Research Center
Cleveland, Ohio

Aerospace Software Engineering Award

Barry Boehm

TRW Professor of Software Engineering
Computer Science Department, University of Southern California
Los Angeles, California

Air Breathing Propulsion Award

Thomas Kaemming

Research Engineer, Innovative Scientific Solutions, Inc.
Technical Fellow (Retired)
The Boeing Company
St. Louis, Missouri

Aircraft Design Award

Egbert Torenbeek

Professor Emeritus, Aerospace Engineering
Delft University of Technology
Delft, The Netherlands

DeFlorez Award for Flight Simulation

William W. Chung

Senior Systems Engineer, Guidance, Navigation and Control
AMERICAN SYSTEMS Corporation
Lexington Park, Maryland

Energy Systems Award

Ryoichi S. Amano

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University of Wisconsin
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F. E. Newbold V/STOL Award

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Assistant Chief Engineer (Retired)
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Bristol, United Kingdom

Jeffries Aerospace Medicine and Life Sciences Research Award

Jonathan Clark, M.D.

Associate Professor, Neurology and Space Medicine
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Department of Neurology/Center for Space Medicine
Houston, Texas

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NASA Langley Research Center
Hampton, Virginia

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Propellants and Combustion Award

James F. Driscoll

Professor of Aerospace Engineering
University of Michigan
Ann Arbor, Michigan

Space Automation and Robotics Award

Robonaut 2 Development Team

NASA Johnson Space Center
Houston, Texas
Award Accepted By: Ron Diftler, Principal Investigator

Space Operations and Support Award

Orbital Express Flight Operations Team

Award Accepted by:
Robert Friend, Boeing Defense Space and Security
Col. Fred Kennedy, USAF, Robbins AFB
Randy Rubens, Boeing Advanced Space Systems

Space Systems Award

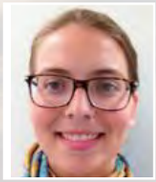
Lunar CRater Observation and Sensing Satellite (LCROSS) Team

NASA Ames Research Center
Moffett Field, California
Award Accepted By: Anthony Colaprete, Principal Investigator

Von Braun Award for Excellence in Space Program Management

Lt. Gen. Eugene Tattini

Deputy Director
Jet Propulsion Laboratory
Pasadena, California



AIAA Foundation Guidance, Navigation, and Control Graduate Award

Aude Marzuoli

Georgia Institute of Technology
Atlanta, Georgia

Thank You Nominators!

AIAA appreciates your time and efforts in preparing the nomination package!

William Anemaat
Werner Dahm
J. Paul Douglas
David Eames
Charles Elachi
Steven Fredrickson
Bruce Hildreth
Shane Jacobs
Essam Khalil
Amy Lo
Daniel Paxson
Michael Piszczor
Brenna Stachewitz

An object entered the atmosphere over the Urals early in the morning of February 15, 2013. The fireball exploded above the city of Chelyabinsk, resulting in damage to buildings and injuries to hundreds of people. Photo was taken by Alex Alishevskikh about a minute after he noticed the blast. Credit: Alex Alishevskikh, courtesy ESA.

NEO threats

Near-Earth objects whose orbits take them dangerously close to Earth are no longer dismissed as an exaggerated threat. The bolide that exploded over Russia in February caused widespread damage and injuries, sparking renewed concerns about the problem. Technology for improved detection and even deflection of NEOs already exists, say experts, but an effective planetary defense will require international cooperation as well.

There is mounting global interest in celestial bodies that may be on a collision course with our planet. These near-Earth objects, or NEOs, primarily are asteroids circling the Sun in orbits that come close to our own. So far, there are over 600,000 asteroids identified in our solar system. Nearly 10,000 of them are NEOs.

The historic record is clear—comets and asteroids have been punching our planet since its formation 4.5 billion years ago. While the near-term odds that an intruder will crash into us are slight, they are not zero…and the effects of a strike by a sizable body would be severe.

Homeland security for planet Earth

But there is good news on the planetary defense front, in areas ranging from detection of NEOs to understanding their properties to determining what action plan must be in place to deal with a potential collision.

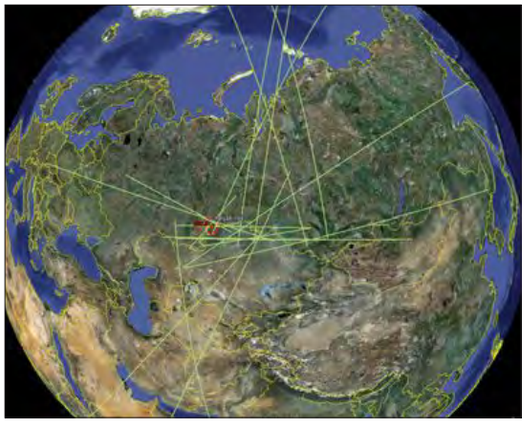
Wake-up call

In large measure, the 'giggle factor' associated with discussions of NEO strikes is on the wane. That was brought home, quite literally, on February 15 near Chelyabinsk in Russia, when a space rock plowed through the atmosphere above the area, exploded, and let loose window-shattering shock waves over an expansive region.

The results: some 1,500 individuals injured, dozens hospitalized with cuts from flying shattered glass and other materials, and over 4,000 buildings damaged. It was the largest extraterrestrial object encountered since June 30, 1908, when a NEO believed to be an asteroid flattened 1,000 square miles of forest in Tunguska, Siberia.

Many experts consider the Chelyabinsk event a cosmic wake-up call. The previously undetected object, weighing an estimated 7,000 tons and measuring roughly 55-65 ft in diameter, struck the atmosphere at about 40,000 mph, exploding nearly 15

by Leonard David
Contributing writer



Seventeen infrasound stations in the Comprehensive Nuclear-Test-Ban Treaty Organization's network detected the infrasonic waves from the meteor that brokeup over Russia's Ural Mountains. Credit: CTBTO.

mi. above Chelyabinsk with 20-30 times the energy of the Hiroshima atomic bomb.

As it moved through the Earth's atmosphere at a shallow angle, the fireball—or the 'superbolide,' as it is sometimes called—released a huge amount of energy. The high-altitude breakup produced a shower of fragments that fell to the ground as meteorites.

The far-flung system of detectors that comprise the Comprehensive Nuclear-Test-Ban Treaty (CTBT) network made its largest-ever detection as the body shattered over the Urals. The CTBT Organization, based in Vienna, runs the International Monitoring System, which consists of widely dispersed infrasound stations. When the space rock detonated, the resulting blast was detected by 17 stations in the CTBTO's network, which tracks atomic blasts across Earth. The farthest station to record the blast was some 9,320 mi. away in Antarctica.

According to former Apollo astronaut Russell Schweickart, there *is* need to sweat the small stuff. Schweickart is cofounder and recent chairman of the B612 Foundation, a group dedicated to protecting the Earth from asteroid strikes.

"The main thing we're seeing evolve is a gradual understanding—although it's not there yet—that the dominant challenge is going to be the smaller objects. While they don't do as much damage, the world will not want them to hit. And that's the issue. If you don't want them to hit, then the smaller ones are the ones you're going to be dealing with," Schweickart tells *Aerospace America*.

An image from the spinning enhanced visible and infrared imager aboard Eumetsat's Meteosat-10 geostationary satellite shows a vapor trail left by an asteroid that struck Earth near Chelyabinsk. This image uses data from the high-resolution visible channel of the imager that can provide both high spatial and temporal resolution. Credit: Eumetsat.

Congressional reverberations

The February blast over Russia had far-flung ripple effects, reverberating even in the halls of the U.S. Congress. The event highlights the need to pay greater attention to the NEO threat, according to Rep. Dana Rohrabacher (R-Calif.), vice chairman of the House Science, Space and Technology Committee. He noted that although the U.S. has been spending millions to find and track asteroids and comets, the space rock that exploded over Chelyabinsk was apparently so small that sky-watchers are not even looking for objects that size.

"This is the only preventable natural disaster, and we have mounting evidence that this is a real and tangible danger," said Rohrabacher. "Our heartfelt prayers go out to all those affected by this event, and it shows that we must protect ourselves, and the planet, from this clear danger."

What concerned the lawmaker even more, he said, was that "we have no plan that can protect the Earth from any comet or asteroid. So, even if we find one that will hit us, we might not be able to deflect it."

Rep. Jim Sensenbrenner (R-Wis.) also expressed concern, noting that the damage caused many to wonder how such an event could happen without warning.

"Locating and tracking these objects is clearly just the first step in preparedness," said Sensenbrenner. "The ability to eliminate the threat of an asteroid or meteor impacting Earth, colliding with the Moon, or disrupting our space-oriented communications and scientific equipment could be vital," he added.

Referring to Chelyabinsk, Sensenbrenner said, "We would be remiss if we did not use such headline-making events as an opportunity to survey our current capabilities and assess how we can better use limited resources to identify potential threats."

Characterizing the danger

The NASA Authorization Act of 2005—in a section called the George E. Brown Jr. Near-Earth Object Survey Act—directed the agency to detect, track, catalog, and characterize 90% of all NEOs with a diameter of 140 m or more by 2020. It extends a 1998 congressional directive that tasked NASA with locating at least 90% of all NEOs with a diameter greater than 1 km—those judged by many experts to have the potential to threaten civilization—within 10 years.

The 1-km goal was achieved in 2011, according to John Holdren, assistant to the

president for science and technology and director of the White House Office of Science and Technology Policy (OSTP). Testifying before Congress after the Chelyabinsk event, Holdren said statistical calculations indicate that more than 90% of NEOs this size have been found.

The prospect of detecting 90% of NEOs 140 m and larger "is much more challenging," said Holdren. He noted that President Obama's 2010 National Space Policy reinforced NASA's charge to "pursue capabilities, in cooperation with other departments, agencies, and commercial partners, to detect, track, catalog, and characterize" NEOs.

Holdren also said the OSTP has been working closely with several departments and agencies to draft plans and procedures, including potential mitigation strategies, that could be used in the event of a NEO threat. Under these plans, it is NASA's responsibility, he said, to provide initial notice of such a threat. Following that notification, the Federal Emergency Management Agency would communicate the information domestically. The State Dept.'s diplomatic mechanisms would come into play for international communications as needed.

Holdren told Congress that the U.S. program for discovering larger NEOs is effective, but that our capabilities for identifying and characterizing smaller NEOs need improving. "With our current or near-future capabilities, both on the ground and in space, it is unlikely that objects smaller than 100 m in diameter on collision courses with the Earth will be detected with greater than weeks of advance warning—a matter of some concern, since the larger objects in this range could be city-destroyers," he concluded.

Eyes closed

"We citizens of Earth are essentially flying around the solar system with our eyes closed. Asteroids have struck Earth before, and they will again…unless we do something about it," said former NASA astronaut Ed Lu, chairman and CEO of the B612 Foundation. "Currently there is no comprehensive, dynamic map of our inner solar system showing the positions and trajectories of these asteroids that might threaten Earth," he told the Senate Committee on Commerce,

Dealing with NEOs: Key steps

The past several years have brought real and significant advances in understanding and dealing with the threat of NEOs. Reflecting this progress are recommendations cited in a specially prepared International Academy of Astronautics white paper, based on a meeting of nearly 250 experts gathered at the 2013 IAA Planetary Defense Conference in April. Key recommendations include:

•Discovery: Locating Earth-threatening objects continues to be the most critical aspect of planetary defense. Only a small percentage of those that could destroy a city or devastate a region have been discovered, and such an object could enter our atmosphere today with little or no warning.

•Characterization: Research is increasing our understanding of the types of structures and materials that might be encountered by deflection/ disruption missions, and of their responses to kinetic impact and other such efforts. This work will increase confidence in the success of such missions and potentially limit the number of launches needed to achieve the desired result.

•Skills for moving an asteroid: Proposed ideas include missions that would use kinetic impactors to move an asteroid while an observer spacecraft verifies the impact and motion away from the original path. Designing these missions and developing the tools and payloads they require would verify model predictions and build confidence in our ability to deal with an actual threat.

•Disaster mitigation: Several 'tabletop' exercises conducted for limited audiences have proven effective in making people aware of the unique aspects of asteroid threats and of where work is needed. These drills, which involve disaster response agencies at the local, state, national, and international levels, would help agencies prepare for impact events.

•Being prepared: Although atmospheric entries of NEOs—those of sufficient size to cause serious damage—are rare, the need for an active deflection/disruption response could arise at any time. The challenge is to develop response plans and put in place cost-effective procedures to maintain the needed technologies and capabilities. Procedures should be developed for cataloguing the necessary equipment and tools and for ensuring that the required capabilities are tested and verified on other missions. Similarly, procedures for launching spacecraft should be examined to see if ways can be found to reprogram an existing launch vehicle and to mount and launch a new payload quickly.

•International efforts: Planetary defense is an international responsibility. Current efforts at the U.N., which is seeking to provide opportunities for space agencies to plan for shared responsibilities and coordinated actions, should be supported. Bilateral and multilateral agreements will also be necessary for coordination of resources and capability.

•Communications: There is a need to increase and solidify awareness of the requirement for developing and moving forward on an overall coordination and communication plan for planetary defense-related efforts. Information on the nature of the NEO threat, deflection/disruption options, the evolution of a threat scenario, risk and uncertainty, and credible tools for simple deflection mission design should be added to currently available, authoritative web pages.

Special thanks to 2013 IAA Planetary Defense Conference organizing committee cochairs William Ailor of The Aerospace Corporation and Richard Tremayne-Smith.

Japan's Hayabusa-2: Building on success

JAXA is staging an ambitious sojourn to asteroid 1999 JU3 via Hayabusa-2, spurred by the success of its predecessor spacecraft. The flight of Hayabusa-1 to asteroid Itokawa and its return to Earth took place from May 9, 2003, to June 13, 2010.

Hayabusa-2, slated for launch next year, is to arrive at its target asteroid in 2018. It will loiter there and carry out a slew of challenging firsts before leaving in late 2019 and returning to Earth with asteroid specimens around the end of 2020.

Its roughly one-and-a-half-year stay at 1999 JU3 will permit scientists to carry out observation and sample collection duties.

The two probes are comparable in design, but the newer one will haul inventive hardware. While the first spacecraft's antenna was parabolic in shape, Hayabusa-2 will sport two flat high-gain antennae to support faster communication speeds. Also, Hayabusa-2 is to be nudged through space by increased propulsion power from its set of ion engines.

Another key add-on is a 4-lb (2-kg) 'collision device'—a way of producing an artificial crater on the asteroid's surface. That small depression, expected to be just a few meters across, should enable the probe to acquire samples that are newly exposed by the impact and less weathered by the brutal environment of space.

To create the crater, Hayabusa-2 will use a small carry-on impactor (SCI), a 30-cm-diam. disk made of copper. The SCI will be deformed by an explosion to form a semispherical shell and will then be accelerated to a velocity of roughly 2 km/sec for the collision onto the asteroid's surface.

1999 JU3 is a C-type (carbonaceous) asteroid whose 4.5-billion-year-old material is believed to have changed very little. It is a more primordial body than Itokawa, which is an S-type (stony) asteroid. Hayabusa-2 will deploy the Japanese-built MINERVA (micro/nano experimental robot vehicle for asteroid), a small robot lander. The German Aerospace Center's (DLR) Institute of Space Systems in Bremen is contributing the MASCOT (mobile asteroid surface scout), developed by DLR in collaboration with the French space agency, CNES, and JAXA.

MASCOT is a 'hopping' lander that will move about and take measurements at different sites. It will use a camera to image the fine structure of the surface and a radiometer to take its temperature. The lander is designed to work on the asteroid for a total of 16 hr.

Under the current plan, Hayabusa-2 has a 2014 launch window and would reach the asteroid in the middle of 2018. It would return to Earth at the end of 2020 with its asteroid samples safely tucked inside a return capsule.

Science and Transportation in March.

The B612 Foundation is leading the Sentinel project, an effort to build, launch, and operate a solar orbiting infrared space telescope. Commercial practices are being used to manage this deep-space telescope under a milestone-based, fixed-price contract with prime contractor Ball Aerospace and Technologies. Sentinel is philanthropically financed and privately managed, but with a crucial government partnership.

