RAeS Quarterly

WASHINGTON DC BRANCH

SUMMER 2015 NEWSLETTER

INAUGURAL ISSUE

ROYAL AERONAUTICAL SOCIETY

The Royal Aeronautical Society is the world's only professional body dedicated to the entire aerospace community. Established in 1866 to further the art, science and engineering of aeronautics, the Society has been at the forefront of developments in aerospace ever since. The Washington, DC Branch was launched in 2003.

ROYAL AERONAUTICAL SOCIETY

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Launch of the Heritage Collections Website

Since its formation in 1866, the Royal Aeronautical Society has been at the forefront of developments in aviation and aerospace.

As the world's only professional body dedicated to the aerospace community, we exist to further the advancement of aeronautical art, science and engineering around the world.

Through this new site, we aim to showcase the treasures from our historical collections and to bring to life some of the great figures of aviation history.

We hope that it inspires you to learn more about our collections, visit our library and consult with our knowledgeable librarians.

AeroSocietyHeritage.com

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RECAP

LATEST EVENT FROM THE WASHINGTON, DC BRANCH

Keith Hagy, Cpt. Kevin Hiatt, Kenneth P. Quinn, John DeLisi

GLOBAL AIRCRAFT TRACKING, LOCATING AND FLIGHT DECK PROTECTION

MAY 18, 2015

Boeing Company Offices, Washington, DC

PANEL

Cpt. Kevin Hiatt
Senior Vice President, Safety and Flight Operations, IATA

John DeLisi
Director, Office of Aviation Safety,
National Transportation Safety Board

Keith Hagy
Director, Engineering and Safety, ALPA

MODERATOR

Kenneth P. Quinn
Partner, Pillsbury Winthrop Shaw Pittman LLP

The Washington Branch held a lively discussion on the critical issue of global aircraft tracking, locating lost aircraft and protecting flight decks from malicious interference. John Moloney, Boeing Director of Transportation Policy, welcomed the RAeS to the new Boeing offices serving Washington, D.C. Robert Francis, former NTSB Chairman and past Chairman of the RAeS Washington Branch, welcomed more than 80 participants to the session and thanked the sponsors, Airbus, The Boeing Company, Northrop Grumman, Lockheed Martin, Pratt & Whitney and Rolls Royce.

RAeS Board member Kenneth Quinn moderated the panel with his “no holds barred” style. He asked the controversial questions and stimulated a provocative discussion, which included the audience participants. Captain Kevin Hiatt, at the time served as Senior Vice President for Safety and Flight operations, International Air Transport Association (IATA) presented the airline view of the issues. His perspective as both a commercial pilot and the representative of the airlines provided a unique perspective for airline management. Captain Keith Hagy, Director of Engineering and Safety for the AirlinePilots Association (ALPA), a leading airline pilot union in the world and

Bob Francis, Neil Jacobs

John DeLisi, Keith Hagy, Cpt. Kevin Hiatt

representing more than 51,000 pilots, provided a view from the cockpit and John DeLisi, Director of Office of Aviation Safety for the US National Transportation Safety Board, contributed his expertise as an aircraft accident and incident investigator.

The panel began the discussion with the recognition that commercial aviation is based on the principle of cooperation. Airline management and pilots cooperate with air traffic navigation service providers (ANSPs) for the operation of flights safely around the world. Aircraft are equipped to be recognized and tracked by ANSPs. Airline procedures support the mutual coordination and cooperation between flight crews and ANSPs.

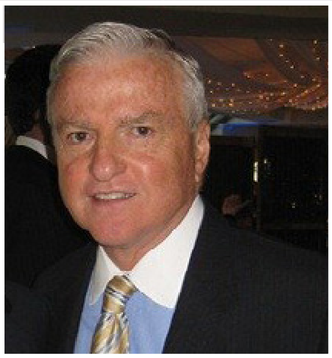
Questions were raised as to why transponders can be turned off and the possible use of cameras in the cockpit to provide video to support the data and voice recorders. Hagy contended that for safety in the event of a fire, the pilot needs the ability to turn off the transponder. He opposed the use of cameras in the cockpit as a distraction to good accident investigation. DeLisi refuted both positions and provided support for transponders being kept on and the use of cameras in the cockpit as providing additional data to analyze, as opposed to being distracting.

Discussion then moved to government's lagging adoption of satellite-based technologies to track aircraft. Hiatt provided an excellent overview of the current systems in place to track and locate aircraft and presented the recommendations of the IATA Aircraft Tracking Task Force (ATTF) to the International Civil Aviation Organizations (ICAO). The ATTF report notes that there are many technologies and services available today to improve global aircraft tracking and encourages airlines to adopt these technologies and implement the tracking solution best-suited to their specific operational needs. The ATTF also recommended that ANSPs are encouraged to adopt performance based management of air space.

Roger Cohen, John Moloney, Sam Balooki

Quinn wrapped up the session with a reflection on the need for the global aviation industry to continue to pursue better solutions for tracking and locating aircraft. ■

Written by Dr. Tulinda Larsen, Board Member of the Washington, DC Branch of RAeS.



CHAIRMAN'S MESSAGE

A MESSAGE FROM THE WASHINGTON, DC BRANCH CHAIRMAN, KENNETH GAZZOLA

Fellow Members and Aerospace Supporters,

Welcome to the inaugural issue of our newsletter. Your board has been working diligently to add member benefits. This newsletter is one of several benefits to be introduced. It will be published quarterly, designed to brief members and supporters, who are unable to attend every event and to serve as a recap for those who do attend. An additional highlight is topical aerospace industry content from the flagship monthly journal, AEROSPACE, published by our parent organization in the UK. We hope you will find it interesting and useful. Please send your feedback.

So far, 2015 is an exciting year. In February, Jim Guyette, President and CEO of Rolls-Royce North America, received our 4th annual Transatlantic Leading Edge Award, presented at the British Embassy by Ambassador Peter Westmacott. Most recently in May, a top level panel revisited the very relevant topic of "Global Aircraft Tracking, and Locating," this year adding the topic of Flight Deck Protection. Highlights of the panel may be found in this issue. Finally in addition to the two remaining meetings, September 24 and November 12, we are working on an attractive new member benefit, a field trip to a well-known aerospace site.

