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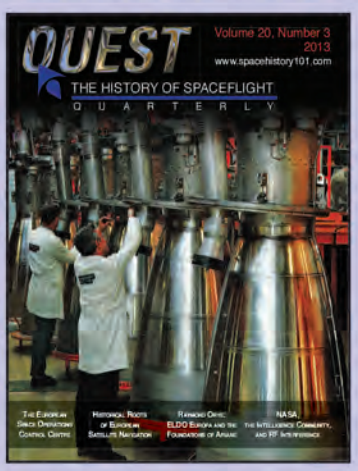

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Regular Features

Cover image: *John and Anna Glenn, a life lived in devotion to each other and dedicated to the service of country and high ideals. See pages 44-47.* *NASA*

"God Speed John Glenn"

The builder of bridges

The Mercury Atlas stack stands ready for launch at Pad 14, Cape Canaveral Air Force Station. NASA

With the passing of John H. Glenn Jr, NASA has lost the only man to fly aboard both the Mercury capsule and the Shuttle spacecraft, America has lost its first astronaut to orbit the Earth and the world has lost one of the most iconic and popular figures in the history of the Space Race.

Yet the name of John Herschel Glenn was heard across America long before the events which catapulted him to international fame. As an aviator he had fought in two wars and taken the science of flight into the engineering of a new age, with contributions as a test pilot and national fame for breaking records. All in a single lifetime and all for a love of the challenge.

Born on 18 July 1921 in Cambridge, Ohio, John Glenn was raised in New Concord and obtained a flying licence for a credit in a physics course at Muskingum College during 1941, funded by the government under the Civilian Pilot Training Programme. Before he could graduate with a Bachelor degree in Science, America entered the Second World War and John Glenn left college to enlist. His choice was the Army Air Force but they failed to call him up so in March 1942 he enlisted as a naval aviation cadet instead.

Glenn re-learned the art of flying the military way at Naval Air Station Corpus Christi and, after a spell flying R4D transport aircraft, in 1943 he joined VMF-155 flying Vought F4U Corsair fighters, a unit just converting to carrier operations with the *USS Nassau*, the first Marine Corps aviation unit to operate in the Pacific, supporting the relief of Attu in the Aleutian Islands. Further training took them to El Centro for additional training and from there to Midway Atoll to protect the garrison. Glenn saw combat over the Marshall Islands before the end of the war. After the Japanese surrender he joined VMF-218 and flew patrols in North China before returning to the US, becoming a flight instructor at Corpus Christi in 1948.

A superb combat pilot, Glenn went to Korea after the communist invasion of the North,

John and Anna Glenn in 1965, a year after he left NASA. NASA

flying Grumman F9F Cougar jet fighters on 63 missions. After a brief turnaround he was seconded to the US Air Force flying North American F-86F Sabre fighters with the 51st Fighter Wing where he downed three Russian MiG-15s over the notorious Yalu River sector shortly before the armistice in 1953. For his 149 combat missions in two wars, Glenn received the Distinguished Flying Cross six times and the Air Medal with 18 stars.

Glenn moved to NAS Patuxent River and graduated from the Naval Test Pilot School in 1954, carrying out many test flights evaluating the effectiveness and efficiency of various armaments at high altitude and high speed. His talents becoming very clear, he was assigned to the Fighter Design Branch at the Navy Bureau of Aeronautics testing Navy and Marine Corps jet combat aircraft between November 1956 and April 1959, attending the University of Maryland, pushing his log book to more than 9,000 flying hours.

Glenn was fascinated with speed and the ability to redefine the boundaries accepted by aircraft designers and weapons engineers providing offensive and defensive equipment for increasingly complex and more capable combat aircraft. On 16 July 1957 he fulfilled an ambition to become the first man to fly across America coast-to-coast at an average speed above Mach 1 – the speed of sound.

Flying from Los Alamitos, California, to

Floyd Bennett Field, New York, he covered the distance in 3 hr 23 min 8.3 sec at an average speed of 1,235 km/hr. The LTV F8U-3P was a souped-up version of the F-8 Crusader, boosted to compete against the McDonnell F-4 Phantom II for a Navy contract. Glenn told his friends about the attempt and that he would be flying over the neighbourhood that day. When the supersonic Glenn streaked by and planted sonic booms on the quiet streets a little boy ran around the block shouting "Johnny's dropped a bomb, Johnny's dropped a bomb!"

A change of pace

Named Project Bullet, the supersonic cross-country flight required three in-flight refuelling operations conducted below 480 km/hr but the publicity made him a household name with appearances on TV shows and sofa-chats with national presenters. With a home-brushed appearance and a winsome smile, Glenn was the perfect poster-boy for the military, showing the "ordinary" face of the American military man doing extraordinary things for a country riding high on a wave of global influence.

The flight allowed Glenn to complete the first continuous transcontinental panorama and this was used to publicise the expanding capabilities of the US military, a time of major expansion with the development of a hemispheric strategic bombing force and the imminent availability of very long range ballistic missiles carrying the new generation of thermonuclear weapons eclipsing in explosive yield the atomic weapons of the 1940s. Into this world strode John Glenn with seven league boots, confidently projecting air power to the outer reaches of the atmosphere.

And it was the thought of carrying winged flight to space that gripped him in that single year of change when the Russians would steal a march and put Sputnik 1 in orbit. He read everything he could get his hands on relating to space flight, boned up on the Air Force Dyna-Soar boost-glide strike system, capable of arching out into the blackness of space and slicing back down into the atmosphere, deploying its weapons and landing back where it started from having circumnavigated the world.

So it was with a quiet confidence in the man that Glenn was selected to participate in high-g tests in a centrifuge at the Johnsville Naval Air Development Center, Pennsylvania. At the time the world's largest centrifuge, it would impose loads of up to 16g on the human body. Aware of the request from the National Advisory Committee for Aeronautics, the forerunner of NASA, for a test pilot to carry out these strenuous physical tests, Glenn made sure he was the one they chose to go.

Each astronaut named their Mercury spacecraft with a suffix "7" to signify the seven in their number. Glenn chose "Friendship" as the name of spacecraft 13. *NASA*

After reporting to Langley Aeronautical Laboratory, Glenn went along to Johnsville and became familiar with the requirements for the Air Force Man-In-Space-Soonest (MISS), a capsule fired by an adapted ballistic missile to evaluate the physiological reactions of a man to the rigours of space flight prior to the ballistic and orbital flight of the Dyna-Soar boost glide vehicle. When the MISS concept was handed over to NASA after it formed in October 1958, the new space agency selected the name Mercury for the MISS capsule.

In January 1959 when NASA began a recruiting programme for Mercury pilots Glenn was fully resolved to apply and to fend off any negative aspects of his application. He was almost 38 years of age and right at the top of the specified age range and he lacked the recommended science degree. But the paper requirements list was there only to weed out clearly unsuitable applicants; the real tests were related to physiological and psychological rigour – these were, after all, the reasons why the MISS capsule had been proposed by the Air Force.

From 508 applicants NASA aimed to select six pilots as its first astronauts but the choice was so close that they elected to employ seven, one of whom was John Glenn. Each man had a specific area of responsibility and Glenn was to handle cockpit design, the ergonomics of instrument layout, the location of displays and the placement of control functions in the cramped cockpit. Glenn spent time at McDonnell, the spacecraft contractor, and worked with the design engineers on those aspects of the capsule.

Among the other six, Glenn stood out as a clean-living, calm and responsible individual marked out from the beginning for his professionalism and experience. Quite quickly the public furore that broke over the announcement of America's first spacemen exceeded expectations and a new public

John Glenn works out on the ergometer during the STS-95 mission in 1998. *NASA*

relations programme was set up to sate the national appetite for news stories. The great emphasis on family life and loyalty to cause and country, defining pillars of civil life that populated the common psyche in the late 1950s, required the astronauts to be the ultimate embodiment of those ideals.

But it didn't turn out that way as the seven men became more famous than pop stars and the attractions of a neo-showbiz frenzy accompanied them whenever they were relaxing or simply having fun. And it was there that the seven men began to show different personalities, different scales of acceptable behaviour and varied reactions to approaches from fun-loving girls and party-goers.

As military pilots, several of the astronauts took advantage of opportunities that challenged their public affirmation of faith and family. Travel between manufacturers, test sites, space facilities and launch pads dictated that they were frequently away living lives that brought challenges for wives, families and homely pursuits. As young, energetic and highly motivated individuals there was a powder-keg lifestyle more acceptable in that age than would ever be tolerated among today's astronauts.

But John Glenn was different: fun-loving to be sure, and at times a prankster, but always stable, balanced and known to be the first to slip away from a party and call his wife and children. John had married his childhood sweetheart, Anna Margaret Castor, a year younger than he, in 1943. They would remain a devoted couple throughout their lives together and his love for her showed in so many ways. Quite early in the programme, NASA management had singled Glenn out as a new poster-boy, that of the all-American hero.

When flight assignments were announced, three men were selected but the specific order in which they would fly was held back from the public until very close to the launch itself. But the order surprised no one. Alan Shepard and Gus Grissom would fly the two suborbital ballistic flights and John Glenn would serve as back-up to both, flying the first manned orbital flight.

The final frontier

And so it was that he became the first American astronaut to orbit the Earth, on 20 February 1962. Iconic in its significance, the moment of launch was full of the drama reminiscent of text summoned up by an over-eager Hollywood script writer. Except this was no fictional drama, the emotion was real, as a steady voice said over the countdown, noting the final seconds to lift-off: "God speed John Glenn". And Friendship 7 was away on its historic flight, less than nine months after President John F. Kennedy had stood before a Joint Session of Congress and laid down the challenge: "I believe that this nation should commit itself to achieving the goal, before the decade is out, of landing a man on the Moon and returning him safely to the Earth".

Life magazine ran stories on the astronauts through an exclusive deal which prevented other news agencies prying into their personal lives. *Life*

Glenn's flight was followed by three more Mercury missions, each taken by a separate astronaut. Only four of the original seven would make a second flight and one – Deke Slayton – would wait until 1975 to make his first flight during the Apollo-Soyuz Test Project while Grissom would die in the Apollo fire of 1967 (see pages 54-58) and Shepard would command the Apollo 14 Moon landing in 1971.

But for John Glenn there was seemingly no way back to space. He retired from NASA in January 1964 resolved to enter politics. But a slip of the foot and a fall which induced concussion delayed that entry until 1974 after a stint in business. The next two decades were to see Glenn pursue a busy life campaigning for the legal rights of the ordinary citizen. Glenn was adamant that his role in the Senate was to serve the people, even if he never met individuals who would benefit from legislation he supported.

Persistently, Glenn regretted missed opportunities and lost experiences he might have nurtured had his career as an astronaut not lasted less than five short years, providing only one three-orbit flight. Never far away from the NASA leadership, he began to lobby for the chance to fly as a Payload Specialist on the Shuttle. But events dictated that he was to face a bigger challenge getting back into space than he had the first time around.

After the Challenger disaster there had been a diktat that private citizens were not to fly in such a risky vehicle again. Senators Bill Nelson and Jake Garn had flown aboard the Shuttle before the loss of Challenger in January 1986 but the new rules seemed clear. Something else was needed, that being the vital medical information he could provide. For John Glenn to fly again into space would not only realise a dream but also provide a link between two very different ages of space travel, separated by several decades of human achievement and performance by both male and female astronauts.

NASA Administrator Daniel S. Goldin needed little convincing: "Not only is John Glenn a Marine test pilot, an astronaut, and the first American to orbit the Earth, he brings a unique blend of experience to NASA", said Goldin. "He has flight, operational, and policy

experience. Unlike most astronauts, he never got the opportunity for a second flight. He is part of the NASA family, an American hero, and he has the right stuff for this mission."

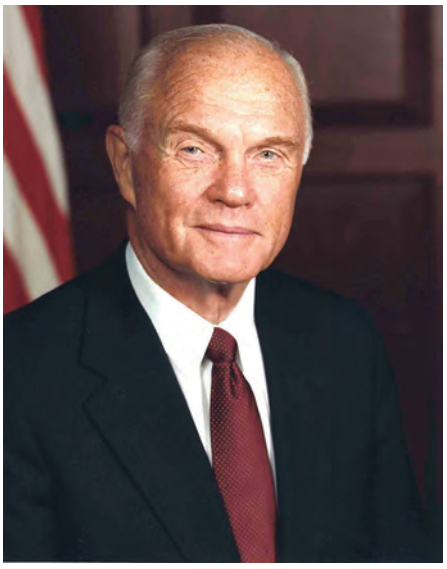
But John Glenn had been used to bridging gaps: overseeing the transition of combat flight from the subsonic to the supersonic era, and of starting the process of moving from winged flight within the atmosphere to orbital flight in space. Now he was about to do it again, bridging the era of one-shot missions to permanent habitation aboard an international space facility – for this was the year assembly of the International Space Station would begin.

But there was a more fundamental bridge Glenn was building with his flight aboard STS-95. Physiological research into the reaction of the human body in space revealed that astronauts quickly acquire all the symptoms of rapid ageing, only slowly returning to their pre-flight condition. At 77 years, John Glenn was the perfect choice for a variation on that, his flight being a little too short to see real change. But he could serve to provide a yardstick on basic physiological performance across two distinct phases of a human life, separated by almost 37 years.

"The research on this mission will contribute to building our knowledge and understanding of the ageing process", said Dr. Richard Hodes, director of the National Institute on Aging. "The data collected will be used to conduct continued research on how aging affects sleep cycles, muscle deterioration, and balance."

Dr. Michael DeBakey, Chancellor Emeritus of Baylor Medical College, who reviewed the medical data on Glenn, said he sees "no evidence to prevent him from going into space. Flying Senator Glenn offers important opportunities to study the effects of the space environment on aging systems as has never been done in the past".

Senator John Glenn, 24 years representing the State of Ohio. *US Congress*



Quincy Jones, John Glenn and Neil Armstrong during NASA's 50th anniversary gala in 2008. *NASA*

Dr. Robert Butler, professor of Geriatrics at Mount Sinai Medical Center, director of the International Longevity Center, agreed. "It serves both science and a better understanding of what human beings of all ages will experience as we enter the next century to have an older person included on a space flight," said Butler, one of the nation's foremost gerontologists.

NASA had previously flown astronauts up to 61 years old. At least eight crew members over the age of 55 had flown multiple missions. Shannon Lucid was 54 when she spent six months aboard the Russian space station Mir. Before NASA made the decision to fly Glenn, the senator underwent a battery of medical tests conducted by NASA physicians and by independent consultants. They all found him medically qualified for space flight. According to NASA flight surgeons, Glenn's fitness level was excellent.

So John Glenn went back to space aboard Shuttle Discovery on STS-95 launched on 29 October 1998 and spent more than eight days in orbit. During his Mercury flight the citizens of Perth, Australia, had switched their lights on as he passed over their city in the blackness of space. Glenn never forgot their gesture on that lonesome flight in 1962 and in the intervening years had frequently sent messages of goodwill to its citizens. They did so again for STS-95, lighting the ground below.

John Glenn always stood for correctness in high places. As ranking minority member of a committee examining the backdoor influence of China, accused of making clandestine donations to the Democratic Party to influence the Presidential elections of 1996, Glenn had many feisty moments. "*Chinagate*" would taint the Clinton/Gore ticket for years to come and uncover illegal interventions by that country in directing foreign funds to the Democratic National Convention to prevent a Republican presidency.

But that was just one of the many battles fought by Glenn as he struggled against opponents in Congress, never letting up on his determination to rout out corruption and pork-barrel politics. This was the true measure of John Glenn. A Cold War soldier on the frontier of an ideological divide, he adapted his stoic resolve and deep commitment to fair play. This helped many people he never met and eased the burden of the disposed in the bills he supported and the charitable and ethical approach to politics that kept him in Congress for just over 24 years.

John Glenn retired from the Senate in January 1999 and received numerous awards and honours from NASA, other government organisations, academia and foreign governments. He spent the last few years reigniting interest in the space programme among those who had no memory of his historic mission, sharing as he always had, with those less fortunate than he.

John Glenn was one of the truly outstanding human beings that gave much for so many others and he will be remembered by many not for his experiences as an astronaut but for his humanity – and that is probably the greatest legacy of all.

John Glenn died on 8 December 2016 at the James Cancer Hospital in Columbus, Ohio, his body interred at Arlington National Cemetery. He is survived by his wife and their children and grandchildren. "God speed John Glenn."

ISS Report

16 November – 8 December 2016

By George Spiteri

The orbital outpost is now manned by Shane Kimbrough, Andrey Borisenko, Sergey Ryzhikov, Oleg Novitskiy, Peggy Whitson and Thomas Pesquet.

On 16 November, Kimbrough transferred cargo from the Cygnus vehicle and two days later configured the vehicle for release. Borisenko and Ryzhikov continued to record their food and medical intake as part of the Russian Morze hormone and immune experiment. The crew also completed their weekly questionnaire for NASA's Interactions study.

Soyuz MS-03/49S was launched from Baikonur's Site 1 at 20:20 UTC on 17 November (02:20 18 November local time) carrying Oleg Novitskiy (45) on his second spaceflight, NASA biochemist Peggy Whitson (56) on her third mission and French aerospace engineer Thomas Pesquet (38) a space rookie. Before launch Whitson joked that she hoped the new upgraded Soyuz variant "would be bigger" and Novitskiy said they would test both the "thrusters and telemetry between the vehicle and the ground" during the 34 orbit trip to the station.

Soyuz docked to the Rassvet module at 21:58 UTC on 19 November, 404km above the north east coast of Brazil. Following leak checks the hatch to Soyuz was opened at 00:40 UTC on 20 November and the new arrivals floated into the station, returning it to a six person complement. The crew made their way to Zvezda and spoke to family, friends and officials. Pesquet described the ISS as "amazing, better than in my dreams" in one of his first tweets from orbit and added that he wished "everybody could get the chance to come up here!"