B612's goal is for Sentinel to be launched in July 2018. During its first 6.5 years of operation, the spacecraft will be able to discover and track the orbits of over 90% of the population of NEOs larger than 140 m, and the majority of those bigger than the asteroid that struck Tunguska (roughly 40 m). Sentinel's instrumentation, Lu said, is capable of discovering 100 times more asteroids than have been found by all other telescopes combined.

"Deflecting asteroids is technologically feasible, *if* we have adequate early warning," Lu emphasized. "If we know decades in advance of an impact, we can predict and actually prevent an impact using existing technology—kinetic impactors, gravity tractors, and, if required, even standoff nuclear explosions—to nudge the asteroid and subtly change its course to miss Earth. Conversely, we can do nothing about an asteroid we have not yet found and tracked."

Planetary defense, or public safety, will be Sentinel's primary mission, said Lu. Once it is in operation, it will generate a flood of new NEO discoveries, far in excess of those found by all other observatories combined. After 6.5 years of operation, it will likely discover and track approximately 1 million NEOs; the currently known total is about 10,000.

This catalog not only will "provide a list of potential targets for robotic and human exploration," said Lu, but also "can allow us to successfully mount a deflection campaign and prevent a catastrophe" should any of these NEOs threaten us. "Our future may depend on it," he concluded.

Global response

One group keen on evolving a global response to the NEO impact threat has been the U.N. Scientific and Technical Subcommittee's Action Team on Near-Earth Objects (AT-14), chaired by Sergio Camacho. A former director of the U.N. Office for Outer Space Affairs, he has been an assiduous advocate for international cooperation on this matter.

AT-14's recommendations for an international response to NEOs have been years in the making. They include establishing an International Asteroid Warning Network (IAWN) and a Space Mission Planning Advisory Group (SMPAG).

IAWN would be open to contributions from a wide spectrum of organizations. It would be formed by linking together institutions that are already performing a variety of relevant functions, including discovering, monitoring, and physically characterizing the potentially hazardous NEO population and maintaining an internationally recog-

nized clearinghouse for receiving, acknowledging, and processing all NEO observations. The network would also recommend criteria and thresholds for notification of an emerging impact threat.

SMPAG would comprise U.N. member states that have space agencies and would include representatives of spacefaring nations and other relevant entities. It would be responsible for laying out the framework, timeline, and options for initiating and executing space mission response activities. It would also promote opportunities for international collaboration on research and techniques for NEO deflection.

In the wake of the Chelyabinsk impact, Camacho was quick to note that if the proposed coordination mechanism had been in place, then "at minimum it would have allowed for more observation and better understanding and education of the population on what to expect, rather than having a surprise effect with people not knowing what was happening."

Increased global attention to NEOs was evident as nearly 250 experts from around the world attended the International Academy of Astronautics (IAA) Planetary Defense Conference, held in April in Flagstaff, Arizona.

Participants included Alan Harris, a senior scientist and NEOShield coordinator at the German Aerospace Center's Institute of Planetary Research. The NEOShield consortium consists of several world-leading European research institutes and organizations and leading U.S. and Russian space research groups.

While there are great strides being made in NEO research, Harris emphasized, there is plenty of work ahead.

"We really don't know what the consequences will be of a very severe NEO impact. You can make rough predictions as to what would happen if it occurred over a populated area. But we really don't know," he said. As the world becomes increasingly interconnected, he added, loss of a city due to an asteroid strike would have consequences for the entire world.

"But we do need to have some sort of background level of competence," Harris told *Aerospace America*. Research must continue, he said, adding that we need to "make sure we spend money on space missions that are multipurpose, and one of those purposes should be impact hazard mitigation."

For the U.S., the next steps in dealing with the NEO threat should include better coordination of the relevant government agencies, suggested Lindley Johnson, program executive for NASA's NEO Program Office in Washington, D.C.

"I think more thought is needed at the

USAF Space Command-operated Defense Support Program satellites are a key part of North America's early warning systems. In their 22,300-mi. geosynchronous orbits, DSP satellites can detect missile and space launches, nuclear detonations, and large fireballs entering the Earth's atmosphere. Credit: USAF.

Security duty for OSIRIS-REx

OSIRIS-REx (origins, spectral interpretation, resource identification, security, regolith explorer) is a name reflecting the many missions of this NASA spacecraft. It is to be launched in 2016 on a journey to a worrisome asteroid named 101955 Bennu (formerly 1999 RQ36). OSIRIS-REx would rendezvous with Bennu in 2019-2021, gather specimens of the near-Earth carbonaceous asteroid, and return them to Earth in 2023. The mission is a partnership of the University of Arizona, NASA Goddard, and Lockheed Martin, with collaborators worldwide.

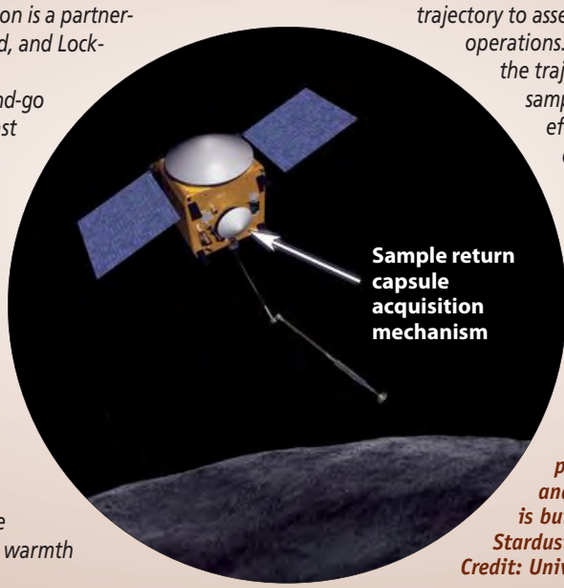
The spacecraft is to use a TAGSAM (touch-and-go sample acquisition mechanism) to collect at least 60 g of material. That would be the largest specimen of an extraterrestrial object brought home since the days of Apollo, the human exploration program that ended over 40 years ago.

The 'security' aspect of OSIRIS-REx involves Bennu's high potential for crashing into Earth in the late 22nd century. Indeed, every six years its orbit takes it to within 278,867 mi. of Earth. Calculations of Bennu's future orbits indicate that for the next few centuries its probability of impacting Earth will be among the highest of any known asteroid.

OSIRIS-REx will measure what is termed the Yarkovsky effect, the degree to which the daily warmth of the Sun affects the asteroid's path. This warm-up generates escaping radiation that acts like a tiny thruster on the space rock. That small nudge, day after day, year after year for hundreds of years, can alter an asteroid's orbit. The shift can result in an Earth impact, a close flyby, or a 'clean miss.'

After the OSIRIS-REx encounter, scientists will recalculate the asteroid's trajectory to assess the actual long-term effect of sampling operations. Depending on TAGSAM's location on Bennu, the trajectory may be altered. That touch-and-go sampling is a 5-sec, light touch, unlike the Yarkovsky effect, which, although minuscule each day, occurs daily over centuries.

Quantifying the Yarkovsky effect on this potentially hazardous asteroid will demonstrate yet another way of helping to protect Earth from future impacts. With time, policymakers may well be required to agree on what steps, if any, should be taken to mitigate asteroid Bennu's risk of colliding with Earth.



NASA's OSIRIS-REx has an amalgam of asteroid duties, including spectral interpretation, resource identification, security, and regolith exploration. Lockheed Martin is building the spacecraft using heritage from Stardust, NASA's comet sample return mission. Credit: University of Arizona/NASA Goddard.

A new resource

NEO research efforts have an important new resource. Data gleaned by sensors aboard U.S. military spacecraft that detect bright bolides entering Earth's atmosphere are now posted on a NASA NEO Program Office website.

A newly crafted memorandum of agreement was signed earlier this year by the Air, Space, and Cyberspace Operations Directorate of the Air Force Space Command and NASA's Science Mission Directorate. The MOA details the public release of bolide data collected by U.S. spaceborne sensors.

Capt. Chris Sukach of Air Force Space Command says that as a result of the agreement, the NEO Observation Program is receiving information on bolide/ fireball events based on analysis of data collected by U.S. government sensors. In fact, data on the Chelyabinsk event was released as the first new entry on the civilian website.

The MOA was signed on January 18 at Peterson AFB, Colorado, says Capt. Sukach. For security reasons, the actual MOA is classified. At a NASA/JPL website, the entry on the February 15 Russian event provides the following information about the fireball:

- *Date and time of maximum brightness: 15 Feb. 2013/03:20:33 GMT*
- *Geographic location of maximum brightness: Lat.: 54.8 deg. N Long.: 61.1 deg. E*
- *Altitude of maximum brightness: 14.5 mi., (23.3 km)*
- *Velocity at peak brightness: 11.6 mi./s (18.6 km/s)*
- *Approximate total radiated energy of fireball: 3.7 x1,014 Joules. This is the equivalent of about 90 kilotons of TNT explosives, but it does not represent the total impact energy, which is several times larger than the observed total radiated energy.*
- *Approximate total impact energy of the fireball in kilotons of TNT explosives (the energy parameter usually quoted for a fireball): 440 kilotons.*

Testifying before the House Science, Space and Technology Committee last March, Gen. William Shelton, head of Air Force Space Command, said the Joint Space Operations Center (JSpOC) of the Joint Functional Component Command for Space can in some cases task space surveillance sensors to help track close approaches by asteroids and help predict potential collisions with Earth-orbiting objects.

Shelton noted, for example, that when NASA's Stardust spacecraft returned to Earth from collecting cometary samples in 2006, JSpOC was able to modify some parameters of existing models and use space surveillance sensors to track the Stardust sample return capsule in its parabolic return to Earth.

government level to put together a more coherent approach," Johnson noted. "We are attempting to talk to each other across the agencies and stay in synch with each other. But there is not yet a coherent, government-wide effort." He said there is no need for spending huge sums of money, "but there does need to be an overall coordinated effort so that everybody is working toward the same objectives."

An artist's rendition of Japan's Hayabusa-2 spacecraft making an artificial crater on an asteroid, later touching down on the resulting feature for sampling. Specimens would be brought back to Earth for detailed study. Credit: JAXA/Akihiro Ikeshita

There were numerous take-aways from the IAA conference. We are better informed about asteroids and comets that could pose a threat. There has been progress in devising techniques and tools that might be used to deflect or disrupt an oncoming object. And there is a far greater understanding of the potential consequences of an impact, the design of deflection campaigns, and the political and policy issues that might affect a decision to take action.

"We've come so far," said the Planetary Defense 2013 cochair, William Ailor of The Aerospace Corporation. "Back in the old days we were speculating and guessing about so many things. Now there is so much good work under way. Even though we still have uncertainties, those uncertainties are being narrowed down."

Nevertheless, there are a number of thorny issues, he noted. One is the need for improved communications, to increase not only the public's understanding of the NEO issue, but also that of decision-makers.

Another challenge "centers on a cost-effective way to maintain capability," Ailor said. "That's a key piece."

Also, while the February blast over Russia was assuredly a wake-up call, its lingering message is likely to fade over time.

"One real trick here," Ailor concluded, "[is that] we may not see another Chelyabinsk for another 100 years. That's the issue with the probability business. It may not happen for another 100 years, but it might happen tomorrow."

DARPA, NASA, and other agencies are looking at how robotic on-orbit servicing could extend the lives of satellites in space, although making such missions a reality will not be easy. Technology and cost are not the only challenges—liability, regulatory, and other issues also come into play. But despite all the complexities, many nations are showing interest in this area, and several demonstration programs are now moving forward.

Servicing satellites

U.S. governments agencies and private firms often spend hundreds of millions of dollars building and launching a single satellite. Yet for the most part, when that satellite stops working, it becomes space junk, even if some components remain functional.

In the past few decades, spacefaring nations have made several attempts to fix nonworking satellites. The most dramatic were the space shuttle crew repairs of the Hubble Space Telescope (HST). With the shuttle now retired, the U.S. and other governments have several programs under way to develop unmanned systems for servicing satellites. Chief among these is Phoenix, an effort by DARPA to salvage a retired communications spacecraft.

Satellite equipment such as an imaging sensor or a communications payload often "continues to be operational even after the satellite has run out of propellant needed to maintain its orbit," says William Ostrove, an aerospace/defense analyst at Forecast International. "If a government agency or private company could extend the life of that satellite for a few more years for a fraction of the cost of a new satellite, it could benefit them drastically."

Proponents of on-orbit servicing say the urgency and value of such missions is growing, as space is increasingly crowded with nonworking manmade objects.

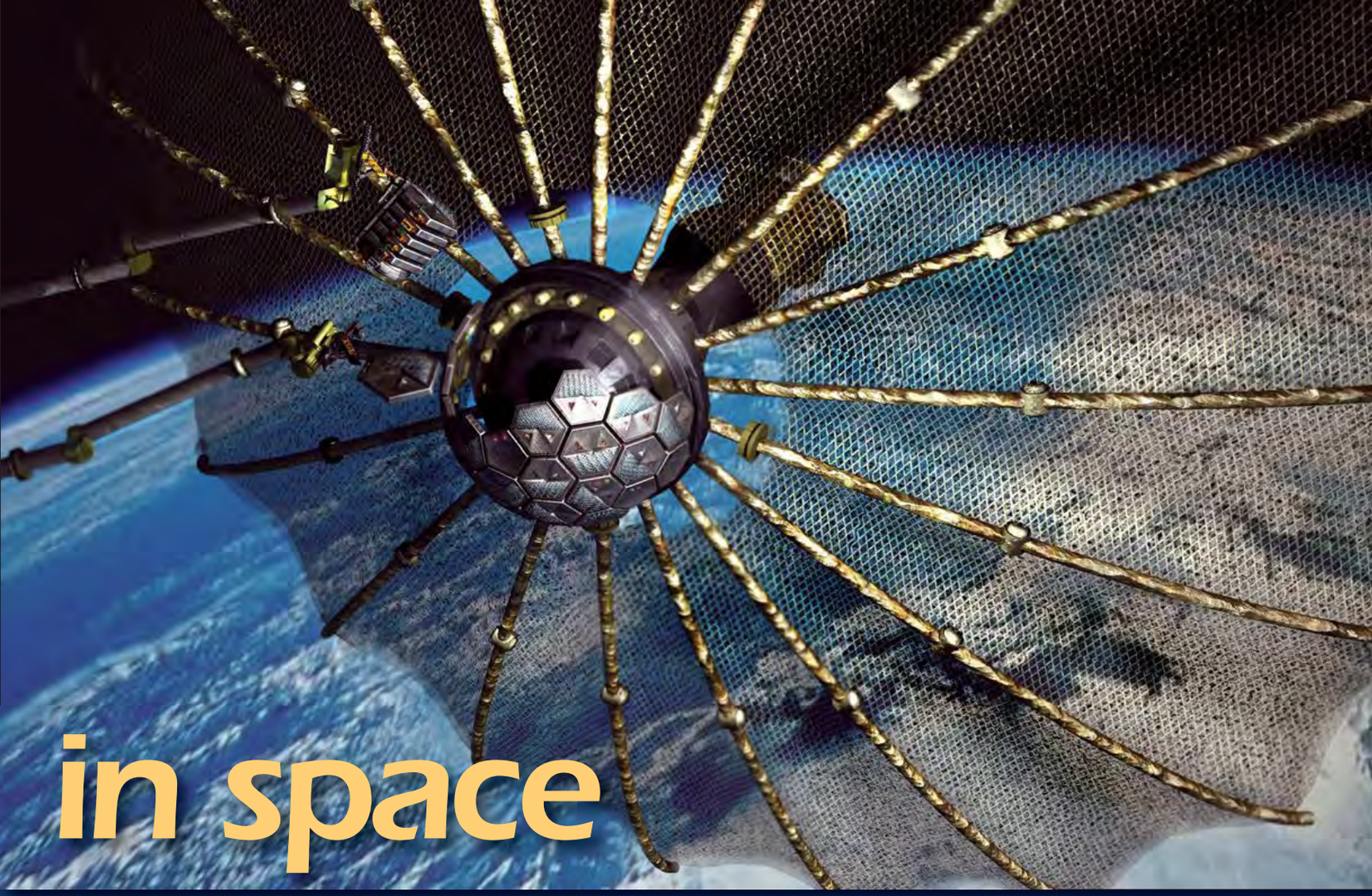
"A more refined consciousness of the need to reduce, reuse, and recycle here on Earth drives towards a similar awareness of these needs beyond our planet," NASA wrote in its *On-Orbit Satellite Servicing Study*, a 2010 report that captures work performed in response to a congressionally mandated study. "The proliferation of abandoned satellites poses known hazards to newer members of the constellation, and may occupy unique and economically valuable orbital real estate that could be recycled for other uses."