Thanks to your support, RAeS DC has reached 200 members. Electronic payment through PayPal has

WE ARE ON TRACK TO ACCOMPLISH ALL OF OUR 2015 GOALS:

Strengthen the board
Appointed members from major aerospace companies.

Grow membership
Increased membership.

Stabilize finances
Established annual corporate sponsorships in addition to event sponsorships.

Enhance 4HP London relationship
Added RAeS Society Journal content to our newsletter.

Establish a new program committee
Initiated new program committee in March.

Improve communications
Ensured early alerts for programs and launched a newsletter.

Increase event attendance
Delivered more advance promotion.

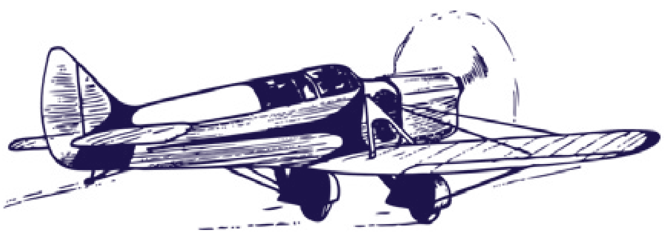
Establish a student membership program
Appointed an aerospace engineering educator as chairman.

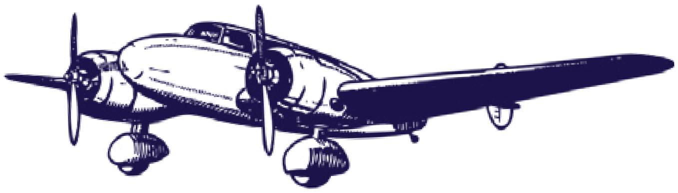
helped to increase our sign-up and renewal rates. We will continue to leverage technology where beneficial. Your input is important.

To serve RAeS DC and its members is a pleasure. Thanks to you, our members, 2015 is stacking up to be a full and interesting year. To our supporters, join us; our membership broadly represents the aviation and aerospace sector.

The board and I look forward to welcoming you September 24, 2015 at the next scheduled event. Please join us at The Boeing Company for a panel discussion & reception on *The Future of Military Technology -- Manned versus Unmanned*, event details on p.23.

Kenneth Gazzola
RAeS Washington, DC Branch Chairman





RAeS Washington, DC Branch Membership

The Washington, DC Branch of RAeS was formally inaugurated on December 17, 2003. This is a momentous date in aviation, as it was the centenary of manned flight by the Wright brothers.

The aims of the branch are to stimulate advances in aviation safety and technology by providing a forum to further improve technical, political and social interchange between the US and UK aerospace communities.

RENEWAL OF WASHINGTON DC BRANCH RAeS MEMBERSHIP

Deadline to Apply:
None

Annual Branch Dues:
$50.00 (25.00 for students)

www.raeswashington.org/membership.htm

BECOME A MEMBER OF RAeS UK, THE SOCIETY'S FLAGSHIP LOCATION

Deadline to Apply:
October 6, 2015

Annual Branch Dues:
Dues vary according to the eight membership options

www.aerosociety.com/Membership

INDUSTRY NEWS FEATURE

ARTICLES FROM *AEROSPACE*, RAeS UK magazine
SUMMER 2015 QUARTER
Featured Industry News from aerosociety.com, *News & Publications*.

PARIS AIR SHOW DAY FOUR AND SUMMARY
JUNE 19. 2015

TIM ROBINSON and BILL READ report from the fourth and final trade day of the 2015 Paris Air Show.

Aerospace giants Airbus and Boeing claimed some $107 billion in orders by the end of the week, with Airbus pipping Boeing by securing commitments for 421 jets, to the US Airframers 331. The Airbus sales were worth $57 billion at list prices, with Boeing's worth $50 billion. Though the total sales of $107 billion were down from the 2013 event where they racked $134 billion in orders, the numbers are still impressive give the seven-year production backlogs and the low expectations for the show. ATR also had a good show, getting orders worth $2 billion by the end of the week, while Embraer announced some $2.6 billion worth of deals in a non-stop single press conference. It was a good week for air cargo, with Boeing announcing 747-8F orders and Airbus relaunching its single-aisle passenger to freighter conversions. Between the stunningly quiet Bombardier CSeries display, the Perlan II project, immersive seats, Pro Line Fusion flight decks, durable coating technology, the Optica, wearable technology, drones, 3D printing and more, the show proved to be one for the books.

DOES THE F-35 REALLY SUCK IN AIR COMBAT?

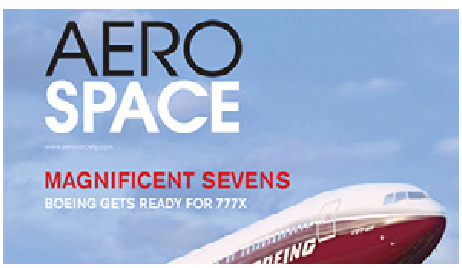
JULY 10, 2015

TIM ROBINSON puts virtual F-35s into perhaps the most accurate non-classified high-fidelity simulation of a future air combat clash. Who comes out on top?

A DECISION AT LAST? DAVIES COMMISSION RECOMMENDS HEATHROW

JULY 3, 2015

On 1 July, the Airports Commission headed by Sir Howard Davies published its long-awaited report into the future direction for the future expansion of London's airports. SIMON WHALLEY, RAeS Head of Policy and Public Affairs, considers the implications of the report and what might happen next.



IN THE LATEST AEROSPACE MAGAZINE - JULY 2015

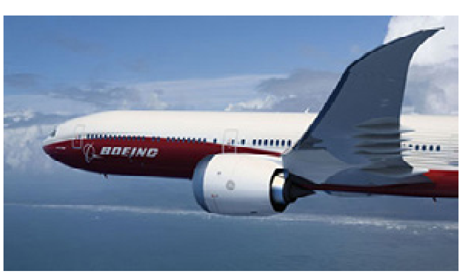
JUNE 26, 2015

In the July 2015 edition of AEROSPACE, the RAeS monthly flagship magazine: Boeing prepares its production process for 777X and 737 MAX, why low-flying fast jet skills are still critical, EBACE report, Europe's 'detect and avoid' UAS project and the importance of regional airports. Plus the usual new...