Farewell Cygnus

With Kimbrough at the controls of Canadarm2 and Pesquet backing him up inside the Cupola, Orbital ATK's Cygnus CRS-5 was released from the robotic arm at 13:22 UTC on 21 November over the west coast of Colombia. Earlier, with the arm still attached, Cygnus had been detached from the Earth-facing port of Unity loaded with 1,120kg of unwanted items. Five hours after being released from the ISS, Cygnus began six days of scientific and flammability experiments, including NASA's Saffire-II space combustion study, which was the second in a series of three experiments to examine the behaviour of a fire's flame growth and oxygen use aboard a spacecraft.

The cargo ship also deployed four Lemur-2 CubeSats on 25 November, sending them to join a remote sensing satellite constellation to provide global ship tracking and weather forecasting. Cygnus fired its engines twice on 27 November to take it out of orbit and re-entered the atmosphere to burn up over the Pacific Ocean, east of New Zealand.

Whitson and Pesquet spent several hours repairing the Waste and Hygiene Compartment (WHC) on 22 November, replacing several components after a leak was detected. Ryzhikov collected blood and saliva samples for NASA's Fluid Shifts experiment and his Russian colleagues worked with the Korrektsiya study, which examines the loss of bone mass during space flight.

The crew collected breath samples on 23 November to help doctors understand how living in space affects bone marrow and blood cells. A new device that indirectly measures an astronaut's intracranial pressure was checked out, while the crew also carried out a retinue of eye exams. Pesquet took time out to answer questions from French journalists and told them he was adapting quickly to weightlessness but felt a bit swollen and compared his first week in orbit "like an unbelievable business trip".

Thanksgiving Day on 24 November gave Kimbrough the opportunity to describe to TV viewers how his crew celebrated with turkey heated up "in a pouch" candy yams, cornbread dressing, fresh green beans, mushrooms,

Background picture: security guards accompany the rollout of Soyuz MS-03 assigned to carrying Expedition crewmembers to the ISS. ***NASA***

mash potatoes, cherry blueberry pie cobbler and sweet tea with lemon. He added that the day wouldn't be complete without American football and Houston relayed some "live football games for us to watch".

Before their dinner, the crew worked on science experiments, Kimbrough installed a new centrifuge in the Cell Biology Experiment Facility. Whitson and Ryzhikov performed ultrasound scans for the Fluid Shifts study, Borisenko and Novitskiy unloaded items from Soyuz and replaced a control panel inside Zvezda, while Pesquet took part in NASA's Story Time From Space project, which involved reading aloud on camera a children's story book about the space adventures of Max the dog.

On 25 November the crew worked with the Cardiovector medical experiment and returned to the Korrektsiya study, while also conducting further Fine Motor Skills research using a touchscreen tablet to perform various interactive tasks.

The crew enjoyed a regular light-duty weekend 26/27 November with the usual housekeeping chores, talking to family and friends and planning for the week ahead.

NASA announced on 28 November that its RapidScat scatterometer mounted outside the Columbus module to track winds over the world's oceans ended its mission due to a technical glitch on 19 August (*Spaceflight,* Vol 58 No 11 pp 409- 410). Ground controllers tried unsuccessfully to reactivate RapidScat but one of the outlets on the power distribution unit experienced an overload. Plans call for it to be placed inside the trunk of a future Dragon vehicle for disposal.

On 29 November Whitson installed NASA's Aerosol Samplers experiment, which aims to collect airborne particles for analysis. Scientists will study the samples using specialised techniques with powerful microscopes. Kimbrough set up JAXA's Marangoni physics study inside Kibo and Pesquet worked with ESA's Sarcolab muscle atrophy experiment and the Russian crewmen worked with several bio-medical experiments including the DAN study.

Kimbrough conducted further work with the Marangoni experiment on 30 November and took his turn reading Story Time From Space. He later partnered Whitson for a series of eye tests, while Pesquet continued with the Sarcolab study and set up ESA's Muscle Atrophy Research and Exercise System (MARES) hardware, tweeting "What a machine!" Borisenko, Ryzhikov and Novitskiy worked with the Russian Vzaimodeistviye-2 experiment, which is similar to the Interactions study and the Otklik experiment which records the impact of particles on the station's exterior.

No Progress

Progress MS-04/65P was launched from at 14:51 UTC on 1 December (20:41 local time). Initially, the launch went well but the third stage RD-0110 engine of the Soyuz-U rocket shut down early causing the spacecraft to separate and burn up in the Earth's atmosphere. Controllers lost contact with Progress at approximately T+6 min 22 sec. Russian Academician Alexander Zheleznyakov said the crew had supplies for 4-6 months.

This was the third failure by a Progress, the first occurring in 2011 (*Spaceflight*, Vol 53 No 11 pp 424-427) and one in 2015 (*Spaceflight*, Vol 57 No 7 p 253).

The international crewmembers (American, Russian and French) of Expedition 50 enjoy Thanksgiving dinner with rehydrated turkey and vegetables. *NASA*

Progress was carrying 2,442 kg of supplies including the first of a new generation of the Russian Orlan EVA suit and the Lada-2 greenhouse which would have attempted to grow wheat, sweet pepper and salad in orbit.

NASA reported that the crew had completed 70 hours of scientific research the week ending 2 December, including the completion of the first round of harvesting six red romaine lettuce plants as part of NASA's Veggie experiment which Kimbrough initiated 25 October (*Spaceflight*, Vol 59 No 1 p 9). Project Manager Nicole Dufour said that at one stage the plants were getting too much water "but they recovered nicely after we instructed Kimbrough to use a fan to dry up the moisture". The harvest is solely for crew consumption with plans to have four harvests in total, the yield from those split between crew consumption and samples for scientific return.

The crew had another light-duty weekend 3/4December. On 5 December, Kimbrough scrubbed the cooling loops on two US EMU suits 3003 and 3008 while Pesquet assisted Whitson with ultrasound scans for NASA's Cardio Ox experiment, which explores the long term risks of atherosclerosis in astronauts. Whitson later helped Ryzhikov with the Fluid Shifts study and Borisenko and Novisky conducted maintenance in the Russian segment and worked on several science experiments.

The following day Kimbrough and Pesquet began several days of practicing robotic techniques for the imminent arrival of Japan's unmanned Kounotori-6 (White Stork-6) cargo vehicle. Pesquet later spoke with the French Science Minister Thierry Mandon and answered questions from French students; Whitson, Borisenko and Ryzhikov conducted further ultrasound scans for the Fluid Shifts experiment which was continued the following day while Novitskiy focused on the Russian Sreda-MKS study, which measures how activities on the ISS affect its magnetic field and microgravity environment.

On 8 December Kimbrough set up gear and ran tests for NASA's Capillary Flow Experiment-2 to study how liquids such as fuel and water behave in microgravity. Pesquet scanned his neck, thigh and heart with an ultrasound for Canada's Vascular Echo experiment and later donned ESA's Everywear "smart shirt" which collects biomedical data for a wide variety of experiments. Whitson worked through the day relocating fluid gear and refilling coolant in all the modules and Novitskiy and Ryzhikov worked with the Russian Biocard medical study and Borisenko researched ways to improve his skills with the Pilot-T experiment.

Briefing notes

- Michael Jones, founder of **Google Earth**, is helping Seraphim manage a global space investment fund which it plans to raise to £80 million for investing in new opportunities with innovative space applications. Increasingly, expansion of opportunity in the space industry is about growing the applications which attach to existing or future satellite projects. The Seraphim initiative has £30 million from the British Business Bank to help support the UK drive to triple the size of the UK space industry to £40 billion by 2030. The UK government is strongly behind the work to increase the size of the British space industry and the Seraphim investment opportunity will go a long way to encouraging start-ups and small companies to diversify in the way they use satellite data today.

- Engineers at the European Space Agency are narrowing the fault-tree in data analysis of why the **Schiaparelli** lander failed to touch down safely on the surface after a successfully surviving entry into the Mars atmosphere on 19 October 2016. Immediately after parachute deployment, which came at an altitude of 12 km and a speed of 1,730 km/hr, the Inertial Measurement Unit (IMU) reached saturation point and remained so for a full second. This is the zone where the IMU was measuring rotation rates and under the greatest information load and when this information was fed to the navigation system the data indicated that the spacecraft was below surface level. This triggered premature release of the parachute and the back-shell followed immediately by firing of the thrusters, but for three seconds instead of the planned 60 seconds. The heat shield had been released at 7.8 km and the "landed" indication shut down all systems with Schiaparelli at a height of 3.7 km. Computer simulations have duplicated this sequence. An independent review board will examine the evidence and report shortly. The ExoMars lander is due for launch in July 2020.

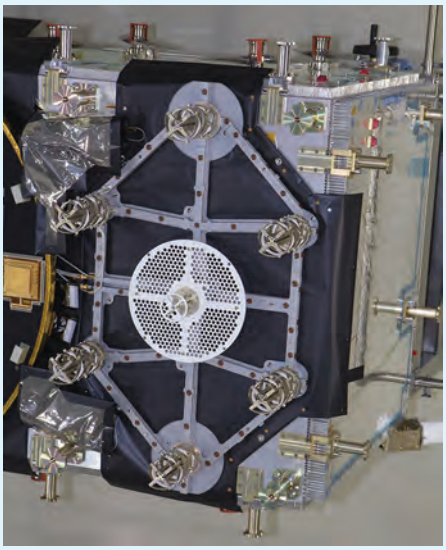
- In a manufacturer's tussle with an unwelcome competitor reminiscent of the Soviet era, another communist country has a fight on its hands as **China's** two rocket giants struggle for supremacy. Casic is making fast progress with a solid propellant competitor to the Long March 6

First launched in 2015, China's Long March 6 seen here is being challenged by the KZ-11 from Casic. *China Daily*

built by CASC (China Aerospace Science and Technology Corporation) and its new KZ-11 launcher is challenging the market lead. The KZ-11 will be capable of placing 1 tonne in a 700 km Sun-synchronous orbit, the same as Long March 6. The solid propellant KZ-11 is more adaptable and can be launched in a rapid-response mode such as that which might be required in response to major natural disaster to obtain survey images from a dedicated satellite. But the military is also interested in its potential for replacing neutralised satellites in the event of a conflict.

- Technically not yet fully operational, the European **Galileo** system is being declared up and running in its search-and-rescue (SAR) role, despite the full complement not yet in place. But the element responsible for the SAR service

The small hexagonal antenna in the centre of the Galileo platform is responsible for the Meosar emergency location system. *OHB System*



was completely independent of the payload on the bus supporting the global navigation satellite service (GNSS). Dubbed Meosar, the Galileo emergency rescue system utilises Doppler positioning to fix a distress beacon and can reduce the location time from 45 minutes and a precision radius of 5km, to 30 seconds for the same radius, five minutes for 1 km and 30 minutes for 100 m. Operating on 406 MHz, the new beacons which will be in place in 2019 will provide a five minute detection time for a 100 m radius.

- Elon Musk has filed for permission to launch 4,425 small Ka/Ku-band satellites over the next 10 years to provide **broadband services** for sustained coverage worldwide. The SpaceX founder and CEO has been studying the idea for two years and believes it will take 12-15 years to realise at an estimated cost of up to $15 billion.

- The Trump Tower New York headquarters for the President-elect **Donald Trump** is not giving much away when it comes to space policy but there are verbal indications that no one wants to see a return to the dramatic change of direction for NASA created after Barack Obama came to office in 2009. All likely candidates for the position of the next Administrator reflect that fact and Donald Trump is known to be a strong supporter of dual partnerships between private and public organisations. Right now the transition team has been given tablets stocked full of NASA activities, programmes and projects with a decided emphasis on exploration and deep-space objectives for the human space flight programme. Averse to having NASA spend money on environmental and climate-research programmes, several Republican sources have remarked on the existing responsibility of other US government services such as the National Oceanic & Atmospheric Administration (NOAA) for that kind of work.

- The loss of a Falcon 9 rocket in a dramatic pre-launch explosion on 1 September 2016 is likely to push the first manned **Crew Dragon** to the International Space Station from late 2017 to early 2019. The Office of the Inspector General issued a report on the same day as the explosion summarising its work over preceding months in which it said it did not believe the first crewed flight of the Dragon capsule would take place before late 2018 .

German female astronauts

By Tony Quine

Amelie Schoenenwald is one of the youngest applicants and is presently working on viruses.

Juliana Socher

In last month's magazine we introduced the motivational programme to get German women into space for the first time. Several candidates have spoken to *Spaceflight*, about their involvement, aspirations and hopes, some of whom are currently pursuing their careers outside Germany.

Amelie Schoenenwald

At 27, one of the youngest remaining candidates. "I finished a Bachelor's in Molecular Biotechnology at the Technische Universität München (TUM) in Munich. Even though I enjoyed it a lot, I felt that I was missing the technical and mathematical aspect but at the same time I did not want to leave life sciences. Therefore, I signed up for two Master's courses at the TUM: Biochemistry and Industrial Biotechnology. During the final stages of my studies, I was given the chance to complete one of my final theses on antibiotics in Israel which was a truly enriching experience!

"Now, I work as a PhD student in a programme called 'Integrative Structural Biology' at the Max F. Perutz Laboratories of the Medical University of Vienna. In my project I am working with a virus that is closely related to the Zika virus and could emerge in a similar way as Zika did."

Marja Seidel

A 28 year old Astrophysicist who explained, "About a year ago I completed my PhD in Astrophysics, researching about dynamics and stellar populations in barred galaxies. Before, I did a Master in Astrophysics and a Bachelor in Physics and another in Earth and Space Sciences. I am also passionate about scientific outreach and in particular encouraging girls and young people to dare to discover.

"Astronomy in my opinion is a wonderful visual tool to use. So I have done many talks, workshops and public observations in my local environment at schools or just for the general public, but have also organized and led expeditions into developing countries to very remote places (Peru, Morocco, Indonesia, Colombia)."

Marja currently works at Observatories of the Carnegie Institution of Washington, in Pasadena, California.

Johanna Maislinger

A 30 year old Commercial Pilot, who has flown professionally for ten years, she is a high-achiever in every sense of the word, having been one of the youngest Boeing 777 pilots when she began flying the large twin-jet when she was only 23. Now Johanna has her sights on making a spaceflight.

"I am an engineer and a Senior First Officer with Aerologic", she says. "I have been flying commercially for the last 10 years. I currently fly Boeing 777, and before that, Airbus A320, Boeing 737 NG and Classic, Citation 500 series. I was promoted to Cruise Relief Captain at 25.

"I am attending the Ludwig Maximilian University Medical School, in Munich. I started my journey to becoming a doctor in 2013 and successfully accomplished a large part of the education towards my medical degree since then.

"Away from my work and studies, I do aerobatics, bush-flying, mountaineering, sailing, riding my racing cycle, horse-riding, skiing, many so called 'extreme sports'. This is never about adrenalin. It is about learning, training, simulating. It is extreme in respect of how much you have to prepare. It is all about preparation. Do it right and the risk drops to a very low level, which is acceptable. Preparing for space requires a similar mentality and approach."

Liv Heinecke

A 31 year old mother of two children, currently a PhD student (Geoscience) at the Alfred-Wegener-Institute, Helmholtz Centre for Polar- and Marine Research in Potsdam, Germany. Liv lived in Manchester for six months, 2014/15. "Of course I had an interest in flying to space, but let's be realistic, I would not have thought this possibility would present itself, so going into space was actually not on my agenda, but when the window of opportunity opened I did not hesitate.

"As a Geologist/Biologist by training, expeditions, including a kind of 'out-door-training' come with it, so I love to explore, I always have. I want to know how things work and how I, or we, can make them better.

"The physical tests, within the selection process, would be amazing! Participating in a parabolic flight and seeing what the body can take, that would be great. However, the part I currently look most forward to (if I make it) would be the second psychological tests, where group behaviour is investigated, coping with challenges, team work, integration etc. I think this would be a lot of fun - to engage and explore."

Carmen Koehler

Age 36, she obtained her Ph D in physics of the

Johanna Maislinger is a highly experienced pilot, one of the world's youngest Boeing 777 captains and now wants to fly to space. Via Tony Quine

atmosphere. "Having previously worked at the DLR (German Aerospace Centre) and DWD (German Weather Service), I am currently working at I-EM (Intelligence in Energy Management) in Italy, as scientific employee and perform numerical weather forecasts for the renewable energy sector.

"In addition, in early 2015, I was selected and trained as the first female analogue astronaut by the Austrian Space Forum (ÖWF), and in August 2015, participated in the two week AMADEE-15 Mars-Simulation Mission. I have had the dream of becoming an astronaut for a long time. That is why I applied to become an analogue astronaut last year.

"Additionally, a hobby of mine is to go sea kayaking. My husband and I went sea kayaking in British Columbia, Canada for one month during summer. These adventurous experiences are physical and psychologically challenging and make me a suitable candidate for becoming an astronaut."

Ariane Wyen

A 30 year old satellite engineer from Bremen, she says: "In June 2012 I obtained the German diploma degree in aerospace engineering at the University of Stuttgart, where I majored in space engineering and structural analysis. Since then I have been employed by OHB System AG in Bremen as an engineer in the structural analysis department. I am responsible for the analysis and testing of the Structural Subsystem of two satellites of the so-called SARah mission, which is owned by the German armed forces and is planned to fly by 2018.

Carmen Koehler is an experienced flyer and has participated in the Mars-Simulation Mission.
Via Tony Quine

"I am passionate about space also outside of work. I participate at school events on a regular basis telling young children and university students about space, my career and my current job. As these events will be a great part of the activities of the first female German astronaut, I already know I truly enjoy them and I am certain my audience does, too."

Anja Schuster

Age 27 and due to start her Ph D in November, at the Helmholtz-Zentrum in Dresden in the working group of Dominik Kraus, she says: "I hold a Masters degree in Physics from the Technical University Darmstadt. In the course of my studies I had two internships at the European Space Operations Centre in Darmstadt coping with ESA's first mission to Mercury called BepiColombo. Furthermore, the Space Studies Programme 2013 in Strasbourg provided me with a fundamental background in the various disciplines of the space business.