Risks and challenges

"Despite this interest, there is still a long way to go in developing this technology," Ostrove tells *Aerospace America*. Whether on-orbit servicing can take off remains unclear, as it faces a host of financial, legal, and technological challenges.

"It's very new and risky, and the space

by Marc Selinger
Contributing writer



DARPA rendering of Phoenix.

industry tends to be conservative when it comes to adopting new technology," notes Ostrove. "Costs are another concern. They need to be kept low enough so that it will pay off to extend a satellite's life rather than launch a new one.…As with any new technology, it's hard to project costs this early in its development."

On the legal front, as the U.S. works with other spacefaring nations, it will have to address potential issues of international liability if its activities create debris that harms another satellite, according to Henry Hertzfeld, professor of space policy and international affairs at George Washington University. These liability and indemnification issues could be especially thorny if the damaged spacecraft belongs to another country and if private U.S. firms are in a partnership with the U.S. government. Current plans for future DARPA and NASA missions include such partnerships.

With on-orbit servicing, says Hertzfeld, "there's a risk that something can go wrong, and it opens up the possibility of interfering with operations in space—of our own or of others' spacecraft or equipment." Such legal and regulatory issues "can be solved, but haven't been," he says.

If countries can overcome these challenges, they still face the risk that such technology will be perceived by others as a potential weapon, even if the developers have no intention of using it for aggressive or harmful purposes. Hertzfeld cautions that "openness, transparency, notification, and understanding" are needed to "defuse that feeling and that worry" and avoid sparking an international incident.

Past efforts

Soon after the U.S. began launching satellites in the late 1950s, it began laying the groundwork for extending their lives beyond their retirement dates. According to NASA, the Gemini program in the mid-1960s demonstrated a technology vital for satellite servicing: the ability of a manned spacecraft to rendezvous and dock with another vehicle in space. In the 1970s, a Skylab space station crew successfully performed the first on-orbit repair when it fixed a failing thermal shield on the NASA-operated facility.

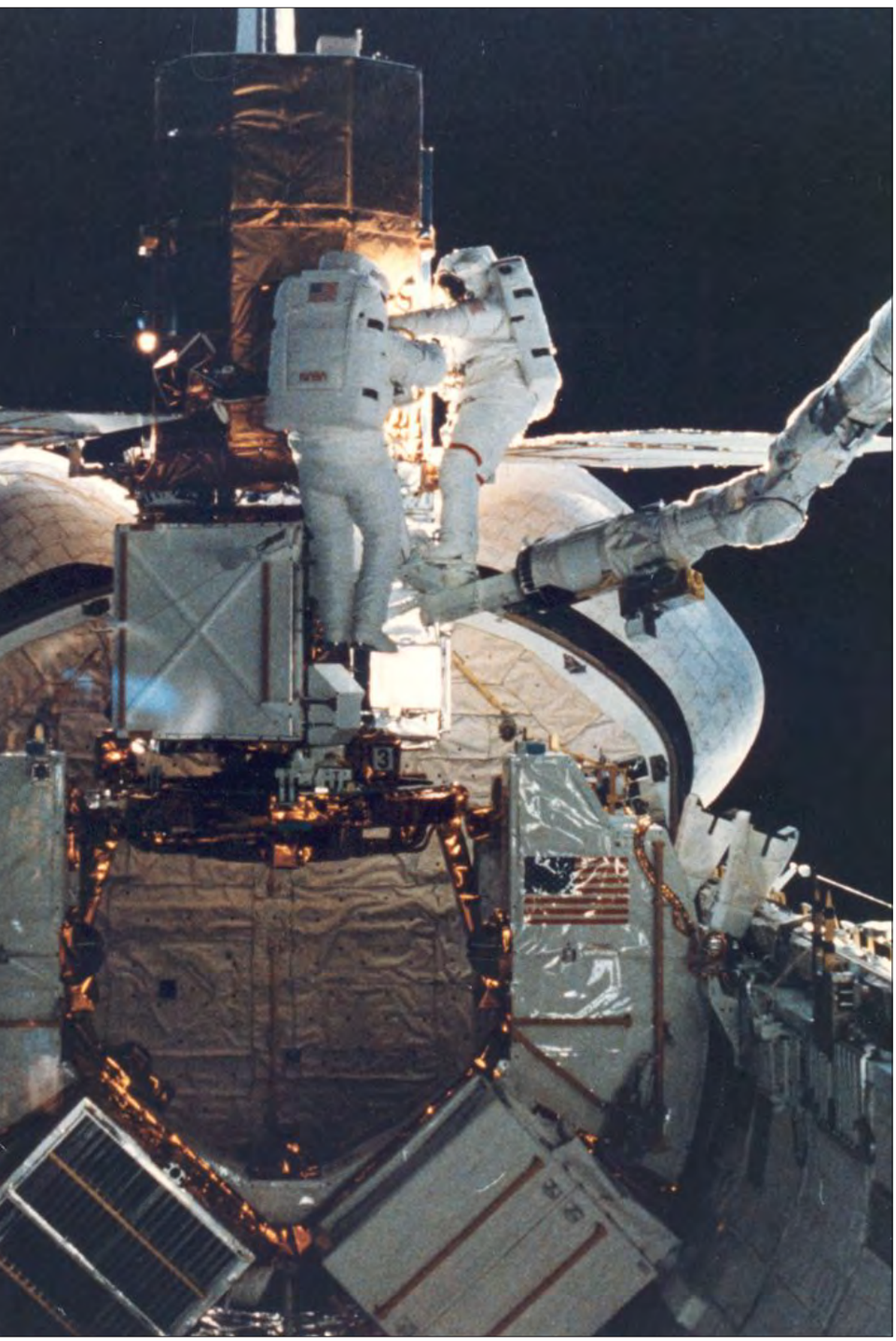
In the mid-1980s, a shuttle mission repaired an ailing satellite for the first time.

The Challenger orbiter captured the Solar Maximum Mission, replaced failed parts in its attitude control system, and then redeployed it so it could continue studying solar phenomena. Another orbiter, Discovery, returned two errant satellites to Earth for refurbishing and relaunch.

Satellite servicing achieved further triumphs in the 1990s and early 2000s. The shuttle program flew five repair and upgrade missions to the HST. On-orbit construction and maintenance of the ISS became a reality. And during DARPA's Orbital Express mission in 2007, the unmanned ASTRO (autonomous space transport robotic operations) vehicle refueled and repaired a prototype modular NEXTSat (NEXT-generation serviceable satellite) in LEO.

"During its roughly four-month mission, Orbital Express provided confirmation that key technologies needed for satellite servicing are now in place," NASA says.

On STS-41, mission specialists George Nelson and James van Hoften repaired the captured Solar Maximum Mission satellite.



DARPA's Phoenix

Building on these earlier efforts, DARPA's Phoenix program aims to show it can recycle part of a defunct communications satellite in space. By 2016, the program hopes to conduct an unmanned mission to robotically remove a disk-shaped antenna, or aperture, from a nonworking satellite in a 'graveyard' or disposal orbit near GEO, which is about 22,000 miles above Earth. DARPA would then reuse the antenna to create a 'new' communications satellite.

"Today's ground-based robotics systems allow surgeons to perform telesurgery on a patient thousands of miles away, and advanced remote imaging systems used for offshore drilling view the ocean floor thousands of feet underwater," states DARPA. "These types of capabilities, if reengineered for zero gravity, high vacuum, and harsh radiation, could be used in space to allow the repurposing of valuable antennas from retired GEO satellites."

The Phoenix demonstration will kick off by launching anywhere from 10 to 50 'satlets,' small spacecraft similar to nanosatellites, as a hosted payload on a commercial satellite launch. Several different satlet prototypes no bigger than a computer laptop are in development. Designers are also working on a payload orbital delivery system (PODS) that will safely house the satlets aboard the rocket.

Launched separately will be a servicer satellite equipped with two 6-ft-long robotic arms. The servicer will capture the satlets from the PODS, place them on its 'tool belt,' remove the antenna from a nonworking satellite, and integrate the satlets with the antenna. The satlets will power and control the reborn space system, tentatively called 'ApSat.'

DARPA is reviewing retired satellites that it could 'harvest' for the demonstration and has identified about 140 candidates from the U.S. and other countries, says David Barnhart, program manager for DARPA's Tactical Technology Office. Before the agency proceeds with a mission for a

particular satellite, it intends to seek permission from the spacecraft's owner.

DARPA plans to spend about $180 million on Phoenix from FY12 to FY15, expressing confidence that it will be able to minimize the impact of defense budget cuts. If the program succeeds, in-space servicing could ultimately revive multiple retired satellites, creating a 'farm' of recycled spacecraft. DARPA believes that recycling several satellites would cost a fraction of sending up new ones.

Phoenix is a "modest effort we are attempting, to essentially increase the return on investments for DOD space missions and find a way to really change the economics so that, ultimately, we can lower the cost of space systems," Barnhart says.

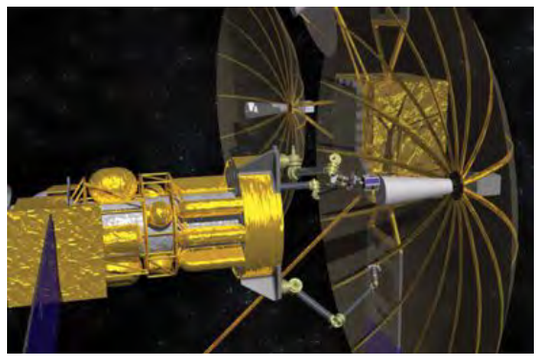
The prime integrator for Phoenix is the Naval Research Lab. For the servicer, the program will use an existing satellite bus developed by ATK, and robotic arms built by MacDonald, Dettwiler and Associates (MDA). The host of other tools now being designed include small cameras to see the mission in real time, and grippers to grasp and control the satlets and harvested aperture. A significant challenge will be severing the antenna from its host satellite while minimizing debris that could jeopardize the mission or endanger other spacecraft.

"Almost all of [the apertures] are tied [to the host satellite] via a boom of some sort—some structural element," Barnhart states. Severing parts from these will not be as easy as the team once thought, he notes, "primarily because many of the booms are carbon fiber, they're not metal, and they flex whenever you attempt to cut."

Another major challenge is that the exact condition of the decommissioned satellite will not be known until the servicer reaches it. And the Phoenix mission will not have people at the construction site, as the Hubble missions did, to handle any surprises that arise.

"If any of the [thermal] blankets are loose, or if an antenna guide wire is not intact, then Phoenix must be flexible enough to create maneuver and operations scenarios to deal with the situation in real time," Barnhart says. "Design-flexible tools and operations are key to the program's goals."

Although DARPA is busy with all these technological tasks, the agency insists it is also addressing the full range of relevant legal, policy, and regulatory issues. For example, to promote greater discussion and acceptance of responsible on-orbit servicing, it sponsored a one-day international conference, Fostering Sustainable Satellite Servicing, in June 2012 in Arlington, Virginia. DARPA described the event as "an open and honest discussion on nontechnical aspects of the new field of 'servicing' in space." The conference drew more than 130 attendees from the international space community and featured speakers from the U.S. and abroad.



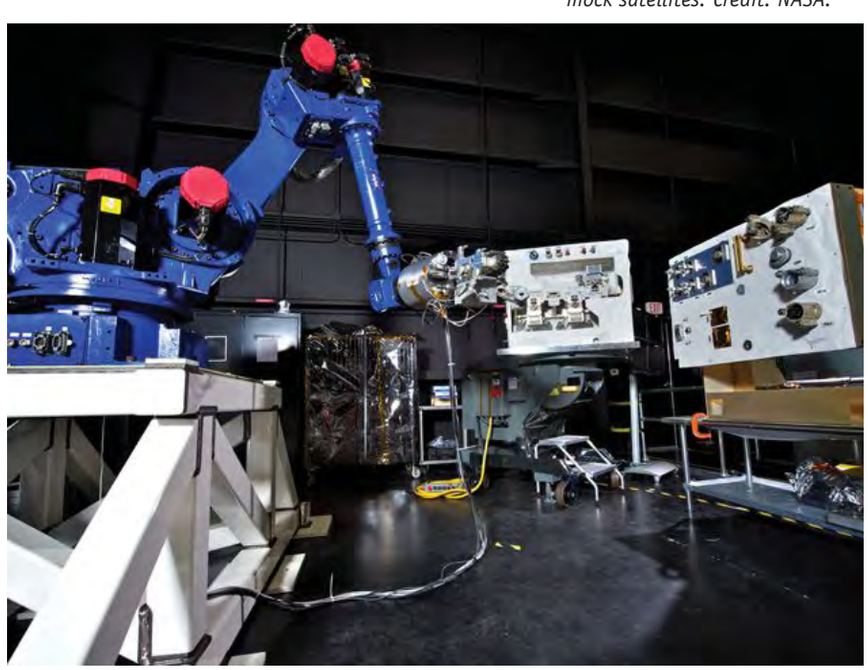
A servicer would attach a satlet to an antenna from a defunct communications satellite. Credit: DARPA.

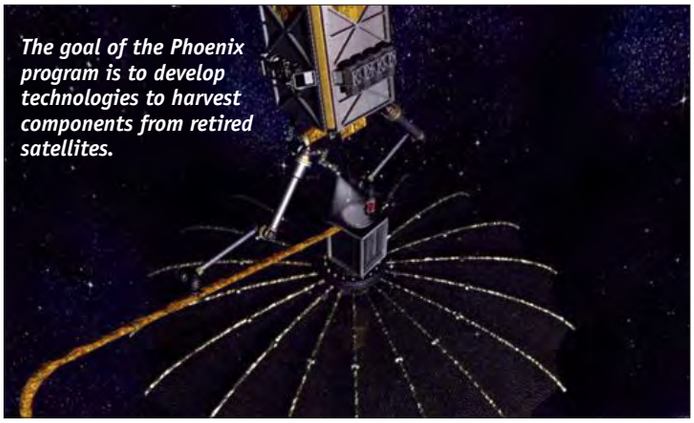
"We're pursuing a technical demonstration….At the same time, we need the right policies and regulations in place to enable the program's successful transition" to a permanent capability, Barnhart says. "Both elements are critical."

Restore

NASA also has its eye on servicing GEO satellites, but instead of reincarnating them, it wants to make them last longer. In a January request for information, the agency asked for industry feedback on the possibility of forming a government-commercial partnership, called Restore, to demonstrate on-orbit servicing for these spacecraft.

In ground tests, a robot practices robotic refueling missions on mock satellites. Credit: NASA.





The goal of the Phoenix program is to develop technologies to harvest components from retired satellites.

"Such a capability would potentially provide life-extension servicing over a range of candidate client satellites," NASA says. Activities could include "remote survey, relocation, refueling, repair, and component replacement."

If NASA leaders give the go-ahead to pursue a full-fledged flight program, a servicing satellite could be ready for launch as early as 2017, according to Benjamin Reed, deputy project manager of the agency's Satellite Servicing Capabilities Office at NASA Goddard. For funding, however, Restore is in the running with other compelling programs, Reed acknowledges.

"As with all program new starts, we are subject to any number of external forces out of our control. Regardless, we'll have the technology ready when given the green light from NASA planners," Reed explains. "There are lots of important things that NASA's doing. This is but one of many."