PARIS AIR SHOW 2015

JUNE 7, 2015

The AEROSPACE magazine team preview the highlights for this year's Paris Air Show, held 15-21 June at Le Bourget.



THE MAGNIFICENT SEVENS

JUNE 4, 2015

Twenty years ago, Boeing's best-selling 777 entered service with United Airlines. As the company prepares to extend this family with the improved 777X, TIM ROBINSON reports from Seattle on the advanced manufacturing changes underway for it and other Boeing airliners.

CLEANING UP SPACE

SARAH CRUDDAS looks at European initiatives to stem the build-up of debris in orbit.

For over half a century humans have been launching satellites and spacecraft into outer space, often without considering what happens to the remaining debris, or how to remove disused satellites from orbit. Today there are millions of tiny pieces of debris orbiting our planet, with around 25,000 larger pieces– such as rocket stages and dead satellites – all from little more than 50 years of space exploration. The rapidly expanding volume of active satellites also adds to the 'junk' already in orbit. Space is becoming crowded. When we first started exploring beyond our atmosphere, it wasn't an issue. In the 50s, 60s and 70s the race for supremacy in space was the priority and a future full of manmade objects orbiting our planet remained lost to the realms of science fiction. Today, space is full; from the heavyweights such as the Russian Federal Space Agency, NASA and ESA, to commercial companies, most nations on Earth now have a satellite in orbit.

But, as we continue to reach for the stars, the crowding of debris around the Earth is becoming problematic. "This is something which has the potential to become very serious, if appropriate action isn't taken," explains Dr. Patrick Harkness, a space systems engineer at the University of Glasgow, who worked on the AEOLDOS (Aerodynamic End Of Life DeOrbit System" CubeSat module with Clyde Space. While the size of much of the space junk may seem small, with satellites orbiting our planet at speeds of 28,000km/hour, collisions with even small fragments can be potentially catastrophic – a collision with an object larger than 1cm will damage or destroy sub-systems or instruments on board and an object larger than 10cm can destroy the whole satellite. There is also the potential for repercussions for life here on Earth, as we become increasingly

SATELLITE OPERATORS IN EUROPE LOSE APPROXIMATELY $152M PER YEAR DUE TO COLLISIONS.

reliant on satellites for everything from communications to weather forecasting. There are more satellites at higher orbits (800-1,000km) that are most at risk than those in lower orbits that are likely to avoid the same amount of debris as it burns up in the atmosphere.

PUSHING UP COSTS

There is also the risk of making missions more expensive for those operating satellites. According to the European Commission, satellite operators in Europe lose approximately $152M per year due to collisions, and that total is predicted to rise to about $228M within the next decade.

"Space junk is also a problem for business," explains Dr. Luca Rossettini, CEO of Italian-based firm D-Orbit, "satellites today are crowded in orbit, so they need to do things to avoid collisions, but every time you perform a maneuver you use up propellant." Although, in the grand scheme of things, one or two maneuvers of a satellite might not seem like a big deal, it is not a decision taken lightly by those operating them. "If you have to keep doing maneuvers, it does have an impact," adds Chris Saunders from SSTL, which makes and operates small satellites. "There have been times when we have had to move spacecraft because of debris." As well as the costs, by doing these maneuvers; you are also losing valuable spacecraft time.

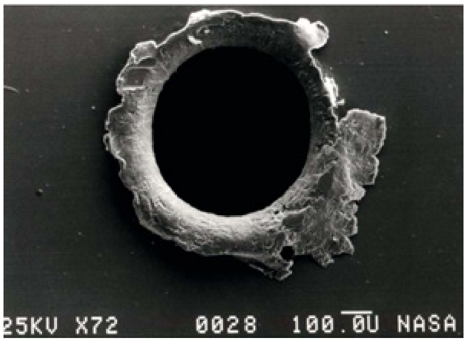
It is not only the satellites we rely on for so many aspects of life on Earth, there is also the risk to space explorers – present and future. The International Space Station has to change its orbit twice a year on average because of debris, a problem glamorized for the big screen in the film Gravity. There is also the threat to deeper space missions. "Any mission to anywhere has to pass through Earth's orbit first, so if Earth becomes an excessively dangerous place to linger, then our access to deep space, for exploration purposes, might be limited in the future too.

REACHING THE TIPPING POINT?

So, although space junk is a serious problem, it is not yet critical. "If we don't do something, it will turn critical," explains Saunders, "the amount of material is reaching a tipping point." The concern is that once you meet a critical mass in orbit, everything begins to collide. "It's an exponential growth," says Alasdair Gow, a Spacecraft Sales Engineer from Clyde Space. "One collision between two objects leads to more shrapnel." Known as Kessler Syndrome, and first proposed by NASA scientist Donald Kessler in 1978, the result is collisions creating more debris. This causes collisions with other objects, creating even more debris. Eventually, through this domino effect, everything is debris and now Earth's orbit is too hazardous for humans or satellites. We are not at that point yet, but this is the situation nobody wants to get to.

IS SPACE DEBRIS REACHING THE TIPPING POINT?

"



THE THREAT. A HOLE CAUSED BY SPACE DEBRIS IN THE PANEL OF NASA'S SOLAR MAX EXPERIMENT.

So how do we stop space from reaching this nightmare scenario? The answer lies as much in legislation as it does in science. The European Commission is committed to the funding of research projects aimed at the monitoring, mitigation and removal of space debris. "A lot of work is being done by Europe into the issue of space debris," says Saunders. With a number of leading technological institutions in the EU, as well as the UN Department for Outer Space Affairs based in Austria, there is the potential for Europe to take the lead in this area. "There are plenty of others investing too but the EU does fund schemes and various national space agencies," adds Harkness.