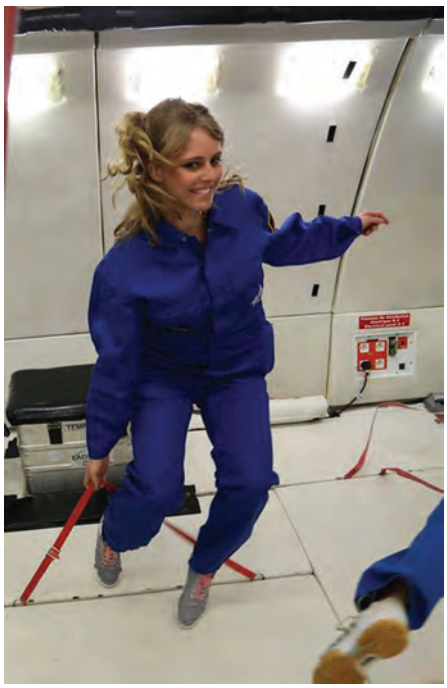
"Another valuable experience was my exchange semester at UC Berkeley as a visiting scholar working on a project based on the search for an extra neutrino generation. I was well aware of the fact that astronaut recruitments took place only three times in the history of the European Space Agency, about every 15 years with the last one in 2008/2009. My aim is to live my life without any regrets – if I always do the very best I can there is nothing to worry about."

Johanna Wessing

Age 29, and in her final year as a PhD student at the German Aerospace Center (DLR) in Cologne, she says: "I have a Bachelor and Masters in Geosciences with a major in Materials Sciences. My studies focus on thermo-physical properties of liquid metals investigated in an Electromagnetic levitation (EML) chamber, similar to the one Alexander Gerst installed on the ISS during his mission in 2014. This area of science has afforded me opportunities to perform experiments under unique conditions. For one project, I had the chance to carry out measurements in microgravity on a parabolic flight. I found the experience of flying in an aircraft at near weightless conditions incredibly exciting.

"Currently, as part of PhD studies, I am an active team member on a project at the Tohoku University in Sendai, Japan. The opportunity to work in my area of interest with such a diverse group of people has been extremely rewarding. Within the scope of this project here I am also experimenting with an EML chamber but the properties investigated differ from those on which I am doing my research on in Cologne.

"At the same time, I have begun studying another area of long-held interest, now working towards a degree in Psychology. I've always found the study of behaviours by individuals and groups interesting, I wonder if I can combine my studies with scientific work in the space field in the long term."



Johanna Wessing flies a zero-g simulation flight and has already applied to ESA for the astronaut corps but was rejected because she was still a student. *Via Tony Quine*

For up to date information, visit www.dieastronautin.de.

A scientist by profession, Liv Heinecke is enthusiastic about the prospect of challenging physical barriers in the human body.
Via Tony Quine

REMEMBERING APOLLO 1

By the Editor

Astronauts Virgil I. Grissom (left), Edward H. White II (centre) and Roger B. Chaffee, the crew who died on 27 January 1967 preparing for the first manned Apollo mission. *NASA*

There can be few over a certain age who were involved with the space programme at the time and cannot remember where they were on the day Gus Grissom, Ed White and Roger Chaffee lost their lives in an Apollo spacecraft atop a Saturn IB on Launch Complex 34 at Cape Canaveral, 50 years ago.

It was Friday 27 January 1967 and it was early evening, 6.31 pm to be precise. Streams of cars carrying NASA and contractor personnel away from Cape Canaveral Air Force Station and the Kennedy Space Center made their way out to the A1A, some heading for the bars and motels in Cocoa Beach, others heading for Titusville, a few heading across State to Orlando. Security had opened the barriers, few vehicles were inbound, and, fender-to-fender, drivers slowly weaved their way in anticipation of a weekend off; chores, relaxation, baseball and soccer games awaiting before a new week. A week closer to the first manned Apollo shakedown flight.

Others were still working at the Cape as dusk fell, lights popping on across the flat open divide between isolated concrete buildings connected by ribbons of concrete roads; but they should have been gone by now. Most of those still on site were spread around the buildings and various facilities, some still winding down getting ready to depart and a few setting in to a weekend of activities on unavoidable assignments. A cluster of managers, engineers and technicians were down at Launch Complex 34 and in the Saturn 1B blockhouse. Even Mission Control in Houston was being held back by delays to the test activity under way with Apollo 1 – Saturn IB AS-204 and its Apollo Command and Service Module CSM-012 – that should have been over by now.

As the prime crew for Apollo 1, Grissom, White and Chaffee had arrived in the White Room adjacent the spacecraft hatch just before 1.00 pm and power was switched to the spacecraft just five minutes before they slipped across the sill. Crossing through the complex triple-hatch assembly, Grissom moved across to the left couch, Chaffee to the right couch and White, last in, to the centre couch. On hooking up his suit circuit Grissom complained of a bad odour, like buttermilk he said, and procedures stopped while a sample was taken. The simulated countdown was halted at 1.20 pm while those samples were taken, the crew now passive and waiting results.

The badge the Apollo 1 crew would have carried into space. *Via David Baker*

Balancing risk

When they entered the spacecraft 56 m above the launch pad it was to rehearse all the events and sequences short of launch vehicle ignition but, as a plugs-out test where the spacecraft went on full internal power, it was every bit as real as it would be on launch day. At just above ambient pressure, the pure oxygen environment was a potential fire hazard. Flames propagate with lightning ferocity in a pure oxygen atmosphere at 1g. And that matters. In space, where there is no convection, a fire is not so bad but the combination of the one-gas atmosphere and the high pressure environment at sea level gives every spark the potential to bring disaster.

The issues had been debated 10 years earlier when the Air Force was designing its manned ballistic capsule and pure oxygen had been chosen; it had, after all, been used in military aircraft for several decades. Having taken over the project when it formed, NASA saw no reason to change that and Mercury, Gemini and Apollo adopted a pure oxygen atmosphere too. Contrary to urban myth, the reason was not to reduce the overall pressure level in orbit and thereby achieve a lighter structure but rather to reduce complexity and lower the probability of a malfunction in space by simplifying the engineering. But the pre-launch rehearsal this day took the risk to a higher level by immersing the crew in a pure oxygen atmosphere above ambient pressure.

None of that, however, occupied the attention of the spacecraft commander as he became increasingly frustrated by a succession of minor problems, technical issues small in themselves but cumulatively sapping confidence that this vehicle would be ready for space within three weeks.

After extensive tests of the suit circuit found nothing awry with the oxygen flow, test conductor Clarence “Skip” Chauvin ordered a resumption of the countdown at 2.42 pm. Three minutes later the closeout procedure began where the triple hatch combination would be sealed, the internal atmosphere purged to a pure oxygen environment and the simulated pre-launch activities got under way.

This plugs-out test was a dry rehearsal of countdown procedures. There was no propellant in the Saturn IB, nor were there toxic propellants in the spacecraft itself. But there was a live launch escape system loaded with two tonnes of solid polysulphide propellants capable of delivering a thrust almost half that of the Atlas rocket which had placed John Glenn in orbit less than five years before. And it was sitting a few metres above the pressurised crew compartment.

The hatch itself consisted of an inner pressure-sealing door and an outer heatshield door sealing the hull of the spacecraft, with a boost protective cover (BPC) fitting like a bespoke cone over the command module incorporating a third hatch for access while the stack was still on the launch pad. The BPC cover was a semi-rigid structure which on a normal flight would be jettisoned along with the launch escape system shortly after dropping off the first stage of the Saturn IB. But for this flight its door could not be fully locked due to a set of wire bundles running from the White Room to the spacecraft distorting its shape.

After several hours in the spacecraft a series of problems emerged with the communication system and at 5.40 pm the count was again put on hold while technicians tried to resolve issues which at times prevented anyone from being able to hear voice messages from the crew compartment. With communications switch panels to his right, those issues were managed inside the spacecraft by Chaffee. And then, at 5.45 pm a microphone refused to turn itself off and that blocked out communication from anyone! After manipulating various switch positions, at 5.53 pm the countdown was back on.

With spacecraft systems being progressively switched to the terminal stages of this simulated countdown, some indications appeared to show a leak from the environmental control system. There were indications of a high oxygen flow rate. Ground technicians concluded that this was caused by the crew moving around on their couches and breathing heavier. But nobody knew for sure. Communication protocols usually restricted to a precise and meticulous sequence of reportage were made more difficult by the continuous lack of clarity

Training for egress from their spacecraft after splashdown, a boilerplate stands in for the Apollo 1 Command Module. *NASA*

on the voice circuit. Not to mention the difficulty various parts of the Cape were having hooking up to the test.

All-up testing

CSM-012 was a spacecraft belonging to a series which nobody wanted. When the contract had been awarded to North American Aviation in 1961 it incorporated 49 manned or test spacecraft, 30 boilerplate engineering test vehicles and 23 full-scale mock-ups as well as five test fixtures, four mission simulators, three evaluators, five trainers, two miscellaneous adapters and all the associated spares required to service a busy and comprehensive test schedule.

When Apollo was first designed in 1960 but before any formal contract had been awarded it was not meant for Moon missions. A circumlunar capability was possible but only as the long-pole on a set of requirements focused more on taking human space flight beyond the limited capabilities of the Mercury capsule. Long duration Earth-orbiting flights of up to two weeks had been proposed for Mercury but that was felt more appropriate for its successor – Apollo.

When North American got the contract however it was to support Moon missions mandated by President Kennedy and an acquiescing Congress, although the mode requiring a second spacecraft – the Lunar Module – was not selected until a year later. It seemed logical to pursue a two-phase approach: a Block I series to test all the basic systems for operating in space and a Block II series for Moon flights, with all the associated docking and deep-space support equipment required for the more ambitious flights.

Through contractual modifications and amendments the definitive agreement with North American called for 20 Block I spacecraft and 18 Block II flights (one less than originally contracted). Paradoxically, in the number sequence for production vehicles, the Block I vehicle would begin with "0" and Block II would start with "1". Thus it was that the Apollo spacecraft assembled for this first manned mission was CSM-012, the twelfth Block I assigned to flight.

When the development programme had been assembled between 1961 and 1963 it was envisaged that early spacecraft (Block I) could give astronauts space flight experience on Saturn I launch vehicles and then the Saturn IB followed by the Saturn V carrying both Apollo and the Lunar Module. But top management changes in late 1963 transformed the test schedule. It became increasingly obvious that the Saturn I flights were unnecessary and that the interim two-man Gemini, expected to fly by 1964, could do the job of giving flight crews experience of operating in space.

This aspect was crucial in deciding to cut back on the number of Saturn IB flights and, eventually, on the number of Block I missions too. Under Mercury astronaut Deke Slayton, who had yet to fly, several groups of astronauts needed space flight experience. NASA had recruited 42 astronauts between 1962 and 1966 along with a few scientists who were not considered early candidates for Moon missions. By replacing expensive and unnecessary Saturn missions with the existing Gemini programme, astronauts could get their space "wings" while management reserved the Saturn flights for vital tests of definitive hardware with experienced astronauts. But that tended to minimise the value of the Block I vehicles.

So it was that even before the first manned flight, the Block I sequence was increasingly seen as test-beds for the real Apollo and some crews, including Schirra, Eisele and Cunningham who were to fly the second Block I as Apollo 2, chafed at the repetition taking them out of rotation for more exciting flights just a little way down the road.

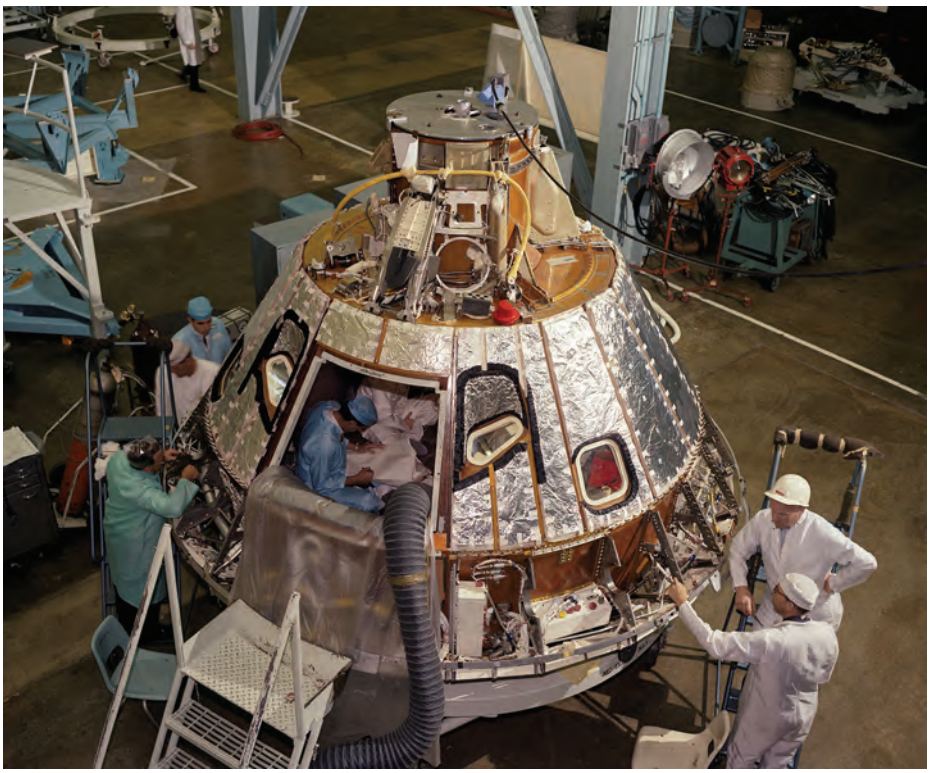
Initially, when crew selections were made in January 1966 Grissom, Eisele and Chaffee were assigned by Slayton to fly the first manned mission followed by Schirra, White and Cunningham but Eisele suffered a minor injury playing sport and was put back to Apollo 2, Ed White taking his seat on Apollo 1. But there were multiple technical and programming issues too which upset the tidy flow of missions as envisaged a year before preparations got under at Cape Canaveral for the first manned Apollo flight.

In a ground test of the CSM-017 Service Module, assigned to ride the first Saturn V flight unmanned, the propellant tanks exploded on 25 October damaging the structure. The Service Module assigned to the second Saturn V flight, SM-020, was moved up to mate with CM-017 for the first Saturn V flight but that left the second mission without a Service Module. In a top-level decision, Apollo 2 was cancelled in November 1966 and its Service Module (SM-014) mated to CM-020 for the second Saturn V. The Schirra crew was moved up as back-up to Grissom's team on Apollo 1 to the intense fury of the demoted commander. That left Apollo 1 as the sole Block I manned mission.

But long before this transformative saga unfolded, the Block I series had been plagued with numerous changes, modifications and replacements for the Cinderella Block II programme and its fully developed Moon-capable spacecraft. The Block I vehicles, dwindling in mission assignment but vital for the development path, were slowly becoming unrepresentative of the definitive Apollo spacecraft, a testing ground for bedding in systems which were still in development. Increasingly, throughout 1965 and 1966 they were viewed as close approximations which would suffice for all-up testing.

The concept of all-up testing had been instituted as a way of cutting back on the

The Command Module for Apollo 1 had serious flaws and was compromised in its application by numerous changes to equipment imposed by NASA and the contractor. *NASA*



The access arm at Launch Complex 34 where the crew would have demonstrated an emergency escape had the test gone as expected. *NASA*

number of launches necessary to support the Moon landing objective. It had been introduced by the radical transformations effected by George Mueller and General Sam Phillips, both of whom were heavily influenced by the systems-engineering philosophy of US Air Force General Bernard Schriever. As it was, there would be only four flights with Block I: two on Saturn IB rockets in February and August 1966 and the first two Saturn V flights in November 1967 and March 1968. Apart, that is, from the first manned Apollo flight with Grissom, White and Chaffee.

A lemon tree

Gus Grissom had been well aware of problems with the ever-changing Block I Apollo. But not perhaps not quite as much as the engineers and technicians working CSM-012 on Pad 34. Long before it was delivered from the contractor, in six specific instances the environmental control system water/glycol coolant had leaked and spilled over a bundle of electrical wiring for test equipment. Returned to the manufacturer, it was repaired and re-installed in SM-012 on 16 December. Earlier that year another environmental control unit had burst into flames in a pure-oxygen test when an electrical arc ignited heater tape.

When it arrived at the Cape it was tested between Christmas and New Year in an altitude chamber in which the crew participated. Problems cropped up, were solved and the preparations rolled along. On delivery from North American, NASA had to correct 113 technical inadequacies but it had itself been responsible for the contractor having to carry out 623 specification changes imposed by the space agency as it continually modified individual items of equipment, components and test items which it wanted installed for this first manned Apollo mission.

It frustrated the flight crews all down the line, none more so that Gus Grissom, not known for tolerance but alarmingly intuitive when it came to sensing underlying problems and fundamental flaws. In wrestling software codes and instrumentation difficulties with the Block I design in the Apollo Mission Simulator, Grissom was fired up to vent his disgust by hanging a lemon on the door. But that lemon fell from a veritable tree of problems, none of which were completely and satisfactorily resolved when the crew sat inside their spacecraft awaiting the final stages of the simulated countdown.

Wrestling virtually insoluble telecommunication problems, the blockhouse personnel chafed at the scratchy voice circuits, interspersed with data drop-outs in the radio telemetry being sent to different places at the Cape. Frustration too at Mission Control in Houston as they sought clarification on the continuous delays and empathising with Grissom when he questioned whether they could ever get to the Moon if they couldn't even talk to each other at the Cape!

Having now been inside the spacecraft for virtually five hours, at 6.10 pm the countdown reached T-10 minutes in this simulated launch preparation. This was the step where the spacecraft would go on internal power – the plugs-out portion – getting electrical energy from the three fuel cells, inert for this test, which were down inside the Service Module below the crew compartment. Communications were still too poor to adequately simulate dialogue, checklist verification and callouts and appropriate sequencing of switch positions. But at least the blockhouse could do their part of the rehearsal if the crew and Mission Control were stalled on a realistic and integrated flow.

Outside in the White Room on the service structure some 27 people were standing around, some sitting on chairs, others at a small desk with sight of the crew vaguely distinguishable through the two opposing side windows. Some cursory nod to the potential hazard (technically declared a "non-hazardous" test) was granted by the presence of a couple of hand operated fire extinguishers. Above, a few metres from all their heads, was the fully fuelled launch escape system. As events would reveal, at least this was inactive for the test.