The Restore spacecraft (right) services a "client" satellite. Credit: NASA.

For example, the agency is developing and testing technologies to prepare for a potential Restore flight program. With the Canadian Space Agency (CSA), NASA demonstrated the ability to robotically refuel satellites that were not designed to be serviced in space. During the Robotic Refueling Mission test, which occurred in LEO aboard the ISS in January, controllers at NASA Johnson used the station's two-armed Dextre robot to cut wire and remove seals covering a fuel receptacle on a box-shaped mock satellite; next, a nozzle tool with an integrated hose transferred fuel-like fluid to the receptacle, which was then resealed.

Upcoming tests aboard the station could demonstrate the ability to replenish a satellite's coolant robotically, says Reed. Equipment to prepare for the exercise was launched aboard a Japanese unmanned resupply spacecraft, H-II Transfer Vehicle 4, this August.

If Restore becomes a flight program, the leading industry participant will serve "not as a prime contractor, but as a partner who would co-invest with the government." Together these partners would create a mission to demonstrate on-orbit servicing, Reed says. The goal is to stimulate the rise of a "domestic, competitive satellite-servicing industry" to routinely maintain on-orbit satellites for both government and nongovernment customers.

The GEO environment

More than 400 commercial and government satellites in GEO are potential candidates for servicing. "We want to prove to the world that it can be done out in GEO," says Reed. "The advantage of GEO, of course, is that there's a whole slew of satellites all parked right next to each other. You don't get that in LEO," he notes.

Although NASA is developing new manned spacecraft, astronaut missions outside a space vehicle are not currently an option in GEO because of high radiation levels. "The radiation environment in LEO is manageable," Reed explains. "Ditto for the Moon. But in between, at GEO, the radiation level is significantly higher—so much so that technology doesn't presently exist to allow humans to remain on station for the time necessary to perform a servicing mission. Of course, robots don't have such constraints. We are designing the electronics to be able to withstand that environment, so they can stay out there for years and years."

Although astronauts could operate mechanical arms from inside a spacecraft—an approach NASA refers to as "man in a can"—the agency concluded it would cost less to keep people on the ground.

International efforts

The U.S. does not have a monopoly on satellite-servicing ambitions. The CSA and MDA are conducting ground tests of a new mechanical arm to see if it could be used to capture a satellite floating in space, according to Jean Claude Piedboeuf, CSA's acting director general for space exploration. "We are not planning to fly it right now," says Piedboeuf of this Next-Generation Canadarm. "It's something we are considering." The device is the newest version of the Canadarm that was deployed on the shuttle and is currently in use on the ISS.

The German Aerospace Center (DLR) plans to launch a robotic spacecraft called DEOS (German Orbital Servicing Mission) in 2018. DEOS will rendezvous with and capture an ailing spacecraft in LEO for one of three potential missions: deorbit the defective satellite so it can burn up as it reenters Earth's atmosphere, put it in a satellite graveyard in space, or prolong its on-orbit life if it can be repaired or refueled.

A mock satellite is kept in a temporary location aboard the ISS before it is moved to an external platform for a robotic refueling test. Credit: NASA.

EADS Astrium, the project's prime contractor, says it expects to brief DLR on the results of the current program definition phase, roughly in late October.

"To a large extent, DEOS is reliant on technologies that have not yet been tested for space operations," the company says. "In the definition phase, therefore, initial prototypes of the key technologies will be developed, so that subsequent realization of the project can progress swiftly."

Out of the

25 Years Ago, October 1988

Oct. 20 Cosmonauts Vladimir Titov and Musa Manarov complete a 4-hr spacewalk to repair a broken X-ray telescope onboard the Mir space station. The cosmonauts are wearing new, more flexible spacesuits for the first time. NASA, *Astronautics and Aeronautics, 1986-1990*, p. 193.

50 Years Ago, October 1963

Oct. 1 Rear Adm. James R. Reedy, USN, makes the first transpolar nonstop flight from Capetown, South Africa, to McMurdo Sound, Antarctica, in a ski-equipped C-130 Hercules aircraft. The 14-hr 31-min flight, which covers 4,700 mi., crosses the entire Antarctic continent and inaugurates Operation Deep Freeze 64, the Navy's logistic support of U.S. Antarctic research. DOD release 1313-63.

Oct. 2 The Short Brothers Turbo-Skyvan light freighter aircraft makes its first flight, from the company's Belfast, Ireland, airfield. The plane will be particularly useful, says Short Brothers, in underdeveloped areas where only unprepared grass landing strips are available. *The Aeroplane*, Oct. 10, 1963, p. 23.

Oct. 8 Short Brothers and Harland's first Belfast aircraft, a four-engine turboprop strategic transport, is rolled out of its Belfast, Ireland, works. It is the largest plane the company has ever built. *Aviation Week*, Oct. 14, 1963, p. 37.

Oct. 10 In the White House Rose Garden, President John F. Kennedy presents the National Aeronautic Association's coveted Collier Trophy to the original seven-man Project Mercury astronaut team. The award is made annually for the previous year's "greatest achievement in aeronautics or astronautics in America." *Aviation Week*, Oct. 14, 1963, p. 37; *New York Times*, Oct. 11, 1963, p. 18.

Oct. 16 The U.S. claims a nonstop flight speed record when an Air Force-General Dynamics B-58 flies 8,028 mi. from Tokyo to London in 8 hr 35 min. Maj. Sidney J. Kubesch commands the flight, which achieves an average speed of 938 mph. The plane is one of three that took off from Kadena AFB, Okinawa, to attempt the record. All three bombers are assigned to the Strategic Air Command. The previous record for the course was 17 hr 42 min, set in 1957 by Great Britain's William Hoy in an English Electric Canberra flown at an average speed of 335.7 mph. *Aviation Week*, Oct. 21, 1963, p. 30.

Oct. 16 The Air Force launches two 485-lb Vela Hotel nuclear detection satellites from Cape Canaveral on a Thor-Agena as part of a tandem-mounted series of satellites. These also include an advanced but far smaller 2.5-lb 'pygmy' tetrahedral research satellite designed to make radiation measurements. *Aviation Week*, Oct. 21, 1963, p. 30; *New York Times*, Oct. 18, 1963, p. 13.

Oct. 18 NASA announces the selection of 14 new astronauts for Projects Gemini and Apollo. They are Edwin E. Aldrin Jr., William A. Anders, Charles A. Bassett II, Michael Collins, Donn F. Eisele, Theodore C. Freeman, David R. Scott, Alan L. Bean, Eugene A. Cernan, Roger B. Chaffee, Richard F. Gordon Jr., Clifton C. Williams Jr., R. Walter Cunningham, and Russell L. Schweickart. This brings the total number of NASA astronauts to 30. *New York Times*, Oct. 10, 1963, p. 1.

Oct. 18 France successfully launches a cat named Félicette into space using a Véronique AG1 sounding rocket, and successfully retrieves the animal in a safe landing. *Washington Post*, Oct. 19, 1963, p. 4.

Oct. 22 Famed British test pilot Michael John 'Mike' Lithgow dies in the crash of a BAC One-Eleven. Born in 1920, he joined the Royal Navy in 1939, entering the Fleet Air Arm, and for three years flew the Swordfish and Albacore torpedo bombers while stationed with the HMS Ark Royal aircraft carrier. He then returned to the U.K. and began flying experimental aircraft. In 1945 he joined the Supermarine works of Vickers-Armstrong and was then appointed chief test pilot. He later played an important part in the One-Eleven design stages. *The Aeroplane*,

Past

An Aerospace Chronology
by **Frank H. Winter**
and **Robert van der Linden**

Oct. 31, 1963, p. 7; Michael John Lithgow file, NASM.

And During October 1963

—Manned tests with advanced prototypes of the Apollo spacesuit and backpack begin at United Aircraft's Hamilton Standard Division at Windsor Locks, Conn. Hamilton-Standard is the prime contractor for this equipment, which it is building for the Apollo astronauts who will explore the Moon's surface. International Latex of Dover, Del., is a major subcontractor for the suit. *Aviation Week*, Oct. 28, 1963, pp. 48-49, 51-52.

75 Years Ago, October 1938

Oct. 2 A prototype Dewoitine D.520, the most advanced French fighter used in WW II, makes its maiden flight. W. Green, *Warplanes of the Second World War: Fighters, Vol. 1*, p. 45.

Oct. 6-8 Capt. D.C.T. Bennett and First Officer Ian Harvey of Great Britain set a new world seaplane distance record of 5,997 mi. from Dundee, Scotland, to Port Nolloth, South Africa, in the Mercury upper component of the Short Mayo Composite aircraft. Mercury separated from its carrier plane Maia over the River Tay, a few miles north of Dundee, with a fuel supply of 2,100 gal, and proceeded at a speed of 160 mph. *Aircraft Year Book, 1939*, p. 468; *Flight*, Oct. 13, 1938, p. 321.

Oct. 10 A prototype of the four-engined Armstrong Whitworth Ensign makes its first passenger flight over London. Imperial Airways, which has ordered 14 of the aircraft, is to introduce it into its London-Paris service. *Interavia*, Oct. 19, 1938, p. 14.

Oct. 14 The Curtiss single-seat XP-40 Warhawk prototype makes its first flight. The aircraft is essentially a P-36 with its radial engine replaced by an inline Allison V-1710 powerplant. Close to 14,000 of these aircraft will subsequently serve with the Allies during WW II. P. Bowers, *Curtiss Aircraft 1907-1947*, p. 474.

Oct. 18 Following his inspection of the German aviation industry's facilities and aircraft, Charles Lindbergh is invested by Field Marshal Hermann Göring with the Order of the German Eagle, with Star, on behalf of Chancellor Adolf Hitler. Lindbergh is the first American to receive the medal and the first American decorated by Hitler's direct command. The controversial award, which was to haunt Lindbergh for the rest of his life, was given to honor his 1927 transatlantic flight. *Interavia*, Oct. 22, 1938, p. 4; *The Aeroplane*, Oct. 26, 1938, p. 486.

Oct. 22 Lt. Col. Mario Pezzi of Italy sets a new altitude record of 56,017 ft in a Caproni Ca.161bis biplane powered with a Piaggio engine and fitted with a sealed cabin. *Aircraft Year Book 1939*, pp. 163-164; *Interavia*, Oct. 26, 1938, p. 14.

And During October 1938

—Britain orders 200 Lockheed Hudsons, the military version of the Super Electra airliner. This is the first U.S.-built aircraft to see operational service with the RAF during WW II. E. Emme, ed., *Aeronautics and Astronautics 1915-60*, p. 36.

100 Years Ago, October 1913

Oct. 5 OWL (over water and land), the Navy's first amphibian flying boat, finishes initial tests at Hammondsport, N.Y. Later renamed the E-1, the plane develops into the A-2 hydro-aeroplane. R. Grossnick, *United States Naval Aviation 1910-1995*, p. 12.

MICHIGAN ENGINEERING

UNIVERSITY of MICHIGAN ■ COLLEGE of ENGINEERING

New Faculty Search - Aerospace Engineering, University of Michigan

The Department of Aerospace Engineering at The University of Michigan invites applications for two tenure-track faculty positions in areas of Aerospace Engineering that align with the principal research interests pursued in the Department. Areas of interest are: (1) Computational fluid dynamics (CFD) of turbulent reacting flows, (2) Autonomous systems with application to autonomous aerospace vehicles, and (3) Composite materials and composites for aerospace structures. Both senior-level and junior-level applicants will be considered. Applicants must have extensive knowledge of and experience with disciplines relating to Aerospace Engineering.

The Department presently has 26 full-time faculty members. Both its undergraduate and graduate programs are highly ranked nationally. Research interests of the faculty cover a broad spectrum of Aerospace Engineering including CFD for high-performance multiphysics computations, aerostructures, smart structures and materials, flight dynamics and control, propulsion, combustion, and sustainable energy. More information about the department can be found at aerospace.engin.umich.edu. Applicants should have an earned doctoral degree in Aerospace Engineering or a closely related field. The successful candidate will be expected to participate in all aspects of the Department's mission, including the development of a strong and relevant externally funded research program, the teaching of undergraduate and graduate courses, and the supervision of graduate students.

Applicants should send an email with an attached single PDF file that contains a curriculum vita, a statement of research and teaching interests, and the names and contact information for at least three references to the Faculty Search Committee, c/o Professor James F. Driscoll at aero-search@umich.edu.

The evaluation process will start on 1 December 2013 and will continue until the positions are filled. The University of Michigan is an equal opportunity/affirmative action employer with an active dual-career assistance program. The college is especially interested in candidates who can contribute, through research, teaching, and/or service, to the diversity and excellence of the academic community.

Faculty Position
Embry Riddle Aeronautical University

The Department of Aerospace Engineering at Embry-Riddle Aeronautical University in Daytona Beach, FL, invites applications for an Assistant or Associate Professor. The position will commence in August 2014. The preferred area of expertise is Astronautics and Space Applications. However, applicants in all areas of Aerospace Engineering will be considered. The Department offers bachelors and masters degrees in Aerospace Engineering and a Ph.D. program began in Fall 2013. The undergraduate program is the nation's largest with about 1200 full-time students and has been ranked # 1 in its category by U.S. News and World Report for the past thirteen years. The Department has been focused on expanding its graduate programs, the research facilities, launching a doctoral program, and recruiting top talent.

Successful candidates for the Assistant Professor rank should demonstrate a potential to establish and grow a strong research program and to excel at teaching and mentoring undergraduate and graduate students. Successful applicants for the Associate Professor rank should have an exemplary record of teaching and scholarly activities including externally funded research. An earned doctorate in Aerospace Engineering or a closely related field is required. Women and underrepresented minorities are especially encouraged to apply. For more information about this opening and to apply online, please visit www.erau.edu/jobs and review IRC54568.

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MISSOURI S&T

MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY

MECHANICAL AND AEROSPACE ENGINEERING DEPARTMENT
Assistant/Associate Professor Positions
(Ref #'s 00031194, 00058751, 00058753)

The Department of Mechanical and Aerospace Engineering at the Missouri University of Science and Technology (formerly the University of Missouri - Rolla) invites applications for several full-time tenure-track Assistant/Associate Professor positions in the general areas of:

- Sustainable energy (Job #10893, Position #00031194). Applicants must have a Ph.D. in Mechanical Engineering or closely related fields. This opening is anticipated to be filled at the Associate Professor level, although qualified applicants will be considered for appointment at any level.
- Advanced aerospace materials and structures (Job # 10889, Position #00058751). Applicants must have a Ph.D. in Aerospace Engineering or closely related fields. This opening is anticipated to be filled at the Assistant Professor level, although qualified applicants will be considered for appointment to a higher level.
- Advanced manufacturing, including but not limited to, nanomanufacturing, biomanufacturing, additive manufacturing, energy manufacturing, cyber-enabled manufacturing, and human-robot collaboration in manufacturing (Job #10891, Position #00058753). Applicants must have a Ph.D. in Mechanical Engineering or closely related fields. This opening is anticipated to be filled at the Assistant Professor level, although qualified applicants will be considered for appointment at a higher level.

The successful candidates will demonstrate the potential to establish and grow a strong research program and will participate in all aspects of the Department's mission, which includes research, teaching and service.

The department currently has 37 full-time faculty members, over 800 undergraduate and approximately 200 graduate students. The Department offers the B.S., M.S., and Ph.D. degrees in Mechanical and Aerospace Engineering. The Department seeks to significantly increase the national visibility of its research and graduate program while maintaining its high standards of teaching. A recently completed $29 million renovation project has produced a state-of-the-art Mechanical and Aerospace Engineering complex with 144,000 square feet of teaching and research laboratory space. Details regarding the department can be found at http://mae.mst.edu/. In addition, details of research centers on campus can be found at http://www.mst.edu/research/.