Besides funding schemes, there are also several strands of work to help reduce the risk from debris, not only to other spacecraft in orbit, but also to the potential damage caused by an uncontrolled re-entry of a large piece of debris.

The first of these initiatives is tracking. Inspired by the fact that we have become increasingly reliant on near space for our everyday lives, in 2013, the European Commission introduced a proposal which was later adopted in April 2014 to help unite member states' space surveillance and tracking (SST) technology. The SST service will, in the future, be accessible to the public, commercial, civil and military operators and authorities. There are also plans for a support program which helps EU Member States combine their capacities, including ground- based radars and telescopes, and offer European SST services. The idea is to make it possible to protect satellites by monitoring and cataloguing their positions; tracking and calculating debris trajectory; and measuring collision risk. It would also mean being able to predict where a large piece of out-of-control space debris could land back on Earth.

CODE OF PRACTICE

Internationally, there is a code of good practice to avoid the unnecessary creation of space debris. The hope is to prevent a repeat of what happened in 2007 when China destroyed its own weather satellite, creating debris, which is claimed later to have hit a small Russian satellite in orbit. Finally, there is a longer-term plan being investigated by the European Space Agency to look at how to remove space debris. "All of this is very important for the space community," explains Rossettini. "We are going through the same steps as we go through with any other industrial sector."

At the moment, the key focus is not to increase the amount of 'junk' in space and later try to handle the existing large amount of debris, which currently orbits our planet. When we first began launching objects into space, there were no standards for space debris and, at the time, with so few satellites, it wasn't really an issue. But, in order to decrease the amount of debris in space, the most important thing is to have standards. The ISO (International Standards Organization) now has standards in place to ensure that satellites are disposed of, so that they minimize the amount of debris.

For higher geostationary orbits there are so-called 'graveyard orbits' satellites can be moved into. For low-Earth orbit, this means that, when a space mission is finished, it needs to re-enter Earth's orbit within 25 years. Aside from the possibility of having left over propellant on board, satellite manufactures have developed systems to get dead satellites out of orbit within the time frame. "We have a deployable drag foil on board the spacecraft, which releases at the end of its life," explains Saunders. "It works by increasing the cross sectional area which causes the satellite to come down within 15-20 years." SSTL's first spacecraft to launch with this was TechDemo-Sat in 2014. "In the future most spacecraft will carry one of these deployable devices," he notes. There is also the possibility of electro dynamic thermo tape, which would be released at the end of the spacecraft's life. The current flows down the tape, interacts with Earth's magnetic field and creates a force that drags down the spacecraft.

MITIGATION TECHNOLOGY

Other European projects to minimize the creation of space debris have a dual purpose. For example, AEOLDOS, developed between the University of Glasgow and Clyde Space, works not only to cause the spacecraft orbit to decay but future systems are being developed to use the pressure of sunlight on the sails to boost the orbit of the spacecraft. This has particular use for CubeSats, which are launched by a robotic arm from the ISS in low-Earth orbit. It will mean they can be taken to a higher orbit but still be able to drag down at the end of their life. The de-orbit system designed by Rossettini uses a solid propellant 'one shot' motor, which can be used not only on new spacecraft before launch, but has the potential to be put on decommissioned craft to take them out of orbit. The other issue of minimizing further debris is that which is created by existing space junk colliding. ISO standards are also in place to try and prevent this happening. "When a spacecraft comes to the end of its life, you need to remove all sources of energy", explains Saunders. There has been the recent case of an old US military weather satellite, which exploded, the most likely cause of which was the battery. "This is something we don't want to risk. There are ways of completely separating the battery at the end of life. You can also put on extra vent and valves to 'empty the tank' so to speak."

Of course, these standards aren't ingrained in law for all satellite manufactures, but Harkness believes they are as good as. "It's something you have got to do. If you don't, you run the risk that a space agency is unlikely to issue a launch license without it." Because of this, countries including France have made the 25-year rule part of their law.

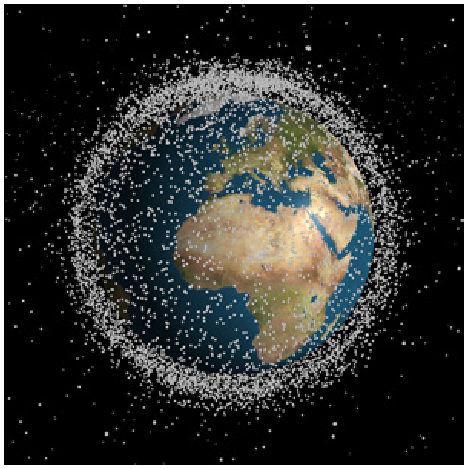
While working to minimize the amount of debris from new missions appears relatively straight-forward, as long as standards are followed, the issue becomes more complicated when you try to address existing debris. "You can't just remove satellites 'willy-nilly'," says Saunders. The problem is that the satellites, which exist in orbit, even if they are no longer in use, are still owned by the government or organization that put them there. This creates a complicated problem with respect to liability. For example, if you were to remove someone else's satellite and something was to go wrong, creating more debris, where would liability lie?

"IF YOU WERE TO REMOVE SOMEONE ELSE'S SATELLITE AND SOMETHING WAS TO GO WRONG, CREATING MORE DEBRIS, WHERE WOULD LIABILITY LIE?

The issue is further complicated with respect to disused military satellites. Would Russia, for example — the worst offender for large space debris — want America removing one of its old spy satellites? The answer, with good reason, is likely to be 'no'. And there is also a fine line between the potential technology to remove debris from orbit, to using that same technology to capture someone else satellite.

ESA

GETTING CLOSER TO DE-ORBIT A SATELLITE WILL PROBABLY INVOLVE PRECISION RANGING SYSTEMS, SUCH AS LIDAR.



What you are left with is the perfect storm of paranoia, risk, money and politics.