As the minutes ticked away the communication difficulty was isolated to Grissom's equipment although links between the operations and checkout building (O&C) and the launch vehicle blockhouse persisted throughout. But it was decided to go ahead and resume the full countdown involving the crew inside the spacecraft. This was the end run, after which there would be a simulated emergency evacuation from the spacecraft demonstrating how the crew would flee a potential explosion, dash across the access gantry and on to armoured vehicles waiting to rush them from harm's way.

End game

With the full countdown about to resume, attention focused on the checklists and events roster as systems were cycled and switch configurations set for what would be an active launch on a real flight day. Very few were aware of the myriad activities associated with an end-of-week retreat by several thousand workers leaving the facilities. Inside the White Room and inside the pad 34 blockhouse, artificial lighting veiled the setting Sun and the darkness of night creeping over Cape Canaveral. Not long now and the test would be over.

Three television cameras were trained on and above the spacecraft and one could see partially inside the Command Module where lights of various colour flickered on and off as the crew went about their routines. In the blockhouse some 300 m away, assistant test conductor Bill Schnick sat at his desk. Nearby, launch operations manager Rocco Petrone observed the TV pictures from the White Room. Engineers were now glued to their consoles, watching the several separate systems, noting power loads, the flow of oxygen to the

crew through the troublesome environmental control system and even watching the physical motions of the crew in their couches, as the little attitude gimbals measured each slight fluctuation.

At 6.31 pm the full count was about to resume when a rise in oxygen levels was observed. Just 21 seconds later the bio-harness attached to Ed White showed a momentary rise in heart rate. Nine seconds later Grissom moved quickly in his couch, the perceptible brushing sound of breathing against his open microphone revealing unusual activity. The gimbals were now showing increased movement inside the spacecraft and just five seconds before 6.31 pm a trace graph on a console recorded an electrical spike in alternating current bus No 2. Somewhere, amid the 20 km of wiring inside the spacecraft, a short had occurred.

Just four seconds later a voice from inside the spacecraft, probably Chaffee, not urgent but positively concerned: "Fire. I smell fire." Two seconds after that, from Ed White: "Fire in the cockpit", his voice insistent. Less than 10 seconds later an urgent cry from Grissom: "Fire! We've got a fire in the cockpit!" It was five seconds after 6.31 pm.

In the blockhouse flames licking the windows of the spacecraft were clearly visible now but there were several seconds of stunned disbelief. In the blockhouse Deke Slayton and Stuart Roosa stood transfixed before the images on the TV screens. Evacuation procedures so carefully worked out in advance cited 90 seconds to remove the two hatches, open the boost protective cover and leave. None of the crews had managed it in that time.

The fire ran rapidly across all interior surfaces, fuelled by the high pressure oxygen and by flammable glycol from burst coolant pipes, by flammable netting throughout the interior designed as a restraint for sundry items, and fuelled by pressurised oxygen from pipes split by the heat. In the seconds when logical response prevailed, Chaffee had turned up the interior lights, previously dimmed to enhance the illuminated instrument displays.

Quickly, the fire turned the aluminium sidewalls into heat trays hotter than the interior of an oven feeding energy to the raging fire. In the last desperate seconds of consciousness the crew had made supreme efforts to undo the interior pressure hatch but it was designed to open inward and as the pressure begin to rise inexorably from the enormous pulse of heat turning everything into fire, the crew rapidly succumbed to asphyxiation.

Outside, galvanised by the sight and hearing screams from inside, technicians fought to wrestle open the outer heatshield hatch but to no avail. The pressure had become so great inside the spacecraft that it burst open the base of the Command Module, splitting the sidewall and sending a gushing torrent of fames and black smoke to the accompanied sound of grinding metal. As the flames shot upward there was a fear-filled moment when it looked as though the fire would reach the escape tower, igniting the propellants and consuming the White Room. But it was not to be. The fire had done its worst, extinguished by the broiling clouds of thick black smoke snuffing out the flames.

The interior of the Command Module after the crew had been removed following the fire. Block II spacecraft would carry several hundred changes to make the spacecraft totally fireproof. *NASA*

Remembering

The days and weeks that followed the deaths of Gus Grissom, Ed White and Roger Chaffee were both difficult and transformative. No Block I spacecraft would fly with a crew, new safety procedures, re-design, complete fireproofing of the interior and a decision not to pressurise with pure oxygen on the launch pad again were obvious consequences. Less obvious were the cultural shifts that occurred, bringing a stronger and a much safer human space flight programme.

NASA was allowed to conduct its own internal review and achieved full disclosure, of events associated with the fire as well as the tortuous process under which engineers and technicians had laboured to build a spacecraft which, as events had showed, was flawed both in design and in management – faults laid squarely where they lay. The political consequences saw management firings, positions shifted and an agency determined to get the job done and put astronauts on the Moon.

But the phantom of near-death for all who challenge the boundaries was made evident again four days later. William F. Bartley Jr and Richard G Harmon lost their lives in an altitude chamber at Brooks Air Force Base, Texas, when a flash fire broke out in a pure oxygen environment. But the road to space brought more casualties.

Yet, if those were indeed tragic days in a year when NASA had hoped to make great strides along the road to the Moon, it brought further losses. On 24 April Vladimir Komarov died when his Soyuz 1 spacecraft plummeted to Earth and on 15 November 1967 test pilot Michael J. Adams died when his X-15 rocket-powered research aircraft fell from the sky. Others have since died. On 30 June 1971 cosmonauts Dobrovolsky, Patseyev and Volkov lost their lives in Soyuz 11. Seven Shuttle astronauts died aboard Space Shuttle Challenger on 28 January 1986 and a further seven in Columbia returning from space on 1 February 2003.

Today we are reminded of the price paid by all these people and that space flight is difficult, dangerous and unforgiving. That what unites us in common loss across nations is greater than what divides us on the wall of ideological and political divide. For those old enough to have been alive at the time, 27 January 1967 was a reminder of the price that can be paid in space flight engineering for flawed designs, faulty workmanship and a cavalier approach to risk.

It was a day nobody would forget. A day to remember.

Humans in Space – An Update

After years of deliberation and debate, human space travel is finally on the cusp of a renaissance in capability, achievement and diversity.

Now three nations are deeply committed to sending people into space, private enterprise is on the verge of running a commercial, non-government, human space flight service and at least two nations have pledged to go back to the Moon while a third deliberates over sending humans to Mars.

Moreover, the long awaited era of space fun rides could be about to dawn, drawing a curtain over the past dominated by tax-funded propaganda missions buttressing ideological battlegrounds. Fuelled by a Cold War now dead, the space agencies of former adversaries are cooperating over goals at levels never imagined heretofore, while a new political will to strike conciliatory deals with former enemies may open innovative ways of doing business in space.

NASA wants to do business with China and the new US President-elect wants to cool hostilities with Russia, connections impossible to have predicted as plausible possibilities merely one year ago. If they work it will open a new age of shared success and, paradoxically, enhance national pride through unified achievement and motivation.

And this is exciting for the UK, not only because Britain is consolidating investment in science, technology and engineering with real new money but because its industry has never been better poised to deliver opportunities for an upcoming generation of young women and men seeking a professional career on the new frontier.

It is good news for the British Interplanetary Society too which has, throughout its near-84 year history, consistently appealed for international cooperation in the peaceful exploration and exploitation of space.

Where's the beef?

However, quoting the phrase voiced by an old-timer in the commercial for Wendy's hamburger store when actress Claire Pellar extolls its attractions: "Where's the beef?" In other words, grandstanding needs substance as a deterrent to disappointment; pragmatism must demonstrate and display its ability for ousting false rhetoric and wasteful propaganda.

The substance of New Space is built on the foundations of an Old Space order, which is already crushed by bureaucratic overload and inefficiencies. Government-run programmes can become bloated and weighed down by conflicting obligations, the platforms for partisan politicking. The commercial world is free of that – owned by no-one and loyal only to its most ambitious imagination.

Despite short-term setbacks, companies such as SpaceX and Orbital ATK have laid a new path wide enough for room in which Blue Origin and Sierra Nevada Corporation can also compete. And where Virgin Galactic and XCOR can provide the firebrand enthusiasm for wannabee astronauts to dip their toe into the blackness of space and return enthralled.

For that is what we need – bright lights shining on the young giving them role models so that they themselves can become inspirational beacons for others in turn, for so very few will ever become "real" astronauts visiting orbiting space stations or walking on the Moon or Mars. Better by far that they should achieve a small slice of that dream than drift away disillusioned because the goal was set too high and the real opportunities too scant.

It is a fascinating statistic that only 1% of failed applicants for astronaut selection stick with some form of science or engineering while 20% of those who are mentored by a scientist or an engineer during their education choose science or engineering as a first-choice career.

The "beef" is in the ladder of opportunities from one-shot space tourism flights to a fully committed career in human space flight. Opportunities which allow entrants to step off at appropriate and applicable levels proportionate to their skills and capabilities.

This is close to the core of what the British Interplanetary Society has consistently stood for – a broad base of widespread educational support for schools and universities.

New capabilities

On the next two pages some of those opportunities are laid out so far as they exist in the United States, which many countries around the world look to not only for inspiration and leadership in space but for cooperative programmes in which national goals can match international capabilities, a classic case of the sum being greater than the separated parts.

Significant change may be in the offing in this year of political transformation: a new President in the White House and a new path for Britain as it repositions itself for a different relationship, not only with Europe but with many other countries in distant places. Britain's industry is capable and primed for those new opportunities and the skills within British science and engineering are well known and recognised around the world.

New Space and Old Space, vital for the challenging decades ahead and both still yet to realise their entrenched potential, not apart but working but together each benefitting from the position of the other. Just as international cooperation unlocks the latent potential of trapped opportunities within separate nations so can private and commercial space partners benefit from close and integrated roles with government-run space projects. It just might be a renaissance indeed.

China's rising accomplishments with the Tiangong programme provide an opportunity for cooperation and the cementing of international relations. *Adrian Mann/Bisbos*

Exploring Further

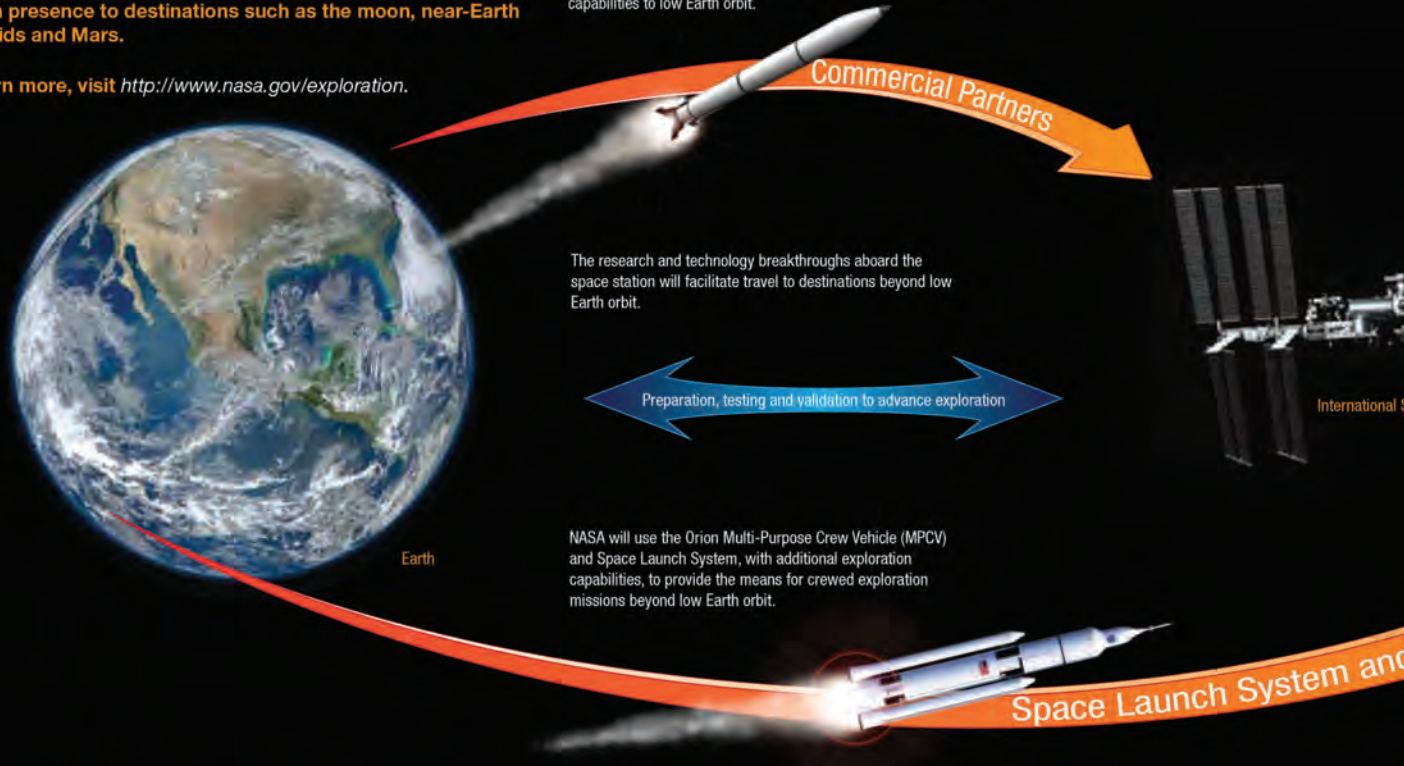
NASA is embarking on a new era of space exploration in which humans will travel deeper into the solar system than ever before. The International Space Station is the centerpiece for space operations. Serving as a test bed for research and new technologies, the space station is a steppingstone toward future exploration destinations. The commercial industry will transport cargo and eventually crew to the space station while NASA focuses on developing the Orion Multi-Purpose Crew Vehicle, Space Launch System, and advanced exploration systems that will enable a sustainable human presence to destinations such as the moon, near-Earth asteroids and Mars.

To learn more, visit *http://www.nasa.gov/exploration*.

The Future of Ame Humans

Following NASA's innovative partnership activities and investments in U.S. commercial launch capabilities, the agency has purchased cargo transportation services to and from the Space Station and will continue to partner in the development of crew transportation capabilities to low Earth orbit.

"This is the next chapter that we can write tog research and technology. We will set far-reach step, we will push the boundaries not only of v



Commercial Spaceflight Development

NASA is investing financial and technical resources to stimulate efforts within the commercial industry to develop and demonstrate cargo and crew space transportation capabilities to and from low Earth orbit.

	Commercial Company	Spacecraft	Launch Vehicle
Cargo Partners			
	Space Exploration Technologies (SpaceX)	Dragon (Cargo)	Falcon 9
	Orbital Sciences Corporation (Orbital)	Cygnus	Antares
Funded Crew Partners			
	Blue Origin	Crew Transportation System	Initial — Atlas V Final — Own Reusable Booster System
	Sierra Nevada Corporation	Dream Chaser	Atlas V
	SpaceX	Dragon (Crew)	Falcon 9
	The Boeing Company	Crew Space Transportation (CST)-100	Initial — Atlas V

Human Spaceflight Capabilities

NASA is developing next-generation spaceflight technology to explore multiple destinat


Mobile Extravehicular Activity and Robotic Platform


Deep Space Habitation


Advanced Spacesuits


Adva Com

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erican
SPACEFLIGHT

National Aeronautics and Space Administration

NASA

ether here at NASA. We will partner with industry. We will invest in cutting-edge ing milestones and provide the resources to reach those milestones. And step by where we can go but what we can do...."

— President Barack Obama

Near-Earth Asteroid

Lagrange Points

Mars

Moon

Space Station

d Orion MPCV

Destinations

Lagrange Points

Lagrange Points are microgravity destinations beyond low Earth orbit that provide opportunities for construction, fueling and repair of complex in-space systems. These points in space can serve as a gateway to reaching multiple destinations in our solar system.

Near-Earth Asteroids

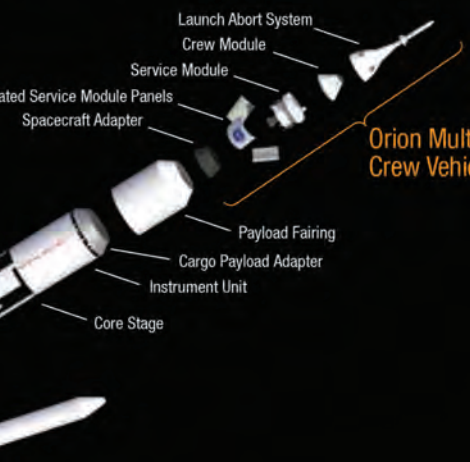
These near-Earth objects may provide answers to some of humankind's most compelling questions, such as these: How did the solar system form? Where did Earth's water and other organic materials come from?

Moon

Earth's nearest neighbor provides significant opportunities for commercial and international collaboration and has critical resources needed to sustain human explorers.

Mars

Mars provides the best opportunity to demonstrate that humans can live for extended — even permanent — stays beyond low Earth orbit. The technology and space systems required to transport and sustain explorers on Mars will expand scientific knowledge and drive technological innovation.



ions throughout the solar system. New technology systems include the following:

nced Space munication

Advanced In-Space Propulsion

In Situ Resource Utilization

Human-Robotic Systems

Launch Vehicle	Saturn V	Space Shuttle	Space Launch System: Initial Lift Capability	Space Launch System: Evolved Lift Capability
Years	1967–1973	1981–2011	First uncrewed launch planned for 2017	to be determined
Height	111 m (363 ft)	56 m (184 ft) (Orbiter 122 ft)	97 m (318 ft)	→ 115 m (376 ft)
Lift Capability to Low Earth Orbit	118 metric tons	28 metric tons (to 28.5° inclination)	70 metric tons	→ 130 metric tons
Crew Capsule/ Capacity	Apollo Spacecraft	Orbiter	Orion MPCV	Cargo Configuration Shown

STRAWMAN: The Deep Black Signals Intelligence Satellite

By Dwayne Day

Converging SIGINT satellite data with the needs of tactical air operations over Vietnam, two-seat Republic F-105G "Wild Weasel" aircraft were employed to knock out the surface-to-air missile batteries. This retired F-105G stands guard at American Legion Post 0325, Blissfield, Michigan. *Dwight Burdette*

On the night of 5 October, 1968 a Thor Agena-D rocket with Castor solid rocket boosters lifted off from Vandenberg Air Force Base, lighting up the skies above California's picturesque central coast. It headed out over the Pacific Ocean.