Candidates should include the following with their letter of application: current curriculum vitae, statement of teaching interests and philosophy, statement of research plans including areas of potential collaboration with other faculty, and names and contact information for at least three references. Review of applications will begin on November 1, 2013 and applications will be accepted and reviewed until the position is filled. All application materials must be electronically submitted to the Missouri University of Science and Technology's Human Resource Office at http://hraadi.mst.edu/hr/employment/. All submitted application materials must have the position reference number in order to be processed, and, if applying for more than one position, you must submit a separate application for each position. Acceptable electronic formats that can be used for email attachments include PDF and Word; hardcopy application materials will not be accepted.

The final candidates are required to provide an official transcript showing completion of the terminal degree listed in the application materials submitted. Copies of transcript(s) must be provided prior to the start of employment. In addition, the final candidates may be required to verify other credentials listed in application materials. Failure to provide the official transcript(s) or other required verification may result in the withdrawal of the job offer.

Missouri S&T is an AA/EO Employer and does not discriminate based on race, color, religion, sex, sexual orientation, national origin, age, disability, or status as Vietnam-era veteran. Females, minorities, and persons with disabilities are encouraged to apply. Missouri S&T is responsive to the needs of dual-career couples. Missouri University of Science and Technology participates in E-Verify. For more information on E-Verify, please contact DHS at: 1-800-464-4218.

NOTE: All application materials must have appropriate position reference number in order to be processed.

College of Engineering: Open Rank Faculty

Department of Aerospace Engineering

University of Illinois at Urbana-Champaign

The Department of Aerospace Engineering at the University of Illinois at Urbana-Champaign is seeking highly qualified candidates for multiple faculty positions in all areas of aerospace engineering, with emphasis on aerodynamics, autonomous aerospace systems, space systems, aeroelasticity, and aerospace materials and structures. Particular emphasis will be placed on qualified candidates who work in emerging areas of aerospace engineering and translate their scholarly activities into high impact applications.

Please visit http://jobs.illinois.edu to view the complete position announcement and application instructions. Full consideration will be given to applications received by November 1, 2013. Applications received after that date will be considered until positions are filled.

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www.inclusiveillinois.illinois.edu

CANADA RESEARCH CHAIR (TIER II) IN AEROSPACE ROBOTICS

Concordia

The Department of Electrical and Computer Engineering in the Faculty of Engineering and Computer Science at Concordia University invites applications for the position of Tier II Canada Research Chair in Aerospace Robotics. The chairholder will be expected to engage in theoretical and experimental research in such areas as space robotics, on-orbit servicing (OOS), vision-based guidance of robotic systems, unmanned aerial vehicles (UAV's), unmanned space vehicles, autonomous and reconfigurable robotic systems, advanced fault-tolerant sensors/actuators, and related areas. A strong emphasis is placed on fundamental and applied research, interdisciplinary research partnerships, and the ability to establish and develop industrial collaborations as well as international collaborations. Teaching is also an important activity of the chairholder. Shortlisted candidates will be invited to make a presentation on their research. Please apply to:

Dr. William E. Lynch, Chair
Department of Electrical and Computer Engineering
blynch@ece.concordia.ca | ece.concordia.ca

Review of the applications begin immediately and continue until the position is filled.

Electronic applications are preferred and should be sent to the appropriate department contact by email no later than January 1, 2014. Only short-listed applicants are notified. Appointments are expected to commence in the summer of 2014.

Applications should consist of detailed curriculum vitae, a statement concerning teaching and research interests and the names of at least three referees. Relevant industrial experience is an asset. Excellent communication skills are required. Knowledge of French is an asset but not essential for an academic career at Concordia. Membership or eligibility for membership in a Canadian professional engineering association, preferably in the province of Quebec, is required.

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Wallace H. Coulter School of Engineering Department of Mechanical and Aeronautical Engineering Two Tenure Track Faculty Positions

Mechanical and Aeronautical Engineering (MAE) Department of the Wallace H. Coulter School of Engineering (CSoE) at Clarkson University invites applications for 2 tenure track positions at the Assistant or Associate Professor rank (anticipated starting date: January or July 2014). A Ph.D. in Mechanical Engineering or Aeronautical Engineering, or related area is required. Applications are encouraged from individuals whose research programs can contribute to areas of Experimental and Computational Solid Mechanics, Micro/Nano Solid Mechanics, Materials Characterization, Biomechanics, Dynamic Systems and Control, Multi-Disciplinary Optimization and Mechanical and Aircraft Design. Candidates who have experience in design are especially encouraged to apply.

Clarkson's MAE Department offers B.S. degrees in Mechanical Engineering and Aeronautical Engineering, and M.E., M.S. and Ph.D. degrees in Mechanical Engineering. Successful candidates will be expected to teach fundamental undergraduate and graduate courses in mechanical/aeronautical engineering, and develop strong externally-funded research programs. Applicants should articulate a clear and substantiated vision of how their background can lead to sustained accomplishments through teaching, research, and an ability to engage in interdisciplinary activities and projects within one of the focus areas identified above. Clarkson University is committed to providing an educational experience in which students develop an appreciation for diversity in both working and living environments. Candidates are encouraged to outline teaching, research, service and/or outreach activities that support this commitment.

Additional information about the MAE Department and the Coulter School of Engineering can be found at www.clarkson.edu. Direct inquires and applications, including a CV, a clear vision statement for sustained accomplishments and the names of at least three professional references to Clarkson University's Human Resources department. To submit your application, go to www.clarkson.edu/hr and click "Career Opportunities" on the left hand navigation bar. Review of applications will begin immediately and will continue until the positions are filled.

Clarkson is among the top 50 universities with the highest percentages of tenured and tenure-track women engineering faculty in the nation (ASEE 2011 profiles of Engineering Colleges). We are building upon this foundation to create a diverse faculty and strongly encourage applications from female and minority candidates. Clarkson University is an AA/EOE. Job Postings Fac 2013000355.

Faculty Position- Experimental Aerodynamics
Department of Aerospace Engineering
Embry Riddle Aeronautical University

The Department of Aerospace Engineering at Embry-Riddle Aeronautical University in Daytona Beach, Florida, invites applications for a senior faculty position at the rank of Full Professor or Distinguished Professor in the area of experimental aerodynamics. The position will commence in August 2014.

The Department offers bachelors, masters, and Ph.D. degrees in Aerospace Engineering. The undergraduate program is the nation's largest with about 1200 full-time students and has been ranked # 1 in its category by *U.S. News and World Report* for the past thirteen years. Plans for significant expansion of the graduate programs, research infrastructure, and recruiting world-class faculty to support University's vision to be a leader in aerospace education and research are underway, which include a new engineering building, state-of-the-art research laboratories and new wind tunnels.

Successful candidates should have an exemplary record of teaching and scholarly activities including advising Ph.D. students, publication, and externally funded research.

An earned doctorate in Aerospace Engineering or a closely related field is required. Women and underrepresented minorities are especially encouraged to apply. Applicants must submit a cover letter, curriculum vitae, a detailed research plan, and the names of at least three references by visiting www.erau.edu/jobs and applying for IRC54507. All inquiries should be directed to Dr. Anastasios Lyrintzis, lyrintzi@erau.edu

Aerospace Engineering
University of Kansas

The University of Kansas Aerospace Engineering Department invites on-line applications for a tenure track/tenured faculty position at the rank of assistant or associate professor. Exceptionally qualified candidates could be considered. Current research areas in the department include aerodynamics, astronautics, computational fluid dynamics, dynamics and control, robotics and AI, flight testing, propulsion, and structures. Candidates with hands-on experience in experimental aerodynamics are particularly encouraged to apply.

Our faculty additions are part of the School of Engineering's Building on Excellence Initiative, which will expand the School faculty by 30 members by 2016. Special consideration will be given to applicants committed to excellence, who can contribute to the University's innovative, collaborative, and multidisciplinary initiatives to educate leaders, build healthy communities, and make discoveries that will change the world.

The University of Kansas is especially interested in hiring faculty members who can contribute to four key campus-wide strategic initiatives: (1) Sustaining the Planet, Powering the World; (2) Promoting Well-Being, Finding Cures; (3) Building Communities, Expanding Opportunities; and (4) Harnessing Information, Multiplying Knowledge. For more information, see **http://www.provost.ku.edu/planning/themes/**.

Applicants must have an earned doctorate in Aerospace Engineering or a closely related field prior to the expected start date of Fall 2014. Applicants should have evidence of the ability to develop and sustain a successful research program. Industry experience is desired.

All faculty members are expected to teach both undergraduate and graduate courses in an effective manner, and to be active in research and service, to both the University and the engineering profession. Research productivity at KU is evaluated with respect to publications in respected academic journals as well as success in acquiring external research grants, and financially supporting and mentoring PhD and MS students.

Review of complete applications will begin on **December 2, 2013**. Successful candidates must be eligible to work in the U.S. prior to the start date of the appointment, **August 18, 2014**. Salary is commensurate with experience.

For additional information or to apply, go to **http://www.employment.ku.edu** under faculty searches and look for the position by key word: Aerospace. Applications should include a letter of application, curriculum vita, three references, a statement of research interests and future plans, and a statement of teaching interests and future plans. *Equal Opportunity Employer M/F/D/V.*

The 2014 Aerospace Spotlight Awards Gala

This annual black-tie event recognizes the most influential and inspiring individuals in aerospace, whose outstanding contributions merit the highest accolades.

Call for Nominations

AIAA is pleased to invite you to nominate your colleagues for the prestigious awards that will be presented:

- **International Cooperation Award**
- **Goddard Astronautics Award**
- **Reed Aeronautics Award**
- **Public Service Award**

Nomination Deadline: 1 October 2013

Save the Date

30 April 2014
Ronald Reagan Building and International Trade Center
Washington, D.C.
Reception begins at 1830 hrs

Visit www.aiaa.org/gala2014 for more information.

AIAA

13-0408

AIAA Bulletin

In conjunction with the 27th Annual AIAA/USU Conference on Small Satellites in Logan, the AIAA Utah Section hosted tours of the Hill Aerospace Museum near Hill Air Force Base. Former AIAA Utah Chair Charlie Vono is shown giving tour guide lessons on the SR-71 to Weber State University Branch volunteers Ian Cox and Spencer Shupe. See more information on this event on page **B10**.

OCTOBER 2013

AIAA Directory

AIAA HEADQUARTERS
1801 Alexander Bell Drive, Suite 500
Reston, VA 20191-4344
www.aiaa.org

To join AIAA; to submit address changes, member inquiries, or renewals; to request journal fulfillment; or to register for an AIAA conference.
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Other Important Numbers: ***Aerospace America*** / Greg Wilson, ext. **7596*** • ***AIAA Bulletin*** / Christine Williams, ext. **7500*** • **AIAA Foundation** / Karen Thomas, ext. **7520*** • **Book Sales** / **800.682.AIAA** or **703.661.1595**, Dept. 415 • **Corporate Members** / Merrie Scott, ext. **7530*** • **International Affairs** / Betty Guillie, ext. **7573***; Emily Springer, ext. **7533*** • **Editorial, Books and Journals** / Heather Brennan, ext. **7568*** • **STEM K–12** / Lisa Bacon, ext. **7527*** • **Honors and Awards** / Carol Stewart, ext. **7623*** • **Journal Subscriptions, Member** / **800.639.AIAA** • **Exhibits / Journal Subscriptions, Institutional / Online Archive Subscriptions** / Michele Dominiak, ext. **7531*** • **Continuing Education** / Chris Brown, ext. **7504*** • **Public Policy** / Steve Howell, ext. **7625*** • **Section Activities** / Chris Jessee, ext. **3848*** • **Standards, Domestic** / Amy Barrett, ext. **7546*** • **Standards, International** / Nick Tongson, ext. **7515*** • **Student Programs** / Stephen Brock, ext. **7536*** • **Technical Committees** / Betty Guillie, ext. **7573***

* Also accessible via Internet. Use the formula first name last initial@aiaa.org. Example: megans@aiaa.org.
† U.S. only. International callers should use 703/264-7500.

Addresses for Technical Committees and Section Chairs can be found on the AIAA Web site at **http://www.aiaa.org**.

We are frequently asked how to submit articles about section events, member awards, and other special interest items in the *AIAA Bulletin*. Please contact the staff liaison listed above with Section, Committee, Honors and Awards, Event, or Education information. They will review and forward the information to the *AIAA Bulletin* Editor.

Event & Course Schedule

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	CALL FOR PAPERS (*Bulletin* in which Call for Papers appears)	ABSTRACT DEADLINE
2013				
6–10 Oct†	**32nd Digital Avionics Systems Conference**	Syracuse, NY (Contact: Denise Ponchak, 216.433.3465, denise.s.ponchak@nasa.gov, www.dasconline.org)		
13–16 Oct†	**22nd International Meshing Roundtable**	Orlando, FL (Contact: Cherri Porter, 505.844.2788, cporter@sandia.gov.www.imr.sandia.gov)		
14–16 Oct	**31st AIAA International Communications Satellite Systems Conference (ICSSC) and 19th Ka and Broadband Communications, Navigation, and Earth Observations Conference**	Florence, Italy (Contact: www.icssc2013.org)	*Feb 12*	**31 Mar 13**
14–17 Oct†	**Reinventing Space Conference 2013**	Los Angeles, CA (Contact: www.ReinventingSpace.org)		
21–24 Oct†	**International Telemetering Conference/USA**	Las Vegas, NV (Contact Lena Moran, 575.415.5172, lmoran@traxintl.com, www.telemetry.org)		
24–25 Oct†	**Satellite Communications (JC-SAT 2013)**	Fukuoka, Japan (Contact F. Yamashita, yamashita.fumihiro@lab.ntt.co.jp, www.ieice.org/cs/sat/jpn/purpose_e.html		
3–7 Nov†	**22nd International Congress of Mechanical Engineering – COBEM 2013**	Ribeirao Preto, Brazil (Contact: Joao Luiz F. Azevedo, joaoluiz.azevedo@gmail.com, www.abcm.org.br/cobem2013)		
5–7 Nov†	**8th International Conference Supply on the Wings**	Frankfurt, Germany (Contact: R. Degenhardt, +49 531 295 3059, Richard.degenhardt@dlr.de, www.airtec.aero)		
5–7 Nov†	**Aircraft Survivability Technical Forum 2013**	Monterey, CA (Contact: Meredith Hawley, 703.247.9476, mhawley@ndia.org, www.ndia.org/meetings/4940)		
2014				
11 Jan	**1st AIAA Sonic Boom Prediction Workshop**	National Harbor, MD		
11 Jan	**Low Reynolds Number Workshop**	National Harbor, MD		
11–12 Jan	**Decision Analysis**	National Harbor, MD		
13–17 Jan	**AIAA SciTech 2014** **(AIAA Science and Technology Forum and Exposition 2014)** **Featuring:** **22nd AIAA/ASME/AHS Adaptive Structures Conference** **52nd AIAA Aerospace Sciences Meeting** **AIAA Atmospheric Flight Mechanics Conference** **AIAA Guidance, Navigation, and Control Conference** **AIAA Modeling and Simulation Technologies Conference** **10th AIAA Multidisciplinary Design Optimization Specialist Conference** **16th AIAA Non-Deterministic Approaches Conference** **AIAA Spacecraft Structures Conference (formerly the AIAA Gossamer Systems Forum)** **55th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference** **7th Symposium on Space Resource Utilization** **32nd ASME Wind Energy Symposium**	National Harbor, MD		**5 Jun 13**
26–30 Jan†	**24th AAS/AIAA Space Flight Mechanics Meeting**	Santa Fe, NM Contact: http://www.space-flight.org/docs/2014_winter/2014_winter.html	*Jun 13*	**2 Oct 13**
27–30 Jan†	**Annual Reliability and Maintainability Symposium (RAMS) 2014**	Colorado Springs, CO (Contact: Jan Swider, 818.586.1412, jan.swider@pwr.utc.com)		
2–6 Feb†	**American Meteorological Society Annual Meeting**	Atlanta, GA (Contact: Claudia Gorski, 617.226.3967, cgorski@ametsoc.org, http://annual.ametsoc.org/2014/)		
1–8 Mar†	**2014 IEEE Aerospace Conference**	Big Sky, MT (Contact: Erik Nilsen, 818.354.4441, erik.n.nilsen@jpl.nasa.gov, www.aeroconf.org)		
24–26 Mar†	**49th International Symposium of Applied Aerodynamics**	Lille, France (Contact: Anne Venables, 33 1 56 64 12 30, secr.exec@aaaf.asso.fr, www.3af-aerodynamics2014.com)		
30 Apr	**2014 Aerospace Spotlight Awards Gala**	Washington, DC		
5–9 May	**SpaceOps 2014: 13th International Conference on Space Operations**	Pasadena, CA	*May 13*	**5 Aug 13**
26–28 May	**21st St. Petersburg International Conference on Integrated Navigation Systems**	St. Petersburg, Russia (Contact: Prof. V. Peshekhonov, +7 812 238 8210, icins@eprib.ru, www.elektropribor.spb.ru)		