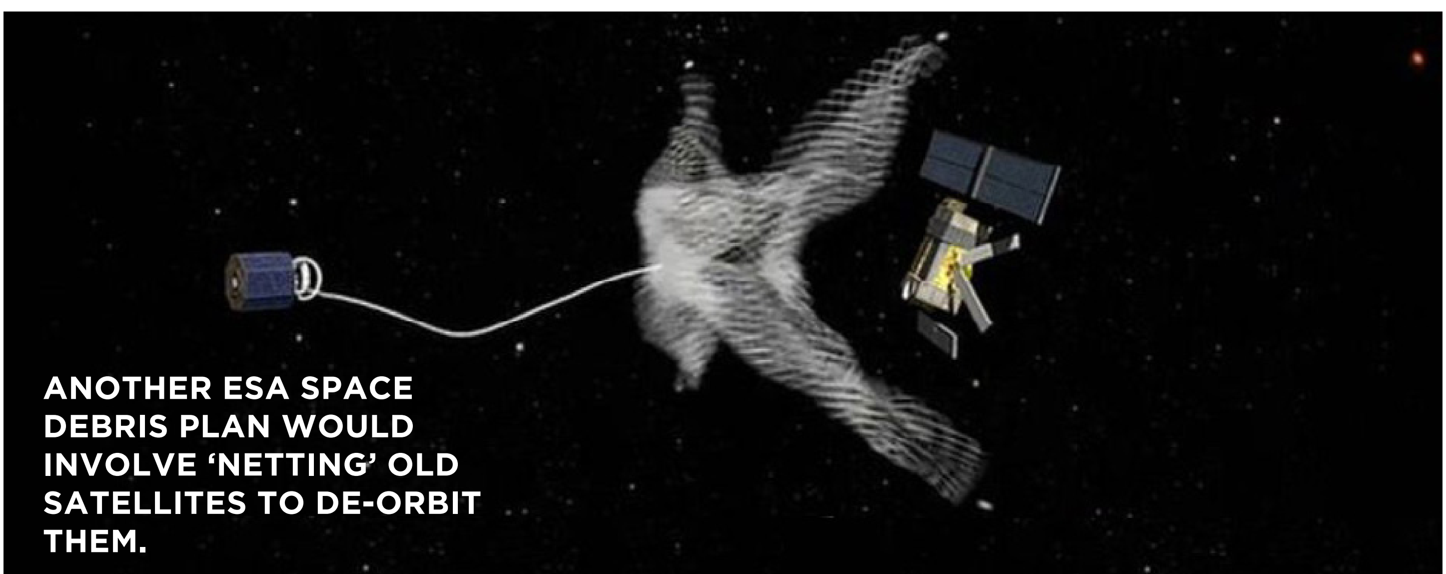
MARITIME SALVAGE A MODEL?

So, it is by no means clear what the final solution will look like, although Harkness believes the thinking is likely to make it similar to maritime salvage law. On top of that, there needs to be a compelling business case for cleaning up space. From a purely technical point of view, the best solution is to pay for a company or organization to get rid of debris from orbit but, at the moment, nobody is offering money to clean up space debris.

Yet despite all of these complications and issues, there are a number of incredible projects that people are coming up with to potentially remove debris from space. “There are projects that seem like sci-fi today,” explains Rossettini. Among the ideas is a pan-European project called CLEANSPACE, which aims to remove small pieces of debris (such as space gloves and screws) using laser illuminations. Swiss Space Systems and EPFL (École Polytechnique Fédérale de Lausanne) are developing the CleanSpace One nanosatallite designed to remove debris from around the Earth. There is also the ESA e.Deorbit mission, to capture debris and remove it from orbit. “Universities and institutions are doing research into grabbing dead satellites and removing them from orbit,” adds Rossettini, everything from space ‘tugboats’ to harpoons are being developed.

But the key to resolving the issue of space debris is about making sure that we don’t get to the point where Kessler Syndrome develops. “We need to act now,” says Rossettini. It might not be as exciting or as sexy as other space missions, but it is critical for space exploration, and the answer lies in legislation. ■

Written by Sarah Cruddas for the June edition of AEROSPACE magazine, a RAeS publication.



ANOTHER ESA SPACE DEBRIS PLAN WOULD INVOLVE ‘NETTING’ OLD SATELLITES TO DE-ORBIT THEM.

YOUR ONLY CONSTRAINT IS WHAT YOU CAN IMAGINE OR WHAT YOU CAN QUALIFY.

Russ Dunn,
Senior VP of Engineering and Technology, GKN

3D PRINTING - ready for take off

BILL READ reports on the 3D printing revolution that has the potential to transform not only aerospace manufacturing and aircraft design but also the MRO and space industries.

Until recently, most metal components for aircraft and aerospace products have been created by cutting large billets down into the required shape — an expensive process that requires both specialist tooling and generates a large amount of waste. However, the past few years have seen the development of new '3D printing' techniques, which have enabled the creation of high-quality, complex aircraft parts in less time and at a lower cost. 3D printing, also known as additive manufacturing (AM), creates three-dimensional products by 'printing' parts layer-by-layer from powdered plastics, aluminum, titanium or stainless steel using computer-aided design (CAD) templates.

The first application of AM techniques in the aerospace industry was the rapid creation of customized, one-off prototype parts. AM techniques have also been adopted to produce tooling parts used in aircraft production — such as templates or jigs — and to produce 'surrogates' which are used as substitutes for high-value assemblies in non-flight applications on the production floor or in training.

However, AM production is now being increasingly adopted by many of the major aerospace OEMs to create parts for aircraft, engines, rockets and satellites. Smaller manufacturers and other organizations are also utilizing 3D printing to construct customized parts for UAVs, while its potential is also being considered for aircraft repairs and the supply of spare parts.

A 3D PRINTED BRACKET FOR THE AIRBUS A350

PRINTED PARTS

AM manufacturing is already being used in aircraft manufacturing. Airbus has begun using 3D printed parts for both new aircraft and replacement parts for out-of-production models. In May it was announced that Airbus had used Stratasys FDM 3D production systems to create over 1,000 flight parts for the first-of-type A350, which was delivered in December 2014. Meanwhile, Bell Helicopter is also working on plans to use AM components in its commercial helicopters and has been working with Harvest Technologies to gain experience through the manufacture of parts for the environmental control system (ECS) before moving on to develop other AM components. Boeing is also already making widespread use of 3D printing for up to 300 parts for ten different aircraft types, including 30 parts in the 787 Dreamliner.