After climbing high into the sky the boosters peeled off the rocket's side. Its core stage continued burning as the rocket headed southward past Los Angeles and then San Diego and Mexico until it too was depleted and jettisoned. Then the Agena second stage fired, pushing the payload higher and faster into the southern hemisphere and then eventually over Antarctica.

The Agena's engine shut off once the spacecraft reached orbit, but fired again later to circularize the orbit. After the nose fairing had been jettisoned the vehicle pitched down 90 degrees and deployed its antennas. Finally, a set of three solar panels deployed from the Agena's aft end.

Soon, arms began unfolding from the forward compartments of the spacecraft and deploying antennas, some of them mesh, others solid dishes, until the spacecraft was a collection of multiple antennas, all pointed downward. STRAWMAN 1 was now active.

Radar watch

STRAWMAN was the last of the Agena-based low orbit multipurpose signals intelligence satellites. The first Agena-based signals intelligence—SIGINT—satellite had been launched in 1962, and by the time of the October 1968 launch twelve of them had been placed in orbit. The purpose of these large satellites was to cover a wide range of targets inside the Soviet Union and Warsaw Pact countries, primarily radar emitters.

The satellites could intercept multiple frequency bands and pinpoint the emitter's location. That data was then used to develop technical collection payloads for smaller satellites so they could gather more precise data on the radars and other electromagnetic emitters like microwave communications systems.

Most of the satellites had confusing numerical designations rather than names, but they had eventually fallen under the general designation "Program 770". In December 1966 a new series of satellites, designated MULTIGROUP, had been launched as part of Program 770. MULTIGROUP 2 launched in July 1967 and MULTIGROUP 3 in January 1968.

Before MULTIGROUP had even started flying, on 1 April, 1966 the head of the National Reconnaissance Office's (NRO) SIGINT department proposed its successor, named STRAWMAN, to NRO Director Al Flax. Flax approved long-lead-time items in June 1966, and fully approved the project in September.

Although details are still limited, ultimately five STRAWMAN spacecraft were approved for construction. It appears that throughout the 1960s, with the exception of the first Agena-based satellite that was assembled from leftover parts from a Samos F-1 satellite, the National Reconnaissance Office purchased Agena SIGINT satellites in blocks of four – four Samos F-2s, four Samos F-3s, and four MULTIGROUP satellites, eventually reduced to three in return for the addition of a fifth STRAWMAN satellite.

Each STRAWMAN satellite had multiple payloads, some of which changed during the course of the programme:

STRAWMAN 1
- THRESHER 1
- REAPER 1
- CONVOY 1

STRAWMAN 2
- THRESHER 2
- REAPER 2
- CONVOY 2

STRAWMAN 3
- THRESHER 3
- REAPER 3

STRAWMAN 4
- THRESHER 4
- REAPER 4
- HARVESTER

STRAWMAN 5
- THRESHER 5
- REAPER 5

Origami

REAPER, which was apparently the descendant of earlier payloads designated BIRD DOG and SETTER carried on earlier satellites, consisted of a nest of helical antennas. THRESHER was partially tucked under REAPER and had two deployable mesh antennas. Combining all of these various payloads together required

some clever packing by the engineers who designed the spacecraft.

The overall STRAWMAN payload was larger than previous Agena signals intelligence satellites. Up to this point all of the Agena-based satellites had payload fairings with the same five-foot maximum diameter of the Agena itself. But STRAWMAN required a more bulbous payload fairing that bulged outward to accommodate the greater number of antennas.

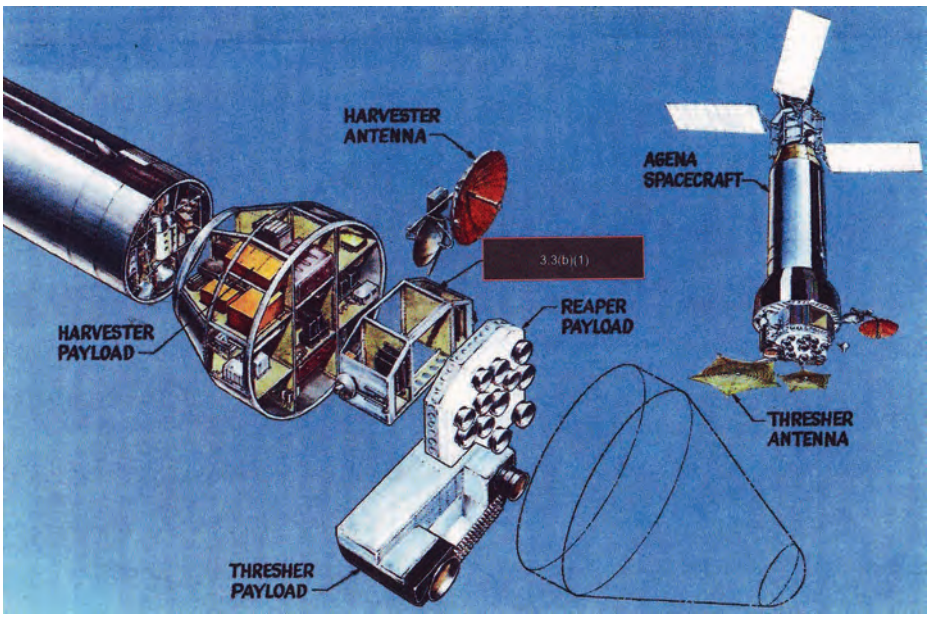
The first two STRAWMAN satellites also carried an auxiliary payload called CONVOY to determine detailed characteristics of Soviet anti-ballistic missile (ABM) radars. Details about CONVOY remain classified and it is unknown if it was focused on the HEN HOUSE ABM radars or a SA-5 missile site at Tallinn in Estonia that was suspected as a new ABM site. STRAWMAN 4 carried the HARVESTER payload which had two dish antennas that folded out to one side of the downward-looking spacecraft.

All payloads that were part of STRAWMAN (THRESHER, REAPER, CONVOY and HARVESTER) were connected to a "pre-detection" analogue recorder in the prime payload. What exactly this means is unclear, but a declassified official history of the programme called "The SIGINT Satellite Story" implies that the satellites were able to turn on their recorders before they detected the signals, perhaps by turning on the recorder at the first hint of a signal before it passed a specific threshold that counted as a detection.

STRAWMAN 1 lasted over a year in orbit, twice the planned lifetime. STRAWMAN 2, launched on 31 July, 1969, operated for over 13 months. The success in orbit of the first two missions resulted in the engineers projecting nine-month lifetimes for the next two missions, but even this proved conservative. STRAWMAN 3 operated for 18 months after being launched on 26 August, 1970.

The final satellite, STRAWMAN 4, was launched on 16 July, 1971. A declassified image of the STRAWMAN 4 payload (the only one to carry THRESHER, REAPER, and HARVESTER) included a small antenna whose label is deleted, indicating that it had one additional still-classified payload. There are unclassified reports indicating that this mission carried a radiometer, a term for a device that can be used to detect the presence of signals, although not their identity.

STRAWMAN 4 lasted over 20 months. But during the mission the small antenna connector to the lower band antenna of HARVESTER failed, eliminating any chance to intercept 5 GHz signals from the SA-5 surface-to-air missile system at Tallinn, Estonia, that some analysts suspected was part of an anti-ballistic missile system.



The configuration of STRAWMAN 1 with triple payload in an exploded view. *Via Dwayne Day*

The SA-5 at Tallinn had proved to be an enigma to American intelligence analysts because it was apparently designed for high-speed intercepts of high-altitude targets. Other than the Mach 3 A-12 OXCART reconnaissance plane, which did not overfly Soviet territory, there was nothing else for the SA-5 to shoot at. Tallinn also was not a militarily important location worthy of such a defensive system, leading to speculation that the missile site was part of an ABM system.

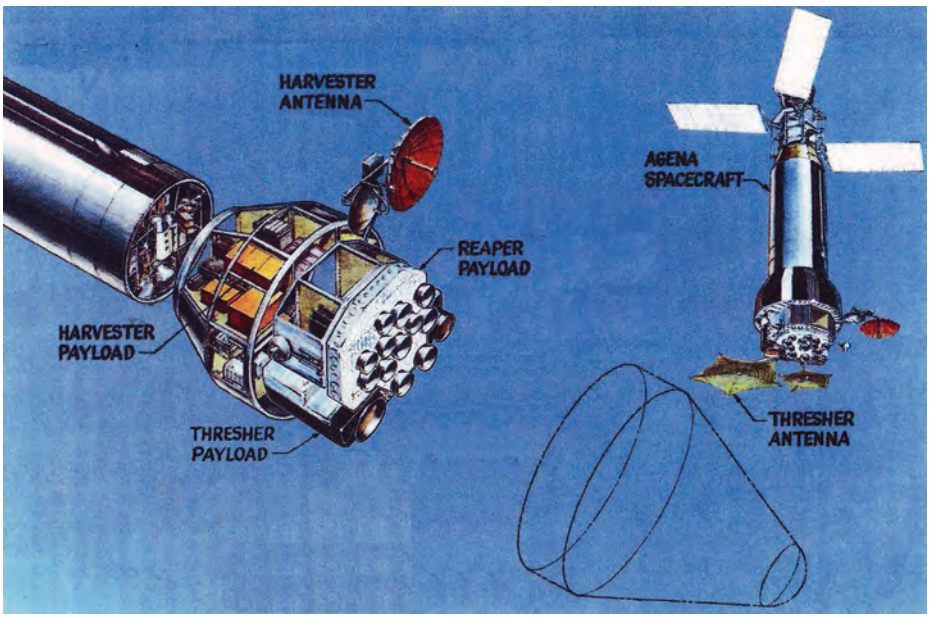
Over time American intelligence analysts determined that the SA-5 was not an anti-ballistic missile, but it still remained puzzling. What they did not realize until much later was that the SA-5 had initially been developed to intercept the US Air Force's B-70 Valkyrie bomber. Even though the B-70 was cancelled, the Soviets continued the SA-5 for a high-altitude high-speed bomber threat that never emerged.

The THRESHER digital electronic order of battle collection and processing system produced radar locations with 27 km accuracy. THRESHER 2 produced 9,444 radar locations, THRESHER 3 produced 11,519 radar locations in its first four months of operation. REAPER 3, also on the same STRAWMAN mission, produced 33,915 locations with 9 km accuracy. The intelligence data from these missions turned into a flood, straining the ground processing systems.

Role reversal

By early 1968 the United States military was involved in an escalating ground and air war in Vietnam. American aircraft were being shot down at the rate of nearly one a day, and Operation Rolling Thunder, the bombing of North Vietnam, was in full swing as B-52s unloaded racks of bombs over the jungle. The

STRAWMAN-4 with the payload elements shown in flight configuration. *Via Sven Grahn*



Agena SIGINT Satellites

Sequence	Launch	Mission Number	Payloads	Lifetime (days)	Notes
1	21/2/1962	7151	Program 102 Group 0	6 days	Samos F-1
2	8/6/1962	7152	Program 102 Group 2D	1 days	F-2
3	16/1/1963	7153	Program 698BK Group 1D	2 days	F-2
4	29/6/1963	7154	Program 698BK Group 1D	10 days	F-2
5	27/2/1964	7156 7212	Program 698BK Group 1A BIRD DOG-2	12 days 15 days	F-2
6	2/7/1964	7155 7211	Program 698BK Group 2D BIRD DOG-1	5 days 5 days	F-3
7	3/11/1964	7157 7213	Program 698BK Group 3D BIRD DOG-3	4 days Failed	F-3
8	16/7/1965	7158 7225	Program 770 Group 1A BIRD DOG-4	51 days Failed	F-3
9	9/2/1966	7160 7228	Program 770 Group 3D SETTER 1A	7 months 40 days	F-3?
10	28/12/1966	7161 7229	MULTIGROUP 1 SETTER 1A	5 months 5 months	
11	24/7/1967	7162 7230	MULTIGROUP 2 SETTER 1B/DONKEY	5 months 5 months	
12	17/1/1968	7163 7232	MULTIGROUP 3 SETTER 1B	14 months 14 months	
13	5/10/1968	7164 7233 7238	STRAWMAN 1/THRESHER 1 REAPER 1 CONVOY1	12 months 12 months 12 months	
14	31/7/1969	7165 7234 7239	STRAWMAN 2/THRESHER 2 REAPER 2 CONVOY2	13 months 13 months 31 days	
15	26/8/1970	7165 7235	STRAWMAN 3/THRESHER 3 REAPER 3	17 months 17 months	
16	16/7/1971	7167 7236 7240	STRAWMAN 4/THRESHER 4 REAPER 4 HARVESTER	17 months 16 months 5 months	
17	Cancelled	7168 7237	STRAWMAN 5/THRESHER 5 REAPER 5		

U.S. Air Force was engaged in a constant battle against Vietnamese SA-2 surface to air missiles (SAMs), jamming them and spoofing them, electrons dueling invisibly in the air.

American airmen with the job of physically destroying the missiles, going by the name Wild Weasels, went into battle with patches on their shoulders bearing the acronym "YGBSM." It was reportedly the response of one electronic warfare officer when first told what he would be doing – "You gotta be shittin' me…" he said.

Launched on 21 February 1962, the first Agena SIGINT was placed in too low an orbit from which it decayed prematurely. Note the silvered Agena skin. *USAF*

Fighting SAMs was a brutal business and eventually the US military brought its top secret signals intelligence satellites into the war, using a strategic asset for tactical purposes. Since 1962 the Agena SIGINT satellites had primarily been strategic intelligence platforms, providing data useful for America's fleet of B-52 bombers. Now they were being used for a much different purpose.

Throughout 1967 the U.S. Air Force and the Soviet advisers who supported North Vietnam's SA-2 surface to air missile forces had engaged in a struggle – the Soviets to enhance the SA-2's ability to shoot down American aircraft, and the Americans to negate the SA-2. According to Steven Zaloga, writing in *Red SAM: The SA-2 Guideline Anti-Aircraft Missile*, over time the Americans had gained the upper hand, degrading the SA-2's performance to the point where the North Vietnamese were launching on average about two dozen missiles to shoot down a single aircraft. Often the missiles flew out of control as soon as they left their launchers.

The third Agena signals intelligence satellite was launched in January 1963. It operated for only two days. *USAF*

The Soviets had been shocked by this poor performance and implemented new equipment and changes in tactics, including optically guiding the missiles and keeping the radars off when they thought that an American Wild Weasel aircraft was in their vicinity.

In spring 1968, when MULTIGROUP 3 had been in orbit for a few months, data on SA-2 surface-to-air missiles and other defensive radars in Vietnam became a high priority, leading to the creation of an activity designated "PENDULUM". Available records do not indicate how or why PENDULUM was started, but on 31 March, 1968, President Lyndon Johnson had announced a halt to bombing of North Vietnam. This undoubtedly reduced American aircraft sorties over the north and reduced the collection of intelligence on the location of the mobile SA-2 missile batteries, so PENDULUM may have been started as an effort to close the gap in intelligence gathering, reporting on any SA-2 radar system in North Vietnam that started emitting. MULTIGROUP 3's improved capabilities made this possible.

There is limited information on PENDULUM, but it appears to have been a programme for providing signals intelligence data directly to forces deployed in Vietnam, making it possibly one of the first examples of a highly classified national intelligence satellite programme being employed for tactical battlefield use.

How exactly this was accomplished remains classified, but the Naval Research Laboratory's POPPY signals intelligence satellite used mobile ground stations located in trailers to receive signals, and it seems likely that some kind of ground station was deployed to South Vietnam air bases to receive signals from the MULTIGROUP satellites.

S-200 (NATO reporting name SA-5) deployments in Tallinn, Estonia, were the target for STRAWMAN 4 but an antenna failure prevented it fulfilling that task. But interest fell away when the missiles which were deployed were not part of a previously suspected ABM screen. This SA-5 is in Vinnitsa, Ukraine.
George Chernilevsky

One declassified document refers to the deployment of mobile units on the periphery of the Soviet Union to assist in better tuning satellites collecting signals over Soviet territory in real time. This may have led to an effort to develop mobile read-out capability for MULTIGROUP, as opposed to relying on ground stations in the United States which then had to transmit their data halfway around the globe to Vietnam.

When the first STRAWMAN was launched in autumn 1968 the PENDULUM effort to provide intelligence data to forces in Vietnam continued, with reporting from the THRESHER/REAPER payloads. This intelligence was reported less than 24 hours from time of intercept, with average time from collection to reporting being about 5.5 hours. During 1969 there were 41 PENDULUM reports and 183 in 1970.

End of Agena SIGINT

The STRAWMAN satellite programme proved to be quite successful with only one major subsystem failure of any of the four vehicles launched. In spring 1970 Director of the National Reconnaissance Office John McLucas reassessed the NRO's SIGINT programme. He considered the design capabilities of satellites then in the development phase such as the CIA's RHYOLITE, which was intended to detect Soviet ballistic missile telemetry, and the Air Force's JUMPSEAT, which was being developed to gather data from Soviet ABM radars such as HEN HOUSE. He also considered the existing capabilities of the POPPY and P-11 subsatellite programmes then operating.