DATE	MEETING (Issue of *AIAA Bulletin* in which program appears)	LOCATION	CALL FOR PAPERS (*Bulletin* in which Call for Papers appears)	ABSTRACT DEADLINE
16–20 Jun	**AVIATION 2014** **(AIAA Aviation and Aeronautics Forum and Exposition)** **Featuring:** **20th AIAA/CEAS Aeroacoustics Conference** **30th AIAA Aerodynamic Measurement Technology and Ground Testing Conference** **AIAA/3AF Aircraft Noise and Emissions Reduction Symposium** **32nd AIAA Applied Aerodynamics Conference** **AIAA Atmospheric Flight Mechanics Conference** **6th AIAA Atmospheric and Space Environments Conference** **14th AIAA Aviation Technology, Integration, and Operations Conference** **AIAA Balloon Systems Conference** **AIAA Flight Testing Conference** **7th AIAA Flow Control Conference** **44th AIAA Fluid Dynamics Conference** **20th AIAA International Space Planes and Hypersonic Systems and Technologies Conference** **11th AIAA/ASME Joint Thermophysics and Heat Transfer Conference** **21st AIAA Lighter-Than-Air Systems Technology Conference** **15th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference** **AIAA Modeling and Simulation Technologies Conference** **45th AIAA Plasmadynamics and Lasers Conference** **7th AIAA Theoretical Fluid Mechanics Conference**	Atlanta, GA		**14 Nov 13**
22–27 Jun†	**12th International Probabilistic Safety Assessment and Management Conference**	Honolulu, HI (Contact: Todd Paulos, 949.809.8283, secretariat@psam12.org, www.psam12.org)		
15–18 Jul†	**ICNPAA 2014 – Mathematical Problems in Engineering, Aerospace and Sciences**	Narvik University, Norway (Contact: Seenith Sivasundaram, 386.761.9829, seenithi@aol.com, www.icnpaa.com)		
28–30 Jul	**Propulsion and Energy 2014** **(AIAA Propulsion and Energy Forum and Exposition)** **Featuring:** **50th AIAA/ASME/SAE/ASEE Joint Propulsion Conference** **12th International Energy Conversion Engineering Conference**	Cleveland, OH		**Nov 13**
2–10 Aug†	**40th Scientific Assembly of the Committee on Space Research (COSPAR) and Associated Events**	Moscow, Russia http://www.cospar-assembly.org		
5–7 Aug	**SPACE 2014** **(AIAA Space and Astronautics Forum and Exposition)** **Featuring:** **AIAA/AAS Astrodynamics Specialist Conference** **AIAA Complex Aerospace Systems Exchange** **32nd AIAA International Communications Satellite Systems Conference** **AIAA SPACE Conference**	San Diego, CA		**Feb 14**
7–12 Sep†	**29th Congress of the International Council of the Aeronautical Sciences (ICAS)**	St. Petersburg, Russia (Contact: www.icas2014.com)		**15 Jul 13**

For more information on meetings listed above, visit our website at www.aiaa.org/calendar or call 800.639.AIAA or 703.264.7500 (outside U.S.).
†Meetings cosponsored by AIAA. Cosponsorship forms can be found at https://www.aiaa.org/Co-SponsorshipOpportunities/.
AIAA Continuing Education courses.

Upcoming AIAA Continuing Education Courses

11–12 January 2014
Course at AIAA Science and Technology Forum and Exposition 2014 (AIAA SciTech 2014)*
www.aiaa.org/scitech2014

Decision Analysis

Instructor: John C Hsu

Decision analysis supports system life cycle development throughout all phases and system hierarchical levels. The course presents the trade study process as part of the systems engineering process, and introduces various decision analysis methods, including the traditional trade study methods, trade space for Cost as Independent Variable (CAIV), Analytic Hierarchy Process (AHV) as a part of the Analytic Network Process (ANP), Potentially All Pairwise Rankings of All Possible Alternatives (PAPRIKA), and Decision Analysis with Uncertain Information/Data.

Saturday, 11 January 2014
Workshops at AIAA Science and Technology Forum and Exposition 2014 (AIAA SciTech 2014)*
www.aiaa.org/scitech2014

1st AIAA Sonic Boom Prediction Workshop

Sponsored by the Applied Aerodynamics Technical Committee

The objective of the First Sonic Boom Prediction Workshop is to assess the state of the art for predicting near field signatures needed for sonic boom propagation. Comparisons will be made between participant solutions on workshop-provided grids. Participants are requested to apply their best practices for computing solutions on the provided geometries. There is particular interest in exploring refinement techniques including grid adaptation and alignment with flow characteristics. Impartial comparisons will be made between different solution schemes as well as with wind tunnel validation data for assessing the state of the art and identifying areas requiring additional research and further development. For more information, please visit the Sonic Boom Prediction Workshop website (**http://lbpw.larc.nasa.gov**).

Low Reynolds Number Workshop

Organized by Ming Chang, Lockheed Martin Aeronautics, and Michael OI, US Air Force Research Lab

Micro Air Vehicles (MAVs) are flight articles resembling natural flyers (birds, bats, insects) in size and functionality. While of extensive defense interest since at least the 1990s, scientific and engineering progress has been episodic, with principal advances more from trial and error than first-principles science. Pacing issues include the aerosciences as well as payloads/energy/materials. We aim to explore the state of the art in both the sciences and applications, examining research directions and interest for academia, industry, and government.

The workshop aims to gather industry, academia, and government to assess new research directions and connection between the sciences and the applications. By the end of the day, we intend to assemble a credible sight-picture of who is pursuing what research, and what might be the beginning of a business case. Outcomes aim to include an understanding of where the MAV community stands in 2014 relative to where we've been throughout the past 20 years, and how to begin bridging scientific/academic advances with the needs of industry and the user community. For questions, please contact Ming Change at 661.572.6228 or ming.chang@lmco.com, or Michael V. OL at 937.713.6650 or michael.ol@wpafb.af.mil.

***To register for courses or workshops at AIAA SciTech 2014, visit www.aiaa.org/scitech2014 and select "Register Now".**

From the **Corner** Office

CELEBRATING OUR MEMBERS' ACCOMPLISHMENTS

Sandy H. Magnus, Executive Director

Mike, Klaus, and I have written many columns for the Corner Office in the last year talking about the changes occurring in the Institute and the need for that change. I would like to take a break from that and talk about an important contribution that AIAA has always made and will continue to make to our community—celebrating our members' and the industry's accomplishments. AIAA, as the professional organization that spans the whole industry, is in a position to be aware of results throughout our community and then to highlight the extraordinary accomplishments that the aerospace industry achieves and the brilliant, creative people who are responsible. We tell the stories of our industry, its breakthroughs in technology, its engineering accomplishments, its scientific advances, and their impact on our society, along with the people behind them, to the general population and the world.

There are several kinds of recognition programs that AIAA conducts to celebrate our members and tell our stories as well as acknowledging outstanding achievements. We showcase the advances in industry in the technical, policy, and management areas through the many lecturships and awards presented at our conferences. It is no small thing to be awarded such honors as the Goddard Astronautics Award or the Reed Aeronautics Award—two awards recognizing the highest achievements in astronautics and aeronautics, respectively! Our lectureships are equally prestigious. Who can fail to feel honored by being asked to present the Dryden Lectureship in Research or the Durand Lectureship for Public Service or the von Kármán Lectureship in Astronautics, or even the Wright Brothers Lectureship in Aeronautics, just to name a few. Legends stalk through the corridors of our history, providing us with the inspiration to follow in their footsteps. And we do—a new lectureship is being created in honor of Yvonne Brill, one of the modern pioneers in the aerospace industry.

We recognize contributions by leading aerospace professionals with our technical excellence awards, publication awards, and lifetime achievement awards. Our technical community is second to none. To receive an award for technical or publication excellence identifies you as being at the top of your field. To be an AIAA Fellow is a high mark of distinction—recognition by your peers at the highest level. Associate Fellows, likewise peer selected, are important contributors to the profession and industry.

We highlight the potential of the next generation of aerospace professionals by means of our highly popular student paper competitions and scholarship programs. We have an active community of members who give hundreds, even thousands, of hours to AIAA because they are dedicated to the advancement of the aerospace industry and its goals. Thus it is proper that we recognize years of dedicated service to the industry and to AIAA, in particular, with our Distinguished Service Award and the energy and excitement created in our sections with our section awards.

Our Gala, held each spring, celebrates our awardees and highlights their accomplishments. Those of us in the industry know that what we do has a major impact on our society and the world, but sometimes that same understanding and level of knowledge is not available to the greater population. Our industry plays a huge role in the economy and in the day-to-day lives of people all over the planet and it is important to tell that story.

I want to mention, briefly, some changes we recently made to the nomination process for one of the premier AIAA awards: The Foundation Award of Excellence. The Foundation Award of Excellence recognizes excellence within the aerospace community exemplifying the inspirational qualities that inspire the global community. Because the level of activity across the industry is incredibly high, the Foundation Board of Trustees decided to open the nomination process to AIAA members to ensure that we gather the most appropriate potential candidates.

The Foundation Award of Excellence, established in 1998 and voted on by the AIAA Foundation Board of Trustees, is given to the team, individual, program, or organization that has:

- A current noteworthy accomplishment
- Extraordinary lifetime contributions
- Unique accomplishments for the duration of a program

Typically the award is given yearly, but that is not required and is based on the quality of the nominations. Previous award winners have included:

2013	Mars Curiosity Team
2012	Boeing 787 Dreamliner
2011	USAF Scientific Advisory Board
2010	Joint Strike Fighter
2009	Challenger Center For Space Science Education
2008	Jet Propulsion Laboratory
2007	Mr. Gordon Bethune, Aloha Airgroup Inc.
2006	Dr. L. S. Fletcher, Texas A&M University
2005	Mr. Alan R. Mulally, The Boeing Company
2004	Gen. John Shalikashvili, Chairman of the Joint Chiefs of Staff, Department of Defense
2003	John Travolta, Pilot and Actor
2002	Gen. Tommy Franks, U.S. Army Commander in Chief
2001	Daniel S. Goldin, NASA
2000	Mr. Norman R. Augustine, Lockheed Martin Corporation
1998	National Reconnaissance Office

The one requirement is that the winners be present at the spring Gala to receive the award. The nomination process opens on **1 October** and will close on **1 December** and requires a one-page description of why the candidate(s) deserve the award. Now that the nomination process has been opened to AIAA members, please consider submitting nominations for those people, projects, or organizations who you feel represent "excellence within the aerospace community" and generate "inspiration for the Global community." (Submit nominations to Bill Seymore: billS@aiaa.org.) I know there are a lot of potential candidates out there!

To submit articles to the *AIAA Bulletin*, contact your Section, Committee, Honors and Awards, Events, Precollege, or Student staff liaison. They will review and forward the information to the *AIAA Bulletin* Editor. See the AIAA Directory on page **B1** for contact information.

AIAA ANNOUNCES CANDIDATES FOR 2014 BOARD OF DIRECTORS ELECTION

AIAA is pleased to announce that its 2014 Nominating Committee has selected candidates for next year's openings on the AIAA Board of Directors. The chair of the committee, AIAA Past President Paul Nielsen, confirmed the candidates who will appear on the ballot, as follows:

Vice President-Elect, Finance
Carol Lane, Ball Aerospace & Technologies Corporation
Laura McGill, Raytheon Missile Systems

Vice President-Elect, Publications
John Daily, University of Colorado at Boulder
Frank Lu, University of Texas at Arlington

Vice President-Elect, Standards
Allen Arrington, Sierra Lobo, Inc.
Jim Keravala, Shackleton Energy Company, Inc.

Vice President-Elect, International Activities
John Evans, Lockheed Martin Corporation
Sivaram Gogineni, Spectral Energies, LLC

Director–At-Large
Brett Anderson, Boeing Defense, Space & Security
Basil Hassan, Sandia National Laboratories
Benjamin Marchionna, Lockheed Martin Corporation

Director–At-Large, International
Scott Eberhardt, Analytical Methods
Christian Mari, SAFRAN Group

Director–Technical, Aircraft and Atmospheric Systems Group
Abdollah Khodadoust, Boeing Engineering Operations & Technology
Dimitri Mavris, Georgia Institute of Technology

Director–Technical, Engineering and Technology Management Group
Nancy Andersen, Lockheed Martin Space Systems
Tsutsumi Bright, Boeing Defense, Space & Security

Director–Technical, Space and Missiles Group
Thomas Duerr, The Aerospace Corporation
Peter Montgomery, Aerospace Testing Alliance

Director–Region I
Dennis Granato, Lockheed Martin Corporation
Ferdinand Grosveld, Northrop Grumman Corporation

The AIAA Constitution also allows board nominations to be made via petition. Members intending to follow this process are asked to contact the AIAA Secretary, Bill Seymore, at 703.264.7540 or bills@aiaa.org, as soon as possible before the **1 January 2014** deadline for more specific instructions and coordination. The petition must be supported by at least 300 voting members of the Institute. All eligible voting members of AIAA will be able to cast their ballot beginning in February 2014.

DR. PING LU APPOINTED AS NEW EDITOR-IN-CHIEF OF THE *JOURNAL OF GUIDANCE, CONTROL, AND DYNAMICS*

On 16 August 2013, AIAA President Michael Griffin formally appointed **Professor Ping Lu** to succeed Dr. George Schmidt as editor-in-chief of the *Journal of Guidance, Control, and Dynamics* (*JGCD*).

Dr. Ping Lu is Professor of Aerospace Engineering at Iowa State University where his research areas include adaptive launch ascent guidance for space transportation systems, advanced planetary entry guidance, autonomous mission planning and guidance by convex optimization, and nonlinear control with applications in aerospace systems. He is a frequent participant on departmental committees at the university, including strategic planning, curriculum review, faculty search, and various departmental evaluation committees. He also is serving currently as a junior faculty mentor. Dr. Lu holds a B.S. from Beijing Institute of Aeronautics and M.S. and Ph.D. degrees in aerospace engineering from the University of Michigan.

Along with his academic responsibilities, Dr. Lu has served as principal investigator for numerous industry and government contracts and grants related to guidance and control systems, and he has served as a technical advisor on flight mechanics and entry guidance for Northrop Grumman Corporation and projects for Barron Associates, Intelligent Automation, and Schafer Corporation. These real-world engineering opportunities have fostered an appreciation of the need for practical and innovative solutions to application problems as well as the importance of the intellectual pursuit of basic applied research.

From a publications perspective, Dr. Lu has been a longtime associate editor for *JGCD*, and he is a prolific reviewer of papers for other journals related to dynamic systems and guidance and control. He contributes frequently to top journals in his field and presents his work at international conferences on a regular basis, with *JGCD* as the primary venue of dissemination of his research results. He has also served as an editorial board member for *Optimal Control Applications and Methods*. Dr. Lu has made significant contributions to AIAA, including serving as a member of AIAA's Guidance, Navigation, and Control Technical Committee from 1994 to 2001 and as treasurer of the AIAA Iowa Section from 1993 to 1998. Honors and awards include the AIAA Mechanics and Control of Flight Award and the AIAA Sustained Service Award. He is an Associate Fellow of AIAA.