BELL HELICOPTER AM HELICOPTER PARTS

AERO ENGINES

Additive manufacturing has also proved particularly adaptable for the production of aero engine parts with complex geometries, such as fuel systems, guide vanes and turbine blades, which would be either impossible or very expensive using conventional manufacturing. MTU Aero Engines in Germany claims to be one of the first companies to use AM techniques, becoming interested in the technology around 11 years ago. From May 2013, the company began using selective laser melting (SLM) to create borescope bosses for the Pratt & Whitney PurePower PW1100G-JM geared turbofan, which will power the Airbus A320neo. The heat-resistant bosses form part of the

A 3 METRE LONG TITANIUM AIRCRAFT COMPONENT PRINTED BY NORTHWESTERN POLYTECHNICAL UNIVERSITY, CHINA

3D PRINTING ADVANTAGES

- Easy to change designs
- Reduced production times
- Reduced waste Reduce number of parts
- Lower cost of production
- No extra costs for one-off or limited production
- Can be printed on demand where needed
- Can be used to produce complex hybrid parts

3D PRINTING DISADVANTAGES

- Restrictions on size of parts
- Certification issues
- Structural properties not yet fully known
- Slow production rates complex hybrid parts

turbine case and allow the blading to be inspected at specified intervals for wear and damage using a borescope. Production of the borescope bosses was initially in small quantities but is expected to ramp up this year once production of the neo gets fully under way. MTU now plans to use SLM to produce more lightweight components and is currently developing a seal carrier to go inside a high-pressure compressor as part of the European Union's Clean Sky aeronautical research program.

Later this year Rolls-Royce is to flight-test what it claims to be the largest 3D printed aerospace component yet to power an aircraft. Incorporated into its Trent XWB front bearing housing are 48 aerofoils which were manufactured using Arcam's electron beam melting technology, following research performed with the University of Sheffield and the UK's Manufacturing Technology Centre.

In 2012, GE Aviation demonstrated its commitment to 3D printing when it acquired metal additive manufacturer Morris Technologies. At the Farnborough Air Show in July last year, GE announced plans for a $50M investment to begin high-volume additive manufacturing of pre-assembled aero engine fuel nozzles at its facility in Auburn, AL. By the end of 2015, the plant could have as many as ten printing machines with the potential to grow to more than 50 printers. The new nozzles will be used in the new CFM LEAP engine, which will power the re-engineered Airbus A320neo and Boeing 737 MAX, as well as COMAC's C919. GE has also incorporated an AM component for the housing on the T25 sensor in its GE90 engine.

MILITARY APPLICATIONS

AM has also impacted the military sector. Lockheed Martin's F-35 Lightning II reportedly has 900 parts made by AM while Boeing is using around 150 parts produced by selective laser sintering in the F/A-18 Super Hornet. In January, BAE Systems conducted a test flight of a Tornado GR4 fitted with printed metal parts, including a protective cover for the radio, landing-gear guard and air-intake door support struts. The aim of the test was to demonstrate how maintenance crews could make replacement parts for the Tornado wherever it was based, including the front line. As well as being produced quickly, the parts could also be produced more cheaply.

PRINTING SATELLITES

The space sector has also eagerly embraced the potential of 3D printing. In January 2014, US commercial space company SpaceX launched a Falcon 9 rocket with a 3D-printed main oxidizer valve (MOV) body in one of the nine Merlin 1D engines. The launch escape system on SpaceX's Dragon 2 spacecraft also includes a 3D printed engine chamber, which was created in-house in just over three months. Rocket manufacturer ULA has begun using AM to produce parts for its Atlas V rocket while NASA has also tested a rocket engine injector made with a 3D printer.

Airbus Defense and Space utilizes AM titanium retaining brackets on its satellites while Lockheed Martin has started using 3D printed components for its satellites, and plans to expand the process with the ultimate aim of building a complete 3D printed satellite. The two NASA Mars rovers currently operating on the Red Planet included 70 3D-printed parts, including flame-retardant vents and housings, camera mounts and large pod doors.

Practical tests have also begun on printing 3D structures in space. In December 2014, NASA emailed CAD drawings for a socket wrench to astronauts aboard the ISS, who then printed the tool using a 3D printer.

CHINESE PRINT OUT

Other countries are also busy developing the potential of AM in aerospace. In China, the State Key Laboratory of Solidification Processing at the Northwestern Polytechnical University (NPU) began research in 1995 into laser additive manufacturing (LAM) of titanium alloys, superalloys and stainless steel. The lab is equipped with two LAM machines which manufactured a 5m long titanium central wing spar for Comac's C919 narrow body in 2013. According to Chinese aircraft manufacturer AVIC, AM is also being used to produce load-bearing parts, including landing gears, for several Chinese aircraft, including the J-15 fighter. In March 2014, Airbus signed a co-operation agreement with NPU to explore ways to further apply

3D PRINTED METAL MODEL AIRCRAFT (NLR)

3D printing technology in the commercial aviation sector. Under this agreement, NPU is manufacturing test specimens of titanium alloy parts for Airbus using its laser solid forming technology.

UAVS

An aerospace sector in which AM has proved particularly useful has been that of UAVs which, with their customized shapes, smaller sizes, lower production runs and no passenger safety regulations,

THE SOUTHAMPTON UNIVERSITY LASER SINTERED AIRCRAFT (SULSA)

are ideal for such production methods.

Several companies lay claim to the distinction of being the first to produce a 3D printed UAV. US company, SelectTech Geospatial, claims to have produced the first UAV made entirely from AM parts to take-off and land on its gear. In 2012, Southampton University designed a 3D printed UAV, which was developed and flown within a month. The University of Sheffield's Advanced Manufacturing Research Centre (AMRC) Design and Prototyping Group (DPG) conducted a study of self-supporting printed structures for unmanned aerial vehicle (UAV) wing design in which the designers used fractal mathematics to model an internal structure resembling that of an insect wing. The aim was to develop a wing that could be printed by the fused deposition modeling (FDM) process, using acrylonitrile butadiene styrene (ABS) without the need for additional structural material. Lessons learned during this study will be used for future projects within the DPG and were used for the first UAV fixed wing prototype.