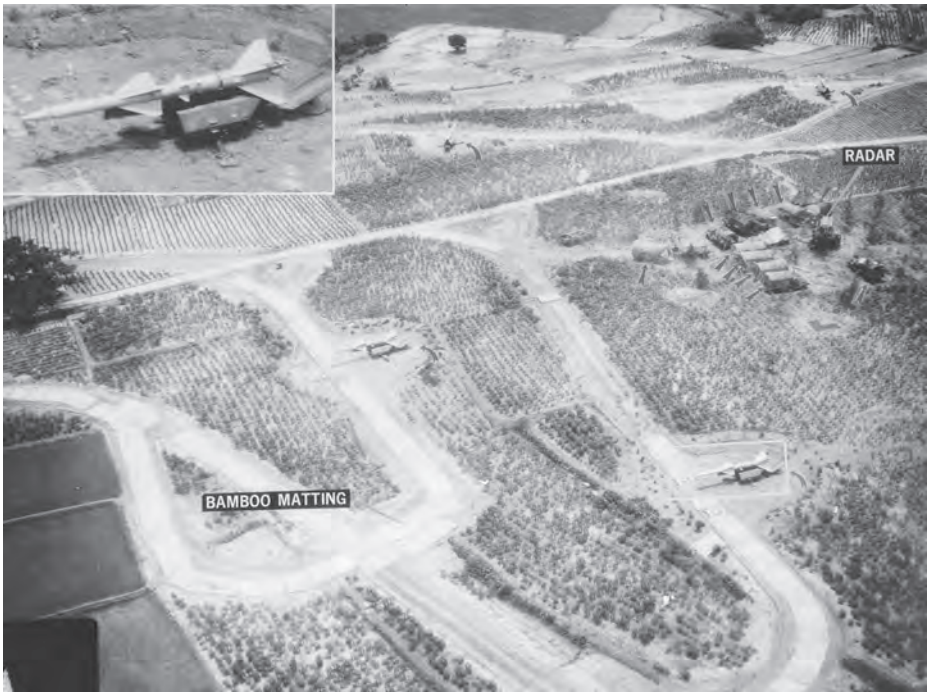
According to "The SIGINT Satellite Story", "the STRAWMAN capability seemed redundant. McLucas therefore directed the cancellation of (Agena) vehicle 2738 and all further development work." It is unclear how far the STRAWMAN 5 payload had been developed and if any of it may have been saved and placed in a classified warehouse like the HEXAGON and GAMBIT-1 satellites that now reside in museums. STRAWMAN 4 continued operations through July 1972. It was not operational in December 1972 when American B-52 bombers, as part of Operation Linebacker II, began bombing Hanoi and were shot down by SA-2 missiles at an alarming rate.

STRAWMAN 4 was the sixteenth and last of the Agena SIGINT satellites launched, from 1962 until 1971. These satellites, begun as part of the Samos programme when they were part of Subsystem F, had a number of name changes over the years: Program 102, Program 698BK, and finally Program 770, which included both MULTIGROUP and STRAWMAN.

Although many details about this effort remain classified, the satellites clearly grew more capable and longer-lived over time. But even though the age of the Agena SIGINT satellites had ended, that did not mean the end of low Earth orbit signals intelligence satellite operations. The Navy's POPPY satellites continued operating and in the 1970s were replaced with the far more capable PARCAE satellites. PARCAE consisted of trios of satellites whose primary mission was detecting emissions of ships at sea, but undoubtedly also gathered electronic emissions over land as well.

Another Air Force programme started in the early 1960s, Program 11, continued even after STRAWMAN stopped operating and remains one of the enigmas of the early American signals intelligence programme. Although the National Reconnaissance Office has released much new information about the Agena SIGINT satellites, there is still a lot of information about these early years and programmes that remains classified.

SA-2 surface-to-air missile site in North Vietnam photographed by American reconnaissance aircraft. The radar is at upper right, surrounded by support trucks. The SA-2 radars and missiles were moved around frequently, and American signals intelligence satellites were used to locate them. *USAF*



Volker Lieberg

Theo Pirard,
Space Information Centre, Belgium

The British Isles captured on a day of typically variable weather by the ESA Sentinel 3A Earth observation satellite. *ESA*

Between 2004 and 2016 Volker Lieberg gave an impressively strong impetus to Europe's development of Earth observation satellites, retiring last July from a successful career as ESA Director of Earth Observation Programmes as well as Head of ESRIN (ESA Institute for Earth Observation) in Frascati, near Rome. He was replaced by Josef Aschbacher, an Austrian scientist.

Recently, Volker Lieberg took time to talk to *Spaceflight* about his highly successful career and the challenges faced during the development of what is one of the world's most important Earth observation programmes, about the relationship of ESA to the European Union and about his hopes and aspirations for the environmental monitoring programme. With resources of €1.603 million for 2016 that represents 30.5 % of the total budget of ESA.

I began by asking him about the greatest hurdles he had faced in these last 12 years: "If you take things together, the biggest change during this period was to make the Copernicus system with the operational Sentinel satellites a reality", he said. "This is a real challenge, representing a great chance for Europe. Now, users around the globe have access to operational data which, at the beginning of my directorate, we were just dreaming about.

"At the same time, we were developing the scientific missions, our Earth Explorers. We had decided about a lot of new Earth Explorer missions, like EarthCARE (Clouds Aerosols & Radiation Explorer), FLEX (Fluorescence Explorer), Biomass, the last one to be approved for funding. We are just in the process of selecting a new one, Earth Explorer 9. Apart from that, we have managed to start the development of two new generations of meteorological satellites, MTG (Meteosat Third Generation) and Metop SG (Second Generation)."

But what did he feel about the future of Earth observations worldwide. On this aspect he had a real vision by embracing the new technologies: "We see rapid development of the internet world with big data and the platform based economy. We have seen that during the last 12 years Earth observation importance in ESA already has quadrupled. The EO programme has become the biggest programme of ESA. Also the value adding sector has grown by approximately 8% per year over the last ten years and we see huge demand for geospatial data together with a revolution in IT. Big data algorithms and cloud processing together with Copernicus is giving fantastic new chances to Earth observation as you can work with enormous amounts of data from your desktop. This was not possible 10 years ago."

Ratings

I asked Volker if cooperation with the European Commission on Copernicus was his main achievement?: "If you take everything together, I would say yes. It is really a major achievement, because we realised for environment and civil security what we have done since 35 years for meteorology. Copernicus is one of the two programmes of the European Union in Space, to serve the global society. Along with Galileo for navigation purposes."

But was it not difficult to create synergy with the European Commission? "It is difficult. ESA and the European Commission are very different organizations. ESA is an engineering organization while the European Commission is built as the executive body of the EU to propose European legislation and managing the day to day business of the EU. We have different objectives and different cultures. But we managed to take the best of both organisations to realise Copernicus and we learn each day to work a bit better together. Copernicus is a successful example of what Europe can reach together and a good role model for the future." I wondered about Volker Lieberg's talents when it came to negotations. Did he have a special trick, as an efficient diplomat, to negotiate with the people of the European Commission? "We could demonstrate that we are a reliable partner. One key was that I could convince the member states to invest in prototype missions on ESA's side, some years before the EU was able to invest to do the prototype developments.

Volker Lieberg during a conversation with Theo Pirard. *ESA*

"Then we supported the Commission successfully in their budget negotiations with Europe's Parliament and Member States. When the EU started with their budget cycle in mid-2000, we were ready to start the manufacturing of the Sentinels, but it took still almost one year to finalize the negotiations of the contract between EU and ESA. As I said before, it was not always easy due to our different backgrounds and missions, but finally we achieved a very good agreement."

Parallels

I wondered about why the achievement of Copernicus appeared, from the outside, to be easier than the development of Galileo: "We had clear objectives concerning the respective rules of ESA and of the Commission of the European Union. What we did in fact was to use the well-proven procurement instruments of ESA and use it for Copernicus' space segment. That we are allowed to use our well proven tools to purchase the Sentinel satellites was different from the Galileo programme for which the contract authority is in the hands of the Commission.

"As the procurement instruments and procedures of the Commission were not developed to contract space systems, they are not always adequate and on time. As a consequence of that the Copernicus procurement decisions for the development of the Sentinels were very fast which saved money and time." But, with contracts signed to four Sentinel satellites, to ensure continuity of observations, are they identical?: "There are only small changes between the A/B and the C/D units respectively. Due to the time which passed between the two procurements, there are some obsolete parts for the electronics. Also some improvements will be made in the instrumentation, such as an AIS (Automated Identification Systems) payload on Sentinel-1 satellites or a high-performance altimeter on Sentinel-3 satellites."

Air Bus Defence and Space engineers ready the Sentinel 2A satellite for delivery and launch, carried out by a Vega rocket on 23 June 2015. *ESA*

I then asked him about the dual role in the Sentinels for operationally observing the global environment and additionally being responsible for security. **"**ESA is the main operator of the Sentinel constellation together with Eumetsat with the control centres in Darmstadt.". He replied, "While ESA is operating the land part of the observations for the Sentinel-3 series, Eumetsat is doing the ocean and atmosphere part.

"From the beginning of Copernicus the existing assets for earth observations in Europe were used. Eumetsat has a great expertise in the permanent monitoring of the atmosphere and the oceans. For the services there is a close co-operation with EMSA (European Maritime Safety Agency), with ECMWF (European Centre for Medium-range Weather Services), and with EEA (European Environment Agency) for in-situ data."

Technicians check the solar array deployment mechanism on the Sentinel 2A Earth observation satellite. *ESA*

Phasing

But as the first two sentinels are functioning very well, I wondered whether he would postpone the launches of already purchased C and D satellites: "When the C & D units are ready, we will decide with the European Commission whether to store them or to put them into orbit. I hope that A and B will work longer than seven years which is the specified life time. If so, we would keep C and D on the ground", he replied.

"However, we would like to have a one year overlap, to cross calibrate and validate the instruments. Frequent repetition, open and free data policy and long-term availability of data are the keys to make users confident to invest in new applications… and it works. Now that Copernicus is becoming an operational reality, we have already signed collaborative ground segment agreements with 11 different countries. This will continue with more and more national services to be added. In addition, companies are starting to develop commercial services based on Copernicus. We have already more than 30,000 self-registered users from industry and science. The enormous increase in users represents a challenging but very good development." There will be Sentinel 5P to be launched this year but I wondered why it is being launched and what it is

for. Volker explained that, "It will be a precursor for atmospheric chemistry observations, followed by Sentinel-4 and Sentinel-5 payloads which will fly as instruments on Eumetsat meteorological satellites, respectively on MTG-S (Meteosat Third Generation-Sounder) and on Metop-SG (Second Generation). There will be no successor for Sentinel-5P, which is a small satellite and relatively cheap mission with the Dutch TROPOMI (Troposperic Monitoring Instrument) designed for atmospheric chemistry measurements. It is in fact a gapfiller, until we have the first Sentinel-4 and Sentinel-5 in space."

With free access to satellites observations it is hard to see where the financial return will come from, but Volker explained: "Free data policy is the entry ticket to the new economy at a time of big data. Big data dominates more and more our society and also Earth observations have to go in the platform based economy.

"For the Sentinels, there is an investment for which the taxpayers of the European Union have already paid – so why let them pay again? In the USA, the use of the Landsat system went down to some percent when users had to pay for the access to the data. It is like satellite navigation: the signal is free but a lot of economic value is created by services using the free signal.

Today the utilization of GPS data has created a value much higher than that of the investments for the system. Therefore, free data is a prerequisite to give innovative business a chance and to establish new and unexpected applications with promising prospects."

"Copernicus is a game changer. First, the high repetition, with Sentinels able to map every five to six days the entire Earth. With the Envisat of the early 2000s, it was only every 32 days. For operational applications, that makes a big difference. Second, the sustainability of an operational infrastructure for minimum the next twenty years with Sentinel C and D series. I do not see any commercial constellation in the area of the Sentinels and, by the way, the Copernicus programme is buying a lot of commercial data, e.g. very high resolution data."

Reflection

I wanted to know what, in a long and distinguished career, was his main disappointment: "Very clearly, the loss of Cryosat. It was my first launch as ESA Director for Earth Observations. I was at ESRIN, near Rome, when the Rokot launch from Plessetsk failed in October 2005. We lost Cryosat-1, because the satellite never separated from the upper stage and fell in the Arctic. This failure was my main disappointment. However there was some positive insight: ESA managed within three months to get a Council decision to rebuild it in a short time. I don't think that such a decision could be taken so fast in any other international organisation. It demonstrates the strength of ESA's Earth Observation Envelope Progamme."

But that begged the question as to why the loss of Envisat was not his most disappointing moment and he was clear; was not that a very great loss? "Not really", he replied. "Envisat had a specified lifetime of five years but was 10 years old, when it stopped working in April 2012. So it was not a big disappointment. Of course, I was hoping Envisat would last until the Sentinels were in orbit; but this did not happen." I knew that he had been reluctant to use microsat technology, such as Belgium's Proba satellite, and wondered how that fitted within his overall strategy. "The Proba platform was developed and tested in orbit within the GSTP (General Support Technology Programme) of ESA and later handed over to the EO programme to operate it. There is no scepticism concerning the operational services with small satellites. Of course, ESA was founded at the beginning to realise projects which are too big for one nation alone and too strong for their operational management.

"Finally, the experimental Proba-1 micro-satellite turned out to be a big success. It reveals how a light and compact spacecraft can be a useful tool for Earth observations. We still operate Proba-1 after so many years – it is in orbit since October 2001 – and we operate the successful Proba Vegetation mission together with VITO in Belgium. In the next years we plan to use more small satellite platforms for ESA EO missions and a Proba-type platform is foreseen for the planned SAOCOM-CS mission in cooperation with Argentina."

Staying with Belgium's consideration for a Global Vegetation mini-satellite, I wondered what his thoughts were about the proposed cooperation with China. "Global Vegetation is an initiative the Belgian government is pushing ahead with a public partner in China", he assured me. "There is discussion also with us on how ESA can be involved in its development. Cooperation with China is complicated due to the American ITAR rules we have to respect. Therefore, ESA has to be very careful not to violate them. This could endanger all other ESA missions.

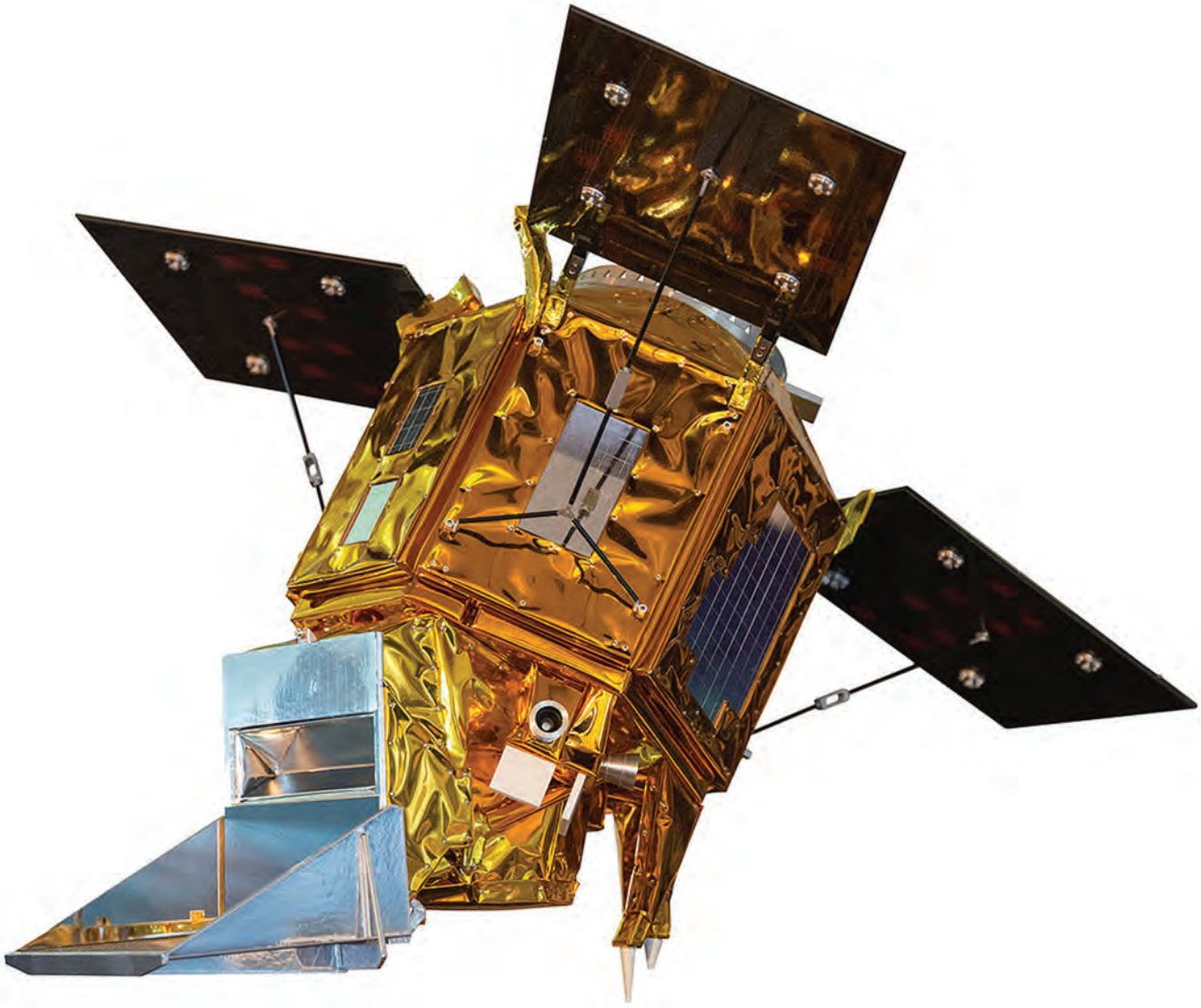
"By the way, the new Sentinel-3 satellites deliver very good vegetation products. Proba-Vegetation was a very good precursor and gap-filler until the two Sentinel-3 satellites will become operational. Of course, Proba-V is still useful as any additional vegetation mission increases the repetition of the data."

Built by Thales Alenia Space at its Cannes Mandelieu Space Centre, Sentinel 3A is operated by EUMETSAT. *ESA*

Competition

How did he see the competition from commercial satellite systems? "It is too early to judge whether they will have success. I hope so. Some have interesting target markets like live TV from space. I am convinced that the future of commercial Earth observations is not related to the direct data sales but in good ideas how to connect the innovating services with the new internet economy. These new service ideas are the key to success in the future. I am myself from the industry and I know how difficult it is to start a new business. So I really hope that some of these systems will know success."