Originally titled the *Journal of Guidance and Control*, *JGCD* was launched in January 1978, under the leadership of Donald Fraser. In his inaugural editorial, Fraser wrote, "In addition to publishing the expected analytically oriented papers, our intention as editors is to emphasize, to the extent we can, the word applications in the scope. … Articles which show how new ideas or theoretical results can be reduced to practice will be encouraged." This emphasis on applications over theory has been the guiding focus behind *JGCD* since its inception. Dr. Fraser served as editor-chief of *JGCD* until 1992.

Dr. Lu becomes the fourth editor-in-chief of *JGCD*, following George Schmidt (1996–present) and Kyle (Terry) Alfriend (1992–1996). He was selected after an extensive search and evaluation of candidates by an ad hoc committee appointed by Vigor Yang, VP–Publications, and co-chaired by Dr. Donald Fraser and Dr. Michael Bragg, former VP–Publications. Upon recommending Ping Lu as the new editor-in-chief, Fraser noted that "as an associate editor of the *JGCD* since 1996, Dr. Lu is very familiar with its current issues and execution and has offered an exciting plan for its continued success. I am confident that he will work tirelessly to assure the Journal maintains its applications focus—the most important issue at the time of the Journal's creation and what has separated it from its competitors for over 30 years."

Looking toward the future, Dr. Lu notes that "Thanks in no small part to the leadership of the editors-in-chief since 1978, the *JGCD* today is the world's premier journal in this much developed but still expanding field of guidance, control, and dynamics. The next editor will have the responsibility to carry the torch, continue the proud tradition, and expand the reach and impact. My background of having worked on both real-world applications and basic applied research gives me a unique perspective to guide the *JGCD* successfully on this strategic path."

UCF AIAA STUDENT CHAPTER RECEIVES AWARD

The AIAA University of Central Florida (UCF) Student Chapter received the 2012–2013 Knights of the Round Table Organization of the year award for their activities. AIAA UCF's main work was participation in their Aviation Design and Design, Build, Fly projects. In Aviation Design, 10 teams of 4 students go through a two-semester design process, where they are guided in designing, constructing, then compete their own plane design. An up-scaled version of this, Design, Build, Fly, is done every year by our most promising and passionate upperclassmen. They are very proud of this project, and after the competition the planes are displayed on a stand in the middle of the engineering atrium.

Adding to their extensive list of projects, the chapter also participates in hosting workshops for students, providing tours to industry, and going to outreach events for the local community. They have hosted workshops in STAR-CCM, Pro-ENGINEER, SolidWorks, Matlab, and Excel, and taken students on tours to NASA Kennedy Space Center, Mitsubishi Power Systems, Lockheed Martin Missile and Fire Control, as well as many other industry-related locations. The organization also gives back to the community by regularly attending local outreach events, including a regular outreach program to visit Rock Lake Elementary twice a month to teach students about science and engineering through fun and informative workshops.

It has just been so exciting to see the enthusiasm from students who have made this organization their own. All of these things culminated in our organization proudly receiving the Knights of the Round Table Club of the Year 2012–2013 award.

AVIATION 2014

16–20 JUNE 2014

ATLANTA, GA

CALL FOR PAPERS

The aviation enterprise is in a phase of evolving business models, increased efficiency demands, emerging manufacturing methods, and constantly evolving technology integration. These trends offer unprecedented opportunities and challenges for new capabilities.

In addition to cutting-edge technical research presentations, AIAA Aviation and Aeronautics Forum and Exposition (AVIATION 2014) will feature panel discussions and keynote presentations addressing such matters as:

- The implementation of new air traffic management capabilities,
- A rethinking of traditional commercial aviation operational models,
- The integration and utilization of unmanned platforms to enhance our existing fleets,
- An evolving financial landscape for both commercial and military aviation system acquisition,
- Increasingly connected and networked aviation platforms,
- The implications of policy decisions on how we define, design, and field new operational systems.

These are just a few of the key themes we will address at AVIATION 2014. A full program of detailed technical discussions will underpin the high-level conversations to provide a wide-ranging overview of the state of the art in our industry.

ABSTRACT SUBMISSION DEADLINE: 14 NOVEMBER 2013

Sponsored by

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13-67

FEATURING:

- 20th AIAA/CEAS Aeroacoustics Conference
- 30th AIAA Aerodynamic Measurement Technology and Ground Testing Conference
- AIAA/3AF Aircraft Noise and Emissions Reduction Symposium
- 32nd AIAA Applied Aerodynamics Conference
- AIAA Atmospheric Flight Mechanics Conference
- 6th AIAA Atmospheric and Space Environments Conference
- 14th AIAA Aviation Technology, Integration, and Operations Conference
- AIAA Balloon Systems Conference
- AIAA Flight Testing Conference
- 7th AIAA Flow Control Conference
- 44th AIAA Fluid Dynamics Conference
- 20th AIAA International Space Planes and Hypersonic Systems and Technologies Conference
- 11th AIAA/ASME Joint Thermophysics and Heat Transfer Conference
- 21st AIAA Lighter-Than-Air Systems Technology Conference
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AIAA SSTC EXPANDS NATIONAL ESSAY CONTEST FOR MIDDLE SCHOOL STUDENTS

LA–LV section officers and essay award winners (Margot Mel is second from right)

Each year the AIAA San Francisco Section chooses a topic related to aeronautics and aerospace, and area 7th and 8th graders submit essays. When AIAA Space Systems Technical Committee (SSTC) member, Samantha Infeld, became the K–12 Outreach director for the AIAA San Francisco Section in 2010, she realized she could connect the TC's desire to inspire students and local sections directly by working to expand the section's essay contest to a national one run by the SSTC.

In 2011, SSTC members became familiar with the essay contest process and cosponsored it with AIAA San Francisco. SSTC members are working with their local sections to start parallel contests to feed into selection of a national winner awarded by the SSTC. In 2012 AIAA San Francisco and AIAA Los Angeles sections both participated, with the topic "Choose a science fiction movie and discuss how scientifically realistic the ideas and scenes are." This year, AIAA's Hampton Roads and Palm Beach sections joined for a total of four sections from which a 7th and 8th grade national winner was selected to receive $100, plus $250 for their classroom toward STEM materials or activities. The 2013 topic was "How can humans and robots work together to explore Mars?"

San Francisco section officers present 7th grade essay award (Bhargavi Gogineni is second from right).

The winners are 7th grader **Bhargavi Gogineni** and her teacher, **Mrs. Kristina Park**, at Hyde Middle School, Cupertino, CA, and 8th grader **Margot Mel** and her teacher, **Ms. Rebecca Allen**, at Manhattan Beach Middle School. The Hyde Middle School Science department plans to use the award money toward renting a kit that enables students to perform genetic engineering. The pGLO transformation kit is loaned out by SCCBEP (Santa Clara County Biotechnology Education Partnership) and involves transferring genetic information from one organism to another. In this specific kit, a gene that produces a fluorescent protein under UV light is transferred into a non-pathogenic bacteria and causes it to fluoresce. Ms. Allen says she will use the award to purchase a stunning periodic table iPad app called "The Elements" for all of her students to use. They each have access to iPads through a school iPad program.

A big thanks to Northrop Grumman for sponsoring the prizes. To read the winning essays, go to **www.aerospaceamerica.org**, and click on Bonus Content.

In conjunction with the 27th Annual AIAA/USU Conference on Small Satellites in Logan, the AIAA Utah Section hosted tours of the Hill Aerospace Museum near Hill Air Force Base. Over 900 people attended the museum that day and were greeted by volunteers from the Utah Section.

This photo shows AIAA Utah Section volunteers at the Hill Aerospace Museum. From left to right, Charlie Vono, Ian Cox, John Metcalf, Spencer Shupe, Dan Henshaw, and Jeffrey C. Boulware. (Photo courtesy of Mike Petkovic of the Australian National University.)

PICATINNY COMMUNITY DAY AIAA-SPONSORED PAPER AIRPLANE CONTEST

On 11 July, as a part of the Picatinny Community Day, the AIAA Northern New Jersey (NNJ) Section, in conjunction with the NJIT student chapter, hosted a paper airplane contest. While the contest was gear toward children, adults were welcomed to participate. Throughout the day, heats were held in 30-minute intervals, giving everyone plenty of time to construct their airplanes with supplies provided. Supplies were available for everyone to use. For each heat, two winners were chosen, one for longest flight and a second for the plane that landed closest to the target. Each winner received a balsawood plane kit.

Thanks to the AIAA National Headquarters, each participant also received a foam Space Shuttle, a forget-me-not seed packet, an AIAA ruler, and literature for aerospace careers. The NNJ chapter provided additional mini foam flyers for all participants.

At the end of the day, all of the heat winners were invited back for a final fly-off. The final two winners for longest-flight and closest-to-target received certificates and propeller beanies.

Overall attendance throughout the day was between 75–100 students, as well as additional adults. The vast majority of all children who were at the Picatinny Community Day made an airplane for the contest.

Two unanticipated conditions helped with the high participation level. The first was the heat of the day. We were given indoor, air-conditioned space and most people were in our area for a good portion of the time to cool off. Second, all the other children's activities were giving tickets as prizes that the children had to save up to get something. We had prizes for doing the one event. These two circumstances combined to ensure that we had a high, constant level of interest and participation throughout the day.

HISTORIC AEROSPACE SITE DESIGNATED IN AUGUST

In August, AIAA designated Kitty Hawk, NC, as an AIAA Historic Site. This year marks the 110th anniversary of the Wright Brothers' historic flight there, and the designation ceremony took place on 19 August, which was the birthday of both Orville Wright and his sister, Katharine. The ceremony was held in conjunction with the First Flight Society's annual Aviation Day.

Tony Springer, the chair of the AIAA Historic Aerospace Sites Committee, addressed the crowd on the role of historic preservation and recognition, and the ongoing importance of the recognition of these iconic and historic sites. Bob Lindberg, AIAA Board of Directors Member-at-Large, commented on AIAA's history, its ties with the Wright Brothers, and its ongoing mission to support the aerospace community.

AIAA presented a plaque that will be held by the National Park Service while the current Visitors' Center is undergoing renovations over the next few years.

AIAA Board member Bob Lindberg (l) and Historic Sites Committee chair Tony Springer (r) presenting the plaque to Barclay Trimble, the Superintendent of Wright Brothers National Memorial Park.

TEACHER FLY HIGH AT PLYMOUTH STATE UNIVERSITY

The AIAA Educator Academy Electric Cargo Airplane Workshop was held at Plymouth State University (PSU) in Plymouth, NH, on 25 June. The 29 attendees included high and middle school Science, Technology, Engineering, and Math (STEM) specialists and an English teacher and a pair of middle school students. Plymouth State University graciously provided the basketball court area of their recreational facility for the event, which proved to be an ideal venue with plenty of room for two "flight circles" to be run to test airplanes the participants built. This particular workshop was put together with the assistance of James Brough, National Aviation and Space Education Manager at the Federal Aviation Administration, who was in attendance along with Mary McLaughlin, Regional STEM Manager.

The Educator Academy Electric Cargo Airplane Module is based on the Maryland Engineering Challenges Electric Cargo Plane Challenge for middle and high school students, which is a long-standing staple of the AIAA Mid-Atlantic Section's K–12 Program. It is based on the concept of "tethered flight". A "power pole" at the center of a "flight circle" is fed electricity by a pair of small gauge wires taped to the floor and powered by a 16V DC transformer. A tether attaches, connected to a rotating phonograph jack at the top of the power pole, which extends to the student designed plane whose centerline must be 10' from the pole. The tether provides both electrical power to the airplane's motor as well as a mechanical constraint that forces the plane to fly in a circle about the power pole.

The challenge for the students is to get their plane to carry as much "cargo weight" as possible. The "tethered" concept greatly reduces cost for students and teachers by avoiding the need for expensive Radio Control equipment and allows for indoor flight so the module can be taught during any season of the year and regardless of weather conditions. In a sense it is a middle and high school equivalent to AIAA's Design, Build, and Fly Competition for college students (http://www.aiaadbf.org).

The main instructor for the workshop was Educator Associate Paul Wiedorn of Wilde Lake High School in Columbia, MD, who is also the Electric Cargo Workshop lead for the Maryland Engineering Challenges. Paul was assisted by "Engineer on Call" Tom Milnes, who is organizer and head judge of the Maryland event for the AIAA Mid-Atlantic Section, as well as a member of the AIAA K–12 STEM Outreach Committee. Joining them was Gar Bering, AIAA K–12 STEM Outreach Committee Chair.

Participants were welcomed to Plymouth State University by Dr. Cynthia Vascak, Dean of the College of Arts and Sciences, and a letter was read from Senator Jeanne Shaheen (D-NH) congratulating the teachers for attending and emphasizing the need for STEM education. Formal instruction on STEM content by Weidorn was punctuated by lively commentary on various technical and historical topics until the building began in earnest.

The instructors went from table to table assessing the progress of the participants. After lunch, testing of the aircraft began on two flight circles. Participants vied to add additional cargo weight. By the end of the day, all participants successfully flew an airplane they had built themselves both empty and with cargo!

The workshop is only one component of the support AIAA offers to teachers for this activity. A complete set of curriculum materials for a 5-week unit can be found at **https://www.aiaa.org/AIAAEducatorAcademy/**.

Plymouth State University and the local K–12 educators present have since really taken the concept and run with it; they held a camp for middle school students in July and ran a build session/competition in nearby Laconia in August. Lots more Electric Cargo events are planned for the school year. It looks like New Hampshire is "flying high" with the AIAA Educator Academy Electric Cargo Plane Module! For information about the AIAA Educator Academy, please contact Lisa Bacon at lisab@aiaa.org.

OBITUARIES

AIAA Senior Member Mills Died in June

Barton Mills, a member of AIAA since 1958, passed away on 3 June. He was 85 years old.

In 1950 during the Korean action, Mr. Mills served aboard the USS Lenawee. He received a BS degree in mechanical engineering at the University of California, Berkeley, in June 1957, and joined Lockheed Burbank immediately. He took many supplementary University Extension courses and company training courses in the aerospace disciplines, computer technology, and management.

Mr. Mills spent his 33 years at Lockheed working primarily in the Engine Accessories Group of the Propulsion Department of the Flight Sciences Engineering Division. He worked on almost all commercial and military aircraft programs during the period, including out-of-production, in-production, and advanced designs. He conducted functional and performance analyses of propulsion, mechanical, electrical, and fluid accessory systems, including auxiliary power units (APUs), emergency power units (EPUs), and pneumatic, fuel, cooling, venting and fire protection systems.

AIAA Member Favaregh Died in July

Noah M. Favaregh, age 31, died from injuries resulting from an airplane crash on 27 July 2013, in Milwaukee, WI.

Mr. Favaregh completed his undergraduate and graduate studies at Old Dominion University, finishing his MS degree in 2006. He was a Supervisor Engineer at Analytical Mechanics Associates, Inc.

He began his association with AIAA in 2005 as a student member. Mr. Favaregh was the incoming 2013–2014 secretary for the AIAA Hampton Roads Section and had participated in many Section activities.

AIAA Associate Fellow Czysz Died in August 2013

Paul A. Czysz, 80, passed away on 16 August 2013.

Mr. Czysz earned a B.S. in Aeronautical Engineering in 1955, and did graduate work in Aeronautical Engineering at St. Louis University in 1955 and at Ohio State University, Extension School-Wright Patterson AFB, from 1955 to 1961 while enlisted in the U.S. Air Force.

His multifaceted career spanned half a century; it began in 1956 as Air Force lieutenant in the Hypervelocity Branch of the USAF Wright Air Development Center (WADC). At WADC he was a project engineer in the Vertical Wind Tunnel built to study aircraft spinning, and where Mr. Czysz designed a new wind tunnel. After being promoted to Senior Engineer he designed the WADC high temperature hypersonic wind tunnel where testing air was heated by passing it over a combustion pre-heated zirconia pebble bed. For this facility he developed an oxygen-rich combustion preheating method that prevented chemical reduction of zirconia by the high temperature vitiated air, one of the causes of pebble deterioration. In 1960 he was appointed Chief of all WADC High Temperature Test Facilities, and received an Outstanding Performance Award twice. The next year, as appointed Chief of the entire Hypervelocity Branch, he became responsible for the High Temperature Gas Dynamics Test Facilities and for the new Magneto-Hydro-Dynamics Facility, supervising 20 engineers and technicians and extending wind tunnel performance from Mach 8 to Mach 10.