PRINT YOUR OWN SPARE PARTS

AN ARCAM Q20 ADDITIVE MANUFACTURING MACHINE AT GKN AEROSPACE, FILTON.

The development of AM techniques has also begun to affect the aircraft maintenance and overhaul (MRO) industry. GKN is currently working on new processes, which will enable the company to use AM techniques at its plants to repair damaged aircraft parts. Currently, MRO companies requiring a replacement part for an aircraft have had to ship it over from a factory or a spares center but there is now the potential in the future to speed up the process by printing out parts where they are needed. Boeing is already looking at this and recently filed a patent application for a 'parts library' for replacement aircraft parts which enable local MRO centers to construct the parts they need instead of having to them shipped over from a central hub.

AM also has potential for producing complex parts for low-volume production runs — such as replacement parts for vintage or out-of-production legacy aircraft.

PRODUCTION RESEARCH

Interest has also begun to focus on the AM production process. In the UK, the newly formed Aerospace Technology Institute (ATI) government and industry partnership and the Technology Strategy Board economic innovation agency — now renamed as Innovate UK is also taking an interest in AM. One of the programs they are backing is a three-year, $3.4M collaborative research program to develop titanium powder specifically formulated and blended to meet the needs of additive manufacturing. Launched in April and led by GKN Aerospace, the TiPOW (Titanium Powder for net-shape component manufacture) program will also look at developing the techniques and equipment that will produce the titanium powder consistently, in quantity and at a lower price, together with its re-use and recycling. Meanwhile, BAE Systems and Cranfield University have also developed the wire arc additive manufacturing (WAAM) method to produce customized titanium parts, including a 1.2m spar section produced in 37 hours.

THE CERTIFICATION CHALLENGE

A major issue now being addressed by aerospace manufacturers is the problem of how to get 3D printed parts to meet the criteria required for certification by the aviation safety regulators. To achieve certification, regulators, such as the Federal Aviation Administration (FAA) in the US and the European Aviation Safety Agency (EASA) in Europe, require that aircraft parts must (a) be established on the basis of experience or tests; (b) conform to approved specifications that ensure that they have the strength and other properties assumed in the design data; and (c) take into account variable conditions in temperature, stress and humidity which may be experienced in service.

Senior VP Engineering and Technology at GKN, Russ Dunn, explains how his company has dealt with the problem: "Once you've made an AM component, the next challenge is to certificate the powder, the part and the process. We've spent a number of years working on both process and part qualification. In part qualification, you are constrained by the function of that part. In process qualification we look at how we can control the way parts are made, including the material they are made from. At the moment we're trying to remove variables and concentrate on one thing. We're currently focusing on replicating titanium parts. As part of the qualification process, we're testing how the strength and capability of AM parts might vary depending on how they are made. With a traditional 'block material' we test a billet and see how strong it is in different directions, both in damage and in static loading. But with a 3D printed part, created from tiny particles

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BOEING RECENTLY FILED A PATENT APPLICATION FOR A PARTS LIBRARY FOR REPLACEMENT AIRCRAFT PARTS WHICH ENABLE LOCAL MRO CENTERS TO CONSTRUCT THE PARTS THEY NEED.

of metal, its properties may differ depending on its microstructure. To test these properties, we are creating what we call 'hedgehogs' — which are blocks with a series of structural rods sticking out at different angles. By testing every single one of these time and time again which enables us to get data sets across the whole build envelope."

STEADY PROGRESS

Russ Dunn explained how GKN sees AM evolving: "We don't want to rush ahead too fast. Our plan is to proceed in steady stages, the first of which is to replicate parts made by traditional methods, which look and operate exactly the same way. We're concentrating on how to maximize the value we're getting from the material by making the most efficient use of the space available. Powder bed machines are getting larger and we're now able to print hundreds of components in one go. Today, there are millions of titanium parts flying around the world. If you can reduce the cost of that by 10%, that's a significant saving. If you can reduce the weight by 10%, that is a major saving for the airlines. "The next stage after this will be to optimize parts with reduced weight and better performance. However, you also have to consider the wider picture of how it may affect the rest of the aircraft structure, such as its loading, segregation, lightning strike, etc. — an issue, which the OEMs are always looking at.

The third stage will be the creation of larger, more complex integrated structures. As far as aerospace is concerned, the pace of development of AM may develop at different rates in different sectors. Engine manufacturers may adopt AM parts faster than say the airframe side, which tends to adopt a more progressive approach."

THE FUTURE IS 3D

In addition to replacing traditional methods of construction, many experts believe that AM techniques offer 'game-changing' opportunities for both production and design techniques. The manufacturing supply chain can be done away with, by manufacturing parts on site closer to where they are needed. "We intend eventually to be able to deploy a blueprint to be manufactured in any part of the world," says Dunn.

Another change is that designers can return to first principles and radically rethink how products can be designed with more complex geometries. "The really exciting capability of AM materials is the ability to create integrated materials which fully optimize their strengths," says Dunn. "Composite parts have proved to be very good for simple load paths while metal components are very capable for more complicated load paths in different directions. Currently, composite parts in aircraft still use traditional fastenings to connect them to metal structures. In the future we expect to see more complex 'organic' structures, which are optimized to provide the best load paths from both materials. Your only constraint is what you can imagine or what you can qualify." ■

Written by Bill Read for the June edition of AEROSPACE magazine, a RAeS publication.