With Copernicus a successful programme, how will the next families address the



Based on the hexagonal ADS Astrobus-L 250 platform, Sentinel 5P is dedicated to monitoring air pollution through interferometers and spectrometers. ESA

global environment and security issues? "The Commission is looking into the user requirements for the next generation. CO_2 or carbon dioxide observations seems to become one of the priorities for the extension of the Copernicus system.

"There are many more proposals; like sea ice monitoring 'a la Cryosat', thermal infrared companion to Sentinel 2 payload, hyperspectral sensors or very high resolution systems I personally believe for the latter; there is room for commercial ventures. ESA would welcome any private initiative in a PPP/ public-private partnership. Finally, the decision in which direction Copernicus will evolve to very high resolution has to be decided by the European Commission.

When will other, or advanced, Sentinels be decided by the European Commission? "We are in the phase of collecting users requirements. The results will be available this year. We are already studying on how to fulfil this demand. We also evaluating some new ways, such AS international cooperation agreements or PPP ventures. There is a top priority to operate a dedicated monitoring system of CO_2, carbon dioxide, from space. On this project, ESA has started to work with the Commission.

"I am convinced that it has to become an international cooperation to be accepted in the framework of the global climate agreement of the United Nations decided at the COP-21 conference in Paris. At ESA, we have some preparatory work done through the Carbonsat project, but the necessary technology needs some years to mature. This development will be part of the next Earth Observation Envelope Programme (EOEP-5) which is proposed to ESA's Ministerial Council in December at Luzern, Switzerland.

I had to ask again. You are confident to see some PPP (Public-Private Partnership) initiatives for Earth Observations in the near future? He was adamant: "We are working on two concepts for high-resolution observation satellites in geosynchronous orbit. One concerns a GEO observatory with around 5 m resolution imagery. The other one is an ocean imaging satellite with 20 m resolution. The European industry is working on potential business cases."

Forecast

As my discussion drew to a close I asked Volker Lieberg whether we can expect a unified approach in Europe with Earth observation satellites for dual-use (civilian and military) purposes. He replied that "Discussions have just started. It is clear that dual use can save a lot of public money. If European projects arise, they could benefit from the great expertise ESA has developed with its engineering teams who have been managing civilian satellites for many decades.

"It would be logical to use the same workforce also for European military satellites. ESA is very well prepared for that. It has regular meetings with EDA (European Defence Agency) to apply technology which works on civilian-military harmonization."

Finally, what was he considering now after a brilliant career with ESA? "First of all, I will support the ESA Director General and my successor for the Ministerial Conference which will take place at Luzern in early December (2016). I will stay until March in ESA. What I will do after, to be honest, I don't know yet. I need a bit time in order to decide it, but we are in a very exciting time of space developments."

All in all, a highly successful career.

Satellite Digest-529

Satellite Digest is *Spaceflight*'s regular listing of world space launches. It is prepared by Geoff Richards using orbital data from the United States Strategic Command *Space-Track.Org* website.

Spacecraft	International Designation	Date	Launch Site	Vehicle	Mass kg	Orbital Epoch	Inclin. deg	Period min	Perigee km	Apogee km	Notes
Himawari 9	2016-064A	Nov 2.26	Tanegashima	H-IIA 202	3,500	Nov 10.85	0.07	1,435.98	35,783	35,789	[1]
Shijian 17	2016-065A	Nov 3.53	Wenchang	Chang Zheng 5	4,000?	Nov 18.71	0.80	1,436.04	35,771	35,803	[2]
Maichong Xing SW	2016-066A	Nov 9.99	Jiuquan	Chang Zheng 11	240	Nov 10.31	97.41	94.64	493	513	[3]
Xiaoxiang 1	2016-066D				8	Nov 11.52	97.41	94.61	492	511	[4]
KS 1Q/CAS 2T	2016-066E				200?	Nov 10.40	98.78	100.13	504	1,028	[5]
Lishui 1	2016-066F				2	Nov 10.45	98.79	100.19	505	1,034	[6]
WorldView 4	2016-067A	Nov 11.77	WTR	Atlas V 401	2,600	Nov 12.49	97.97	96.89	609	614	[7]
Prometheus 2-01	2016-067B				2	Nov 12.69	97.98	96.19	573	583	[8]
Prometheus 2-02	2016-067C				2	Nov 11.89	98.00	96.20	572	584	[8]
Aerocube 8C	2016-067D				3	Nov 12.69	97.97	96.20	574	582	[9]
Aerocube 8D	2016-067E				3	Nov 12.62	97.98	96.22	573	585	[9]
OptiCube 4	2016-067F				2?	Nov 12.69	97.98	96.22	573	586	[10]
CELTEE	2016-067G				1	Nov 12.69	97.98	96.23	575	586	[11]
RAVAN	2016-067H				5	Nov 12.62	97.98	96.23	573	587	[12]
Yunhai 1-01	2016-068A	Nov 11.97	Jiuquan	Chang Zheng 2D	1,000?	Nov 15.85	98.51	100.47	775	790	[13]
Galileo Sat 15	2016-069A	Nov 17.55	CSG	Ariane-5ES	715	Jun 15.62	51.65	92.76	407	422	[14]
Galileo Sat 16	2016-069B				717	Jun 15.62	51.65	92.76	407	422	[14]
Galileo Sat 17	2016-069C				716	Jun 15.62	51.65	92.76	407	422	[14]
Galileo Sat 18	2016-069D				715	Jun 15.62	51.65	92.76	407	422	[14]
Soyuz MS-03	2016-070A	Nov 17.85	Baykonur	Soyuz-FG	7,220	Nov 19.62	51.64	92.59	402	410	[15]
GOES 16	2016-071A	Nov 19.99	ETR	Atlas V 541	5,192	Dec 4.42	0.01	1,435.99	35,784	35,789	[16]
Tianlian 1-04	2016-072A	Nov 22.64	Xichang	Chang Zheng 3C	2,500?	Dec 1.69	3.06	1,435.99	35,778	35,794	[17]

Notes

1. Geostationary weather satellite built by Mitsubishi using a DS2000 bus for JMA with a multi-spectral imaging scanner (AHI) for whole-Earth cloud-cover pictures, atmospheric and sea-surface temperature, water vapour levels and detection of volcanic ash, a transponder (DCS) for relay of data from remote weather stations and an instrument (SEDA) for the radiation environment. Mass quoted above is at launch, dry mass is 1,300 kg. The satellite is located at 141°E for test and will be located at 140°E, replacing Himawari 8.
2. Test launch of new CALT Chang Zheng 5 launch vehicle with new Yuanzheng 2 upper stage. YZ-2 carried out two burns to deploy the Shijian 17 payload in geosynchronous drift orbit. Payload was a telecommunications and technology development satellite built using a CAST DFH-4S bus carrying new systems including ADN and ion propulsion, advanced solar cells and autonomous navigation for performance test and sensors to detect space debris objects. The satellite is located over 163°E, co-located with Zhongxing 5A which is possibly its first inspection target.
3. *Maichong Xing Shiyan Weixing* (Pulsar Test Satellite) or XPNAV 1 (X-ray Pulsar Navigation) is a technology development satellite built by Shenzhen DFH carrying a microchannel plate array for the X-ray background and an X-ray telescope to characterise the signals from pulsars with a system to use the signals for autonomous navigation.
4. *Xiaoxiang* (the Hunan lakes and rivers region) is a technology development 6U Cubesat built by Changsha Tianyi Space Technology Research Institute carrying a camera, an image-stabilising system and communications and navigation systems for performance test. It is not currently clear which object corresponds to which of the Cubesats, nor whether a 2U Cubesat from DFH Satellite called Pina 2 was also launched.
5. Chang Zheng 11 fourth stage with two attached payloads. KS 1Q is a technology development payload built by Kechuang Space with a wide-angle camera, an optical communications system, a Sun sensor and an inertial platform to measure the launch environment. CAS 2T is a 2U Cubesat to demonstrate technology for the planned CAS 2 series of amateur radio communications satellites. It is also known as *Fengtai Shaonian 1* (Fengtai Youth) or *Shaonian Mengxiang 1* (Youth Dream) and was built by Fengtai district schools for CAMSAT.
6. *Lishui* (named for the city) is a technology development 3U Cubesat built by Zhejiang Li Electronic Technology Co. carrying a camera for Earth observation and an attitude control system for performance test.
7. Commercial earth survey satellite built using an LM-900 bus by Lockheed Martin for DigitalGlobe containing a 1.1 m telescope and panchromatic and multi-spectral visible/infra-red imaging scanners (GIS 2) for high-resolution Earth imaging. Centaur stage carried the NRO Enterprise payload of two 6U NLAS deployers for the Cubesats and performed a burn to an Earth escape trajectory after deploying payloads.
8. Prometheus are two 1.5U Cubesats built by Los Alamos National Laboratory for US Special Operations Command (USSocom), each carrying a software-defined radio for tracking and locating data. It is not currently clear which object corresponds to which Cubesat.
9. Aerocube 8 or IMPACT technology development 1.5U Cubesats built by Aerospace Corporation for USAF are each carrying solar cells, carbon nanotube components and a SiEPro ion-electrospray propulsion system for performance test.
10. OptiCube (Optical Cubesat) is a passive tracking target 2U Cubesat built by California Polytechnic for USAF with various surface finishes to act as a target for ground-based space debris tracking sensors.
11. CubeSat Enhanced Locator Transponder Evaluation Experiment technology development 1U Cubesat built by M42 Technologies for USAF with an ELT transponder to demonstrate improved tracking of Cubesats.
12. Radiometer Assessment using Vertically Aligned Nanotubes is a technology development 3U Cubesat built by APL using a Blue Canyon XB 1 bus for NASA with four cavity radiometers, two with VACNT carbon nanotubes, for the Earth's radiation budget, two gallium calibration sources and a communication system using the Globalstar satellites.
13. *Yunhai* means Cloud-Sea. Multipurpose satellite built by SAST for GAD measuring atmospheric, marine and space environment and for disaster

prevention and mitigation and scientific experiments. Apparently intended to measure cloud data from GPS occultation and sea state from GPS reflection.

14. Quartet of Full Operational Capability navigation satellites for the Galileo system, built by OHB for the GSA. Satellites are also named GSAT0207, GSAT0212, GSAT0213 and GSAT0214, Galileo FOC FM07, FM12, FM13 and FM14, and Antonianna, Lisa, Kimberley and Tijmen, the last after four winners of a children's competition. Launched into plane C of Galileo constellation.
15. Spacecraft with two-man, one-woman crew launched to the International Space Station, mission ISS-49S. Crew comprises Oleg Novitsky (Soyuz Commander, ISS flight engineer), Thomas Pesquet (Soyuz/ISS flight engineer, ESA astronaut) and Peggy Whitson (Soyuz flight engineer, ISS Expedition 51 Commander, NASA astronaut). Spacecraft docked with ISS/Rassvet port on November 19.92. Crew are part of ISS Expeditions 50 and 51, with Pesquet performing the ESA *Proxima* mission.
16. Geostationary Operational Environmental Satellite (GOES R) new-generation geostationary weather satellite built using an A2100A bus by Lockheed-Martin for NASA acting as agents for NOAA carries a 16-channel visible/infra-red multispectral imager (ABI) for whole-Earth cloud-cover pictures and vertical profiles of atmospheric humidity and temperature, an infra-red CCD imager (GLM) for lightning, S-band and UHF transponders (DCS) for relay of data from remote weather stations, an L-band transponder (GRB) for transmitting processed data to users, a SARSAT receiver for location of emergency beacons, a CCD extreme ultraviolet telescope (SUVI) to image the Sun and monitor flare activity, three ultraviolet spectrographs (UVS) and two X-ray photometers (XRS) for solar monitoring, two magnetometers for the Earth's field, an angle-detecting sensor (EHIS) for high-energy ions and electrons, two sensors (MPS-Hi and MPS-Lo) for magnetospheric protons and electrons and two proton detectors (SGPS) for solar and cosmic radiation. Mass quoted above is at launch, dry mass is 2,857 kg. The satellite is located over 86°W for test.
17. Tianlian is a data relay telecommunications satellite using a CAST DFH-3 bus. Mass quoted above is estimated at launch. The satellite is currently located over 77°E and will provide global support of future manned missions, apparently replacing Tianlian 1-01.

Additions and Updates

Designation	Comments
1990-079A	Skynet 4C was manoeuvred off station at 1°W September 30 and relocated at 34°E November 11.
1993-076A	NATO 4B was manoeuvred off station at 35°E November 3 and is drifting to the west. It has been retired.
1995-038A	DSCS 3B7 (USA 113) has been relocated from 180°E to 104°E, according to amateur trackers.
1996-030A	Palapa C2 was manoeuvred off station at 146°E October 28 and is drifting to the west. It has been retired.
1997-061A	Cassini performed its 124th targeted fly-by of Titan, passing 1,584 km from the satellite, on November 14.00, non-targeted fly-bys of Mimas at 44,731 km on November 19.31 and Enceladus at 20,306 km on November 27.29 and its 126th targeted fly-by of Titan at 3,158 km on November 29.93. The Titan fly-bys complete a sequence that has put Cassini in a high-inclination orbit with periapsis close to the F-ring.
1998-006A	Brasilsat B3 was manoeuvred off station at 92°W November 12 and is drifting to the east.
1999-013A	Asiasat 3S was manoeuvred off station at 150.5°E November 21 and relocated at 146°E November 27, possibly to reserve PSN slot.
2000-046A	Brasilsat B4 had drifted from 91.7°W to 92.0°W by November 30.
2000-054A	ASTRA 2B was manoeuvred off station at 39°E November 16 and is drifting to the west.
2000-067A	AMC 6 was manoeuvred off station at 72°W November 30 and is drifting to the east.
2001-029A	Artemis was relocated at 123°E November 16.
2002-015A	JCSat 2A was manoeuvred off station at 154°E about November 3 and is drifting to the west.
2002-062A	Nimiq 2 was manoeuvred off station at 23.5°E November 30 and is drifting to the east.
2003-013A	INSAT 3A was manoeuvred off station at 93.5°E about November 10 and is drifting to the west. It may have been retired.
2005-010A	Ekspress AM2 was manoeuvred off station at 80°E November 21 and is drifting to the west. It may have been retired.
2007-046A	WGS 1 (USA 195) has been relocated from 175°E to 180°E, according to amateur trackers, apparently replacing DSCS 3B7.
2008-032A	Jason 2 manoeuvred October 2 to 13 so that its ground track pattern was interlaced with, rather than identical to, that of Jason 3.
2011-001A	Elektro-L 1 attitude control failed October 5 and satellite is apparently a total loss. It is slowly drifting away from its station at 14.5°W.
2015-081A,D,E	Orbcomm FM114, FM110 and FM118 have reached their operational orbital plane. Add orbits: Nov 18.14 47.00° 98.89 min 710 km 712 km Nov 24.17 47.00° 98.89 min 710 km 712 km Nov 18.65 47.00° 98.89 min 710 km 712 km
2016-002A	Jason 3 became the prime oceanography mission, replacing Jason 2, on November 24.
2016-033B	ÑuSat 1 has been given the AMSAT name LUSEX-Oscar 87 (LO-87).
2016-050A	JCSat 16 was manoeuvred off its test station at 150°E November 22 and relocated at 162°E, co-located with Superbird B2, November 29.
2016-053B	Intelsat 33e, following failure of its main orbit-raising engine, has been manoeuvred into geostationary orbit over 59.55°E, co-located with Intelsat 904, using its station-keeping thrusters. Add orbit: Dec 5.90 0.01° 1,436.00 min 35,779 km 35,793 km
2016-061A	Shenzhou 11 crewed by Jing and Chen undocked from Tiangong 2 November 17.20 and landed near Zhurihezhen, Inner Mongolia province November 18.25.
2016-062A	Alan Poindexter was unberthed from ISS/Unity on November 21.47 using the ISS arm and released November 21.56. Carried out Saffire 2 onboard fire experiment November 22 then manoeuvred to a higher orbit and deployed four Lemur 2 Cubesats from NRCSD-E deployers in pairs November 25.88 and November 26.01. Spacecraft was de-orbited over the Pacific Ocean November 27.96. Lemurs are named after members of the Spire team. Add objects and orbits: Lemur 2 Xiaoqing 2016-062C Nov 28.47 51.64° 94.58 min 498 km 507 km Lemur 2 Sokolsky 2016-062D Nov 28.47 51.64° 94.58 min 498 km 507 km Lemur 2 Anubhavthakur 2016-062E Nov 28.47 51.64° 94.58 min 498 km 507 km Lemur 2 Wingo 2016-062F Nov 28.47 51.64° 94.58 min 498 km 507 km

International Space Station activity

There was the following orbital manoeuvre of ISS during November, boosted by Zvezda:

Pre-manoeuvre orbit:	Nov 1.93	51.64°	92.54 min	399 km	409 km
Post-manoeuvre orbit:	Nov 2.56	51.64°	92.60 min	402 km	412 km
End-of-November orbital data:	Nov 30.93	51.64°	92.58 min	402 km	410 km

Recently detailed orbital decays

International Designation	Object name	Decay
1998-067GY	S^3	Nov 23.06
2016-061A	Shenzhou 11	Nov 18.25
2016-062A	Alan Poindexter	Nov 27.98

FLASHBACK – February 1967

A regular feature looking back 50 years this month

While NASA was recovering from the Apollo fire at Cape Canaveral (see pages 54-58), some personnel attended a Mars symposium and others fielded debate over the future of the space programme and its long-term goals and objectives. In Russia, sorrow was expressed over the deaths of Grissom, White and Chaffee, and the Soviet press offered condolences, invoking a sense of inclusiveness, of common links, citing people who went to space as "brothers together" from whatever nation they represented.

1 February 1967

A general circular issued by the Soviet Embassy in Washington, DC, expressed the view that "The sorrow of the American people is shared by peoples from all countries. In reality cosmonauts are somehow representatives of the whole Earth, of the entire mankind in boundless Cosmos, no matter what…country has dispatched them."

The tragic event at Cape Canaveral touched a nerve with ordinary Russians, who embraced the Space Age in a completely different way to Americans at large, and this was little understood in the United States. Seized by the communist State as a propaganda tool, the dawn of this new age was profoundly significant for most Russians. It infused the entire culture and informed the 20th century ethos of "modern" Russia, embraced now by technological wonders akin to the best that the rest of the world could offer.

For Russians, who embraced science, technology and engineering as the three steps to the "electrification" of their emergent State as a great power on the planet, the space programme was part of a national journey that began in the 1920s. To most Russians it was the latest manifestation of the march of progress begun with Stalin's Magnitogorsk – the great Ural industrial complex which sent new energy coursing through the veins of the USSR.

In building that great industrial city, in 1928 Stalin had sent a delegation to Cleveland, Ohio, to understand the giant machine production capacity of the United States. They returned and put together what became the second largest city in the USSR to start building a technological wonder of the world. Space was merely the latest expression of that. Talk to some of the old Russians even today and they will tell you that the space programme was a way of saying "look Americans, see what *we* can do!"

They were proud of that, but they shared a common humanity which politicians and propagandists of the time, on both sides (and perhaps still today), fail to comprehend. It is a little nugget from the past which we would do well to reflect upon in this judgemental age of the 21st century. A window on cultural affinities 50 years ago opened by a terrible and tragic event.

Senior management from NASA face Congressional committees examining the Apollo 1 fire. From left: Robert C. Seamans Jr, Deputy Administrator; James E. Webb, Administrator; George E. Mueller, Associate Administrator Office of Manned Space Flight; Gen Samuel Phillips, director of the Apollo programme. *NASA*

3-4 February 1967

NASA hosted a symposium to study the results from Mariner IV, to this date the only spacecraft to have flown past the Red Planet and transmitted photographs of the surface. There was evidence for significant quantities of methane in the atmosphere and the conclusion was drawn that there must be some form of organic life on or near the surface. While methane does not require life to be present as a molecular contributor to the atmosphere it is more likely to have been produced by some form of biological activity. This added pressure to those lobbying for an ambitious mission for launch in the early 1970s preceding a manned landing in the 1980s.

Mars-mania replaced an initial disappointment with the barren Moon-like surface revealed in the fly-by images but plans emerged for the Voyager programme. At first this envisaged two orbiter/lander combinations carried on a single Saturn V to an orbit about Mars where landers adapted from the Surveyor Moon probes would have been carried down to the surface encapsulated for entry by heatshield and aeroshell. Work began on a biological laboratory to sample the atmosphere and look for signs of life and variations in the Voyager design changed over time.

By 1968 the Voyager programme was considered too costly and too ambitious and in 1968 it was cancelled, the name being resurrected for the Mariner 11 and 12 missions to the outer planets, which became, respectively, Voyager 1 and 2. But the fascinating aspect is the attention given to the significance of methane in the atmosphere, the search for which is only now receiving priority investigation 50 years on.

Reality check

Elon Musk delivers a questionable optimism for massed expeditions to Mars. *SpaceX*

Sir: It seems that, even now, the subject of manned spaceflight can make people go a little crazy. The various ideas for the future of astronautics contained in the December 2016 issue of *Spaceflight* (p 463) are remarkable for their unashamed amateurism: more Apollo to Mars designs for NASA from Boeing and Lockheed Martin; Elon Musk's fantasy ships for carrying a million people to Mars; and of course the UK's belated realisation that the only way to follow a one-off mission is to hustle for another one-off.

The British manned spaceflight policy, in so far as it has one, seems to have been drawn from a literal reading of the title of *The Hitchhiker's Guide to the Galaxy*. Nick Spall's article ends with the by now obligatory pious hope that a UK astronaut might be able to hitch-hike onto NASA's Apollo to Mars.

Elon Musk deserves praise, of course, for restating the need for humanity to become a multi-planetary species in order to secure the long-term prosperity of civilisation. Yet the interplanetary launch rocket and spacecraft he unveiled at the IAC are chiefly striking for their disconnection with any economic, political or technological reality.

Given his emphasis on public–private partnerships, one might have expected Musk to explain how his programme of Mars settlement might dovetail with NASA's Apollo to Mars. Or that the CEO of a company which has suffered two major vehicle failures in the past two years would have had something to say on the multi-decade development process that would be necessary to ensure the levels of low cost and high reliability that his unprecedentedly large Mars colony vehicles are aiming for. But no signs of such concessions to reality are visible.

Meanwhile a deathly hush surrounds the real and immediate issues facing manned spaceflight: the unglamorous, painstaking solution of the problem of achieving affordable, regular and reliable passenger access to orbit; the resumption of private visits to the ISS (on hold since Guy Laliberté's flight in 2009); and the shepherding of that business through falling prices and exponentially increasing traffic to the point where it becomes a normal, self-sustaining economic activity.

Only when that sort of robust foundation is in place will it become practical and sustainable for astronauts to explore Mars in person, let alone create a permanent human settlement there.

Stephen Ashworth
Via email

Bugs in space

Sir: Dr. Cain's article "Humans in Space and Chemical Risks to Health" (Vol 58, No 9, pp 336-341) and the subsequent letter from Dr. Basztyk, "Biohazards of Exploration" (vol.58 No.11, p.435), were both very interesting and thought provoking.

My concerns for such a voyage are the possible psychological challenges for a crew. The recent long-duration stay on the ISS by Scott Kelly was most impressive and I am sure that the data to follow will be of great use in planning for a trip to the Red Planet. Unfortunately however a real test cannot be carried out until a mission actually takes us there. Any length of time in Earth orbit will never prepare an astronaut for the possible feeling of isolation when the Earth is a mere blue twinkle in the distance. I know many tests are carried out but this is one factor that will always remain an unknown no matter how many crews were to be involved. As one who grew up in the Apollo era I would love to see us step away from LEO once more, but Mars is a challenge I am unsure about.

Chris Lee.
Via email

Be careful...

Sir: With regard to the editorial in the December issue (vol 58, No 12, p 446) concerning "commercialisation", immediately following the recent Falcon X explosion, there was an article in the Daily Telegraph by Dr Serge Plattard, a Senior Fellow at the European Space Policy Institute, in which he stated that no conceivable accident could stop the commercialisation of space.

He refers not just to existing fields, such as communication and surveillance, but also to "future" areas such as asteroid mining and orbital manufacturing.

As you may be aware, several centuries ago, the Chinese Empire sent a number of naval expeditions down the East Coast of Africa. Had they continued, the Chinese and Europeans might have met somewhere in the vicinity of Southern Africa, and the whole course of history changed.

As it was, the items and information brought back by the expeditions proved to have an unsettling effect on the Chinese population, and they ended up being banned; even the log-books being burned.

The thing was, these expeditions were purely political, intended to impress the locals with the power of the Celestial Empire. There were no Chinese prospectors looking for gold, no Chinese settlers looking for land – and therefore no Chinese factions prepared to challenge the government's decision.

China turned in on itself and the Westerners, when they reached the country, ended up dictating terms to China, which was wracked by civil war at the time.

As I hardly need say, two Chinese astronauts recently went into orbit, as part of the preparation for a Chinese equivalent of the ISS. (I was surprised at how little attention the flight attracted in this country.) I wonder how the Chinese government will handle the "disturbance" produced by their space programme, and whether they – and we – have learned the lesson that Musk, Branson, etc, have their uses.

Those who learn nothing from history may never end up making more lessons for the future.

Peter Davey
Via email

John Royer Garman (1944-2016)

One of the iconic figures from the hallowed halls of Mission Control Center personnel, John "Jack" Garman goes down in history as a key member of the guidance and navigation team which put American astronauts on the Moon. He was crucial to determining the correct response to several alarm calls during the final stages of descent to the lunar surface during the flight of Apollo 11. Arguably, without his intervention, Armstrong and Aldrin would not have been the first men on the Moon.

Born in Oak Park, Illinois on 11 September 1944, Jack Garman graduated from the University of Michigan, Ann Arbor, MI, with a Bachelor of Science degree in engineering and physics and found an early enthusiasm for computing. He joined NASA in 1966 and continued to pursue his speciality and was assigned work on the Apollo spacecraft computer programmes with the Massachusetts Institute of Technology, working for the Mission Planning and Analysis Division at the Manned Spacecraft Center in Houston, Texas. This resulted in him advising flight control personnel in Mission Control on appropriate responses to alarm codes.

With the extraordinarily low level of potential random failures being assessed at less than 1 in 10^{12}, nevertheless the probability existed that some random and erroneous alarm codes would trigger at crucial points in the Apollo Lunar Module descent phase. The correct response to those would determine whether the spacecraft continued in powered descent to the surface or aborted back into a lunar orbit.

During ground simulations of descent activities, a programme alarm had caused guidance officer (GUIDO) Steve Bales to call for an abort the necessity for which was questioned by Jack Garman. At the instigation of flight director Gene Kranz, Garman listed by hand the possible responses to various alarm codes and placed this piece of paper under a plexiglass cover on his desk so that he would have his previously considered determinations at hand should that be needed.

During the actual descent to the surface during Apollo 11 several computer alarms sounded and Bales rapidly sought specialised advice from Jack Garman, who was able to consult his hand-written checklist and confirm that the descent could continue. The 1201 and 1202 alarms were caused by a computer overload which were in turn a result of an imperfect match between the phase lock on two power supplies, one to the attitude control assembly and another to the rendezvous radar. In only the most obscure circumstance would there be an overload of items queuing for processing, a convergence which occurred precisely at the exact second when an alarm would trigger, indicating executive overflow.

When that occurred Garman was able to give Bales the word to continue with powered descent, which allowed the crew to progress as planned and not trigger an abort back to lunar orbit. What the crew were able to do as a result of Garmin's work enabled them to avoid a total computer lock-up, which would have required an abort using the Abort Guidance System rather than the Primary Guidance, Navigation and Control System.

Jack Garman, who died on 20 September 2016. *Via David Baker*

Life after Apollo

Garman headed up the guidance programming section at the Flight Support Division between 1971 and 1973 and then moved to the Shuttle Orbiter Software Office. In 1986 he moved to NASA Headquarters in Washington, DC, where this writer met with him on several occasions when he was director of (computer) information systems on the space station, then known as Freedom. After almost three years during which he helped configure the overall architecture for the ISS and Shuttle interfaces, Jack moved back to Houston where he progressed through a series of positions until he retired in 2000.

Jack Garman was instrumental in making decisive judgement calls when technical problems were detected with spacecraft or vehicles in various phases of the countdown. He was instrumental in getting the first Shuttle flight off the pad when a series of tests with the General Purpose Computers on Shuttle Orbiter Columbia in April 1981 indicated the potential of a catastrophic failure of all five units. In spite of initial misgivings about giving the launch an "all clear", he was able to demonstrate that Columbia was safe to fly and that a GPC failure would not cascade through the system leaving the crew without any computer power. And he was right.

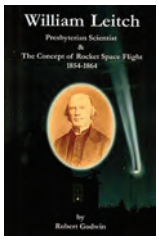
When Jack Garman left NASA he took up a position with the OAO Corporation, a software firm later acquired by Lockheed Martin and Jack finally gave up his monthly pay check in 2010 at the age of 66 years. He received two exceptional service medals and in 1970 was awarded the Presidential Medal of Freedom at the hands of President Richard Nixon for the part he played in getting Apollo 13 back safely.

Throughout, he was a humble man, dedicated to his work and continually surprised at the thought that, had it not been for his spontaneous callout during Apollo 11, faithful to his own judgement, the first attempt at a manned landing on the Moon may have been a failure and the history books telling a very different story.

One of the truly great pioneers of the space programme, Jack Garman died on 20 September 2016 of bone marrow cancer.

David Baker

William Leitch
Presbyterian Scientist & The Concept of Rocket Space Flight 1854-1864



Author
Robert Godwin
Publisher
Apogee Prime
ISBN
978-1926837-36-9
Price
$14.95 plus p&p 152 pages (paperback)

In 1861, the year the American Civil War broke out, a Scottish-born Presbyterian minister, William Leitch, wrote about the possibility of reaching space through rocket propulsion based on Newtonian principles. This remarkable discovery resulted from a string of investigative enquiries and a series of unlikely connections worthy of the great Sherlock Holmes. But no, it was Canadian Robert Godwin who strung the pearls together and came up with this seminal work which pushes back by several decades the first recorded scientific proposition for space travel.

It is generally assumed that Jules Verne first wrote publicly about space travel for the first time in 1865 when publishing his *From the Earth to the Moon*, which used the preposterous and impractical notion of a massive gun to fire a projectile from Earth to the lunar surface. It took a Russian to redress the balance. Renowned for his mathematical calculations around the idea of high-energy cryogenic propellants, Konstantin Tsiolkovsky began writing about the possibilities in rocket power for space exploration in 1883. In 1913 Robert Hutchings Goddard started on a path which would result in the first liquid propelled rocket flight in 1926.

What Robert Godwin has done is to resurrect a lost history of astronautical theorising which predates all the accepted dates for space literature and sets it back to the early years of the Victorian era. The story of William Leitch is fascinating, as are the debated reasons why his work has been lost for so long, despite being quoted by previous writers, including the President of the BIS Kenneth Gatland, in 1953, without knowing how early this work was.

There is little left in mainstream astronautical history to surprise us but this is one which resurrects a prophetic realisation that space travel can only be achieved through reaction engines based on the mechanical principles embodied in the work of Newton. The story of this man and his work is a profound contribution to space literature, uniquely disclosed in this important research.

More than that, this book is the only one around to chronicle the events surrounding the life of William Leitch and to provide a full referenced background. A veritable treasure.

SpaceX's Dragon
America's Next Generation Spacecraft

Author
Erik Seedhouse
Publisher
Springer Praxis
ISBN
978-3-319-21514-3
Price
£16.99 206 pages (paperback)

Elon Musk is well known for his innovative approach to technologies and none more so than in his bold and robust approach to launch vehicle development and logistical supply spacecraft to the International Space Station. This book focuses on the latter and presents a handy reference guide to the development of the Dragon capsule and its derivatives, both under development and speculative; the former being the Dragon V2 crew module carrying astronauts to the ISS from later this decade, the latter being Red Dragon, conceptualised as a spacecraft capable of supporting Mars missions during the 2020s.

The author does a very good job of describing the separate strands of technology employed by SpaceX in the design and development of the Dragon vehicles but there are ambiguities sometimes, perhaps created by the editing process. In other areas there is the distinct feeling that the publisher has perhaps taken explanatory sections from the text so as to fit a specified number of words.

For instance, when discussing the selection of heat sink materials he refers to the fragility of the thermal protection system on the Shuttle, citing the loss of Columbia and aligns that (by inference) with the selection of (a flawed, he says) ceramic tile concept. Heat-sink materials were selected because the weight of ablatives would have been far too great. Moreover, ablatives would not have accommodated thermal expansion without cracking and failing. That aside, Columbia was lost because an impact shattered the brittle reinforced carbon-carbon and not the tiles, which never caused any real problem on any flight.

Nevertheless, the book works very well because it explains in simple lay language why these concepts are viable and how they could be developed to provide the next level of human space exploration. It does not get tangled in the politics but looks squarely at the proposed technology, the launch vehicles and their rocket motors, and the potential for a wide classification of missions.

The book has great merit as a reference to past and present logistics flights, with tables, colour diagrams and many illustrations to populate a tour-de-force of this billionaire entrepreneur's burning desire to put people on the surface of Mars. The book is less flamboyant than the architect of these ideas and if there is the feeling that sometimes Elon Musk just gets levitated by the sound of his own ambition, this book brings his actual accomplishments down to Earth – which is enough to provide solid facts and performance assessment.

Another gem from a prolific author, Assistant Professor, Commercial Space Operations, Embry-Riddle Aeronautical University.

2016 Sir Arthur Clarke Awards

The Sir Arthur Clarke Awards with receiving the Space Achievement – Education and Outreach award: (left to right) Susan Buckle, Libby Jackson, Jeremy Curtis and Lord Willetts.

Last month we published the winners of the 2016 Sir Arthur Clarke awards but space did not permit us to publish a full report on the events of that night, which we are delighted to do now.

This year the awards were presented during the prestigious Reinventing Space Conference Gala Dinner in the Royal Society in London on Thursday 27 October 2016. Hosted jointly by the Chair of the Arthur C. Clarke Foundation Board, Ms Walda Roseman, and President of the British Interplanetary Society, Mr. Mark Hempsell, the finalists, three in each category, were invited to join the 100 guests at a pre-dinner reception.

Mark Hempsell took this opportunity to present one of the finalists, Dr Helen Sharman, with her British Interplanetary Society Honorary Fellowship certificate to mark the 25th anniversary of her trip to the Mir Space Station as Britain's first astronaut in 1991 and to recognize the amazing contribution she has made as a Space Ambassador promoting STEM education, astronautics and an active manned-Space programme in the UK. Tim Just, Head of Space at Innovate UK, as sponsor of the Reception, then spoke about Innovate UK and its support for the UK Space sector before introducing Rick Tumlinson, CEO Deep Space Industries, who reminisced about his meetings with Sir Arthur whose remarkable connections enabled doors to be opened not only to the inner sanctums of the science and technology world, but onto the film sets of the latest science fiction movies as well.

Moving through to the Wellcome Trust Hall, the guests enjoyed a sumptuous dinner before the Award Ceremony, part sponsored by the UK Space Agency, began and the winners of each of this year's 10 Awards were announced (see *Spaceflight* Vol 59, No 1, page 36).

Angie Edwards, Chair of the Judging Panel, began the award ceremony by quickly reminding everyone that Sir Arthur was her uncle. Her father Fred, Sir Arthur's brother, became custodian of the UK 'Clarkives'.

She went on to say, "When Dave Wright and Jerry Stone approached Uncle Arthur to ask if he'd like to put his name to these Space awards he was absolutely thrilled. Though his name had been associated for some years with science fiction awards, as a scientist himself his joy was always hard science and to be recognised and asked to be involved with something that was to do with hard science and space meant an enormous amount to him. He was truly honoured."