In 1963 he joined McDonnell Aircraft Company. As Group Leader in wind tunnel technology he redesigned the Hypersonic Impulsive wind tunnel and made it capable of reaching Mach 12 to 16 while improving flow quality. He also investigated the F-15 air inlet distortion for the Air Force and that in the inlet of the DC-10. In 1969 he was the Deputy Study Manager for the NASA HFAC study, and explored in detail 54 facility concepts, with the ultimate goal of developing the hypersonic vehicle that would later become NASP. From 1970 through 1983 he managed many advanced projects, among them are those associated with CAD engineering of military airplanes, the ATF, the Variable Cycle Engine, the AFTI F-15, and projects in low observable technologies for the Navy and the Air Force.

From 1983 through 1986 he managed a study in Advanced Manned Aerospace Systems that led to DARPA's Copper Canyon and then to NASP. He was Chief Scientist for the NASP industry-government consortium from 1986 to 1990. His performance in NASP led to his appointment as Permanent Staff to the president of McDonnell Douglas. During these years he was invited to visit his counterparts in many countries, including Russia in 1991.

In 1989 he was asked to join the faculty at Parks College of St. Louis University as Adjunct Professor in Aerospace Engineering; he enjoyed teaching and doing research with his students until his retirement in 1992. In 1991 he had started his own company, Hypertech Concept LLC; Mr. Czysz continued giving courses on hypersonics design in Germany, Belgium, Japan, the European Space Agency, and Italy, besides consulting for the U.S. aerospace industries and the Air Force.

Mr. Czysz was a familiar figure at the AIAA Aerospace Sciences Meeting, the Joint Propulsion Conference, the International Astronautical Congress, and the AIAA Aerospace Planes and Hypersonic Technologies Conference. For his work he received many awards, including a McDonnell Douglas Presidential Award. He authored or co-authored two books and more than 200 papers and reports that document issues, methodologies, and progress in aviation and hypersonics.

AIAA Associate Fellow Tobak Died in August

Long-time AIAA Associate Fellow and Associate Editor of the *Journal of Aircraft*, **Murray Tobak**, died 31 August, at age 88, after a short illness.

Mr. Tobak joined the staff of the NACA Ames Aeronautical Laboratory in 1948, after completing his undergraduate engineering training at the University of California, Berkeley. He retired 56 years later as a senior scientist from the NASA Ames Research Center after a long, distinguished, and productive career. In his retirement he continued to work as an unpaid Ames guest worker and as an Associate Editor until shortly before his death.

Mr. Tobak's career spanned the era in which analytic solutions of the linearized potential flow equations for flow about simple bodies were cutting-edge technology, to the era when numerical solution of the time-dependent Navier-Stokes equations for flow about complete aircraft are commonplace. He made significant contributions in the fields of unsteady aerodynamics, in developing techniques for modeling the nonlinear, nonsteady, flow about maneuvering aircraft, in predicting the behavior of tumbling bodies entering the Earth's atmosphere from space. Within basic aerodynamics, Mr. Tobak developed theories explaining the origin of the crosshatching observed on ablating slender bodies in hypersonic flow. He also developed theories of flow topology, linking the surface-flow variations with the behavior of the off-surface flow features, and made significant contributions toward explaining the origin of the steady asymmetric vortex flows observed on slender bodies of revolution at large angles of attack.

Mr. Tobak was never a manager, but he was a colleague, friend, and mentor to countless co-workers over the years. He instilled in them his own high standards of scientific curiosity, his dedication to careful research and analysis, and his clear and elegant style of technical writing. Many of Mr. Tobak's papers, even his early ones, are still being referenced today. He led by example, and he will be missed.

CALL FOR AWARD NOMINATIONS

Recognize the achievements of your colleagues by nominating them for an award! Nominations are now being accepted for the following awards, and must be received at AIAA Headquarters no later than **1 February**. Awards are presented annually, unless other indicated. However AIAA accepts nomination on a daily basis and applies to the appropriate year.

Any AIAA member in good standing may serve as a nominator and are urged to read award guidelines to view nominee eligibility, page limits, letters of endorsement. All nominations must comply with the limit of 7 pages for the nomination package; see details on the webpage (**https://www.aiaa.org/secondary.aspx?id=230**).

Aerospace Communications Award is presented for an outstanding contribution in the field of aerospace communications.

Aerospace Power Systems Award is presented for a significant contribution in the broad field of aerospace power systems, specifically as related to the application of engineering sciences and systems engineering to the production, storage, distribution, and processing of aerospace power.

Air Breathing Propulsion Award is presented for meritorious accomplishment in the science of air breathing propulsion, including turbomachinery or any other technical approach dependent on atmospheric air to develop thrust, or other aerodynamic forces for propulsion, or other purposes for aircraft or other vehicles in the atmosphere or on land or sea.

The industry-renowned **Daniel Guggenheim Medal** was established in 1929 for the purpose of honoring persons who make notable achievements in the advancement of aeronautics. AIAA, ASME, SAE, and AHS sponsor the award.

Energy Systems is presented for a significant contribution in the broad field of energy systems, specifically as related to the application of engineering sciences and systems engineering to the production, storage, distribution, and conservation of energy.

George M. Low Space Transportation Award honors the achievements in space transportation by Dr. George M. Low, who played a leading role in planning and executing all of the Apollo missions, and originated the plans for the first manned lunar orbital flight, Apollo 8. (Presented even years)

Haley Space Flight Award is presented for outstanding contributions by an astronaut or flight test personnel to the advancement of the art, science, or technology of astronautics. (Presented even years)

J. Leland Atwood Award recognizes an aerospace engineering educator for outstanding contributions to the profession. AIAA and ASEE sponsor the award. *Note*: Nominations due to AIAA by **1 January**.

Jeffries Aerospace Medicine & Life Sciences Research Award is presented for outstanding research accomplishments in aerospace medicine and space life sciences.

Missile Systems Award—Technical Award is presented for a significant accomplishment in developing or using technology that is required for missile systems.

Missile Systems Award—Management Award is presented for a significant accomplishment in the management of missile systems programs.

Propellants and Combustion Award is presented for outstanding technical contributions to aeronautical or astronautical combustion engineering.

Space Automation and Robotics Award is given for leadership and technical contributions by individuals and teams in the field of space automation and robotics. (Presented odd years)

Space Science Award is presented to an individual for demonstrated leadership of innovative scientific investigations associated with space science missions. (Presented even years)

Space Operations and Support Award is presented for outstanding efforts in overcoming space operations problems and assuring success, and recognizes those teams or individuals whose exceptional contributions were critical to an anomaly recovery, crew rescue, or space failure. (Presented odd years)

Space Processing Award is presented for significant contributions in space processing or in furthering the use of microgravity for space processing. (Presented odd years)

Space Systems Award recognizes outstanding achievements in the architecture, analysis, design, and implementation of space systems.

von Braun Award for Excellence in Space Program Management recognizes outstanding contributions in the management of a significant space or space-related program or project.

Theodor W. Knacke Aerodynamic Decelerator Systems Award recognizes significant contributions to the effectiveness and/or safety of aeronautical or aerospace systems through development or application of the art and science of aerodynamic decelerator technology. (Presented odd years)

The **William Littlewood Memorial Lecture**, sponsored by AIAA and SAE, perpetuates the memory of William Littlewood, who was renowned for the many significant contributions he made to the design of operational requirements for civil transport aircraft. Lecture topics focus on a broad phase of civil air transportation considered of current interest and major importance.

Wyld Propulsion Award is presented for outstanding achievement in the development or application of rocket propulsion systems.

For further information on AIAA's awards program, please contact Carol Stewart, Manager, AIAA Honors and Awards, carols@aiaa.org or 703.264.7623.

Standard Information for all AIAA Conferences

This is general conference information, except as noted in the individual Event Preview information.

On-Site Check-In

Partnering with Expo Logic, we've streamlined the on-site registration check-in process! All advance registrants will receive an email with a registration barcode. To pick up your badge and conference materials, make sure to print the email that includes your ExpressPass Barcode, and bring it with you to the conference. Simply scan the ExpressPass barcode at one of the ExpressPass stations in the registration area to print your badge and receive your meeting materials.

Photo ID Needed at Registration

All registrants must provide a valid photo ID (driver's license or passport) when they check in. For student registration, valid student ID is also required.

Certificate of Attendance

Certificates of Attendance are available for attendees who request documentation at the conference itself. Please request your copy at the on-site registration desk. AIAA offers this service to better serve the needs of the professional community. Claims of hours or applicability toward professional education requirements are the responsibility of the participant.

Conference Proceedings

Proceedings for AIAA conferences will be available in online proceedings format. The cost is included in the registration fee where indicated. Attendees who register in advance for the online proceedings will be provided with access instructions. Those registering on site will be provided with instructions at that time.

Young Professional Guide for Gaining Management Support

Young professionals have the unique opportunity to meet and learn from some of the most important people in the business by attending conferences and participating in AIAA activities. A detailed online guide, published by the AIAA Young Professional Committee, is available to help you gain support and financial backing from your company. The guide explains the benefits of participation, offers recommendations and provides an example letter for seeking management support and funding, and shows you how to get the most out of your participation. The online guide can be found on the AIAA website, **http://www.aiaa.org/YPGuide**.

Journal Publication

Authors of appropriate papers are encouraged to submit them for possible publication in one of the Institute's archival journals: *AIAA Journal*; *Journal of Aircraft*; *Journal of Guidance, Control, and Dynamics*; *Journal of Propulsion and Power*; *Journal of Spacecraft and Rockets*; *Journal of Thermophysics and Heat Transfer*; or *Journal of Aerospace Information Systems (*formerly *Journal of Aerospace Computing, Information, and Communication)*. You may now submit your paper online at **http://mc.manuscriptcentral.com/aiaa**.

Timing of Presentations

Each paper will be allotted 30 minutes (including introduction and question-and-answer period) except where noted.

Committee Meetings

Committee meeting schedule will be included in the final program and posted on the message board in the conference registration area.

Audiovisual

Each session room will be preset with the following: one LCD projector, one screen, and one microphone (if needed). A 1/2" VHS VCR and monitor, an overhead projector, and/or a 35-mm slide projector will only be provided if requested by presenters on their abstract submittal forms. AIAA does not provide computers or technicians to connect LCD projectors to the laptops. Should presenters wish to use the LCD projectors, it is their responsibility to bring or arrange for a computer on their own. Please note that AIAA does not provide security in the session rooms and recommends that items of value, including computers, not be left unattended. Any additional audiovisual requirements, or equipment not requested by the date provided in the Event Preview information, will be at cost to the presenter.

Employment Opportunities

AIAA is assisting members who are searching for employment by providing a bulletin board at the technical meetings. This bulletin board is solely for "open position" and "available for employment" postings. Employers are encouraged to have personnel who are attending an AIAA technical conference bring "open position" job postings. Individual unemployed members may post "available for employment" notices. AIAA reserves the right to remove inappropriate notices, and cannot assume responsibility for notices forwarded to AIAA Headquarters. AIAA members can post and browse resumes and job listings, and access other online employment resources, by visiting the AIAA Career Center at **http://careercenter.aiaa.org**.

Messages and Information

Messages will be recorded and posted on a bulletin board in the registration area. It is not possible to page attendees.

Membership

Nonmembers who pay the full nonmember registration fee will receive their first year's AIAA membership at no additional cost.

Nondiscriminatory Practices

The AIAA accepts registrations irrespective of race, creed, sex, color, physical handicap, and national or ethnic origin.

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Videotaping or audio recording of sessions or exhibits as well as the unauthorized sale of AIAA-copyrighted material is prohibited.

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AIAA speakers and attendees are reminded that some topics discussed in the conference could be controlled by the International Traffic in Arms Regulations (ITAR). U.S. Nationals (U.S. Citizens and Permanent Residents) are responsible for ensuring that technical data they present in open sessions to non-U.S. Nationals in attendance or in conference proceedings are not export restricted by the ITAR. U.S. Nationals are likewise responsible for ensuring that they do not discuss ITAR export-restricted information with non-U.S. Nationals in attendance.

Fundamentals of Aircraft and Airship Design, Volume 2 – Airship Design and Case Studies

Grant E. Carichner and Leland M. Nicolai

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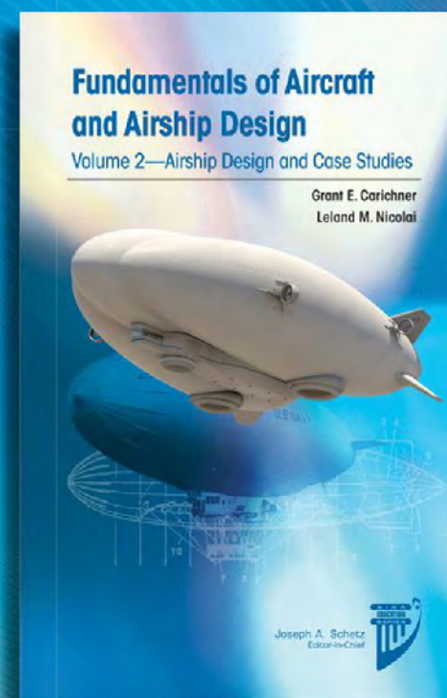

About the Book

Fundamentals of Aircraft and Airship Design, Volume 2 —Airship Design and Case Studies examines a modern conceptual design of both airships and hybrids and features nine behind-the-scenes case studies. It will benefit graduate and upper-level undergraduate students as well as practicing engineers.

The authors address the conceptual design phase comprehensively, for both civil and military airships, from initial consideration of user needs, material selection, and structural arrangement to the decision to iterate the design one more time. The book is the only available source of design instruction on single-lobe airships, multiple-lobe hybrid airships, and balloon configurations; on solar- and gasoline-powered airship systems, human-powered aircraft, and no-power aircraft; and on estimates of airship/hybrid aerodynamics, performance, propeller selection, S&C, and empty weight.

The book features numerous examples, including designs for airships, hybrid airships, and a high-altitude balloon; nine case studies, including SR-71, X-35B, B-777, HondaJet, Hybrid Airship, Daedalus, Cessna 172, T-46A, and hang gliders; and full-color photographs of many airships and aircraft.

About the Authors

GRANT E. CARICHNER'S 48-year career at the Lockheed Martin Skunk Works includes work on SR-71, M-21, L-1011 Transport, Black ASTOVL, JASSM missile, stealth targets, Quiet Supersonic Platform, ISIS high-altitude airship, and hybrid airships. He was named "Inventor of the Year" in 1999 for the JASSM missile vehicle patent. He also holds design patents for hybrid airship configurations. He is an AIAA Associate Fellow.

LELAND M. NICOLAI received his aerospace engineering degrees from the University of Washington (BS), the University of Oklahoma (MS), and the University of Michigan (PhD). His aircraft design experience includes 23 years in the U.S. Air Force, retiring as a Colonel, and 32 years in industry. He is an AIAA Fellow and recipient of the AIAA Aircraft Design Award and the Lockheed Martin Aero Star President's Award. He is currently a Lockheed Martin Fellow at the Skunk Works.

"Leland Nicolai and Grant Carichner have succeeded in providing a cutting-edge two-volume aircraft design text and reference addressing probably the most productive modes of air transportation: fixed-wing aircraft and the promising low-speed hybrid cargo airship."
– Dr. Bernd Chudoba, The University of Texas at Arlington

"This volume combines science and engineering covering the steps required to achieve a successful airship design. It represents an excellent effort to consider every aspect of the design process."
– Norman Mayer, LTA Consultant, AIAA Associate Fellow and Lifetime Member

"Carichner and Nicolai have created the definitive work on modern airship design containing many techniques, ideas, and lessons learned never before published. In addition, they have collected a set of case studies that will enable tomorrow's designers to learn from the experience of many who have gone before them."
– Dr. Rob McDonald, California Polytechnic State University at San Luis Obispo

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