UPCOMING EVENTS

WASHINGTON, DC BRANCH

PANEL DISCUSSION & RECEPTION

The Future of Military Technology – Manned versus Unmanned

Moderator:

• GRAHAM WARWICK (Senior Techology Editor for Aviation Week)

Guest panel speakers to include:

• MARK WILSON (Chief Operating Officer, Rolls-Royce North American Technologies, Inc. (LibertyWorks)

• COLONEL ERIC MATHEWSON (USAF RET.) Former Director, UAS Task Force

• BOB RUSZKOWSKI (Director of Advanced Air Dominance, Unmanned Systems, and Directed Energy Aeronautics Strategy & Business Development at Lockheed Martin Aeronautics Company, Skunk Works).

Event sponsored by

Rockwell Collins

Llywodraeth Cymru
Welsh Government

SEPTEMBER 24, 2015
THE BOEING COMPANY

BATTLE OF BRITAIN 75TH ANNIVERSARY DINNER

Black tie event hosted by the Royal Air Force Museum American Foundation in Conjunction with the British Embassy. Champagne reception.

RAeS Members Tickets $350
Non-Member Tickets $500

The evening will feature the presentation of the Swords of Honor and recognition of the gala guest of honor, Battle of Britain Participant, Wing Commander Thomas Francis "Ginger" Niel, DFC, AFC, AE. Guests include military, diplomatic and industry leaders from the US and the UK. Sponsorship opportunities available. Learn More: http://www.rafmaf.com/2015-gala-dinner.html

OCTOBER 7, 2015
MAYFLOWER HOTEL

PRESENTATION & RECEPTION

The Hubble Space Telescope: Past Successes and a Look to the Future

A presentation to celebrate the 25th anniversary of the Hubble Telescope and look ahead to the James Webb Space Telescope and to future telescopes beyond JWST.

Speaker:

• DR. MATT MOUNTAIN (President of the Association of Universities for Research in Astronomy).

NOVEMBER 12, 2015
BRITISH EMBASSY

MEET RAeS

A MESSAGE FROM RAeS UK PRESIDENT, MARTIN BROADHURST

It is a great honor to have been elected as your President for the next year and I am looking forward to a busy and exciting time. Firstly I must thank Bill Tyack for his tireless efforts over the past year and praise him for the leadership he has shown. I have a hard act to follow.

I am pleased to say that my Presidency coincides with a period that sees the Society in very good heart. It is clear from the attendance at this year's banquet that we continue to enjoy support at the highest levels of government, industry and academia. It is also clear from the breadth and quality of our output and events at national and branch level that we are delivering strongly as a vibrant learned society and I have taken it as one of the challenges for my Presidential year to continue to improve our use of digital media to ensure that the vast range of content is made available even more widely.

Over the course of the past year, I have been working with Council and staff colleagues to review our strategy and in writing my first piece for AEROSPACE I wanted to reflect on one aspect of the Society's purpose as embodied in our 'strap line' which runs:

"We are the world's only learned society dedicated to the entire aerospace community."

This is important — we are not purely a society of engineers and aviators, although, of course, both those groups are immensely important. Our remit runs across a huge range of activity as evidenced by our 24 Specialist Groups encompassing, among many others — air law, air power, air medicine, air traffic, space, unmanned systems and weapon systems. In other words, the whole of the wider community with a connection to aerospace and aviation.

Despite this broad appeal our recruitment of younger members is not as successful as we would like. We need to find new ways of connecting with the under 30s. Not just the engineers seeking chartered status but the buyers, the contract staff, the facilities people and many other disciplines. They are all equally part of our aerospace and aviation community and should share in the peer recognition that membership brings, but more importantly be enjoined in the ethos of professionalism so well promoted by the Society.

During my year the Society will major on unmanned systems and this will be the subject of the President's Conference in October this year. Apart from the normal focus on platforms we will seek to engage with partners in the tech sector to develop a deeper understanding of applications and will encourage debate around some of the ethical and societal challenges along with the implications for

WE ARE NOT PURELY A SOCIETY OF ENGINEERS AND AVIATORS, ALTHOUGH, OF COURSE, BOTH THOSE GROUPS ARE IMMENSELY IMPORTANT.

Martin Broadhurst

MARTIN BROADHURST OBE MA CDIR FRAES FIOD RAeS PRESIDENT

Martin Broadhurst was educated at William Hulme's School and Fitzwilliam College, Cambridge. He joined Marshall Aerospace as a Management Trainee in 1975 and following a number of roles with the company, including Production Director and Director of Programs, was appointed as Chief Executive in February 1996. During his time as Chief Executive he served on the Group Holdings Board.

Following his retirement from his role as Chief Executive of Marshall Aerospace, he was appointed, during the early part of 2011, as Chairman of the Centre for Engineering and Manufacturing Excellence (CEME) and was elected to the Governing Council of the Royal Aeronautical Society and served as Chairman of the Membership Services Board. Martin is also Vice President of the Cambridge Branch of the Society.

Martin was appointed as a non-executive director of Ultra Electronics Holdings plc in July 2012 where he serves on the audit, remuneration and nomination committees of the board.

Martin has served as a member of the European Aerospace and Defense (ADS) Customer Services Commission and is a former treasurer of A|D|S. He has also served as Chairman of the Cambridgeshire Training and Enterprise Council and as Chairman of Connexions. Martin was awarded the OBE in the 2004 Queen's Birthday Honors List for services to the Aerospace Industry and is a Freeman of the City of London. He qualified as a Chartered Director in 2006.

traditional professions and skills.

The Society and the disciplines it represents may be 150 years old but here has never been a more exciting or challenging time to play our part in contributing to the security and prosperity of the world in which we live.
I look forward to meeting as many of you as possible during the next 12 months. ■

Written by Martin Broadhurst, RAeS President

ROYAL AERONAUTICAL SOCIETY
2016 • CELEBRATING 150 YEARS

RAeS Quarterly

WINTER QUARTER January - March
SPRING QUARTER April - June
SUMMER QUARTER July - September
FALL QUARTER October - December

LEXI KAROLYI
RAeS Quarterly Content Coordinator
lkarolyi@xenophonstrategies.com

QUENTIN WHITEREE
RAeS Washington DC Branch Secretary
qwhiteree@ideea.com

DAVID WILLIAMS
RAeS Washington DC Branch Membership Coordinator
david-l.williams@airbus.com

xenophon STRATEGIES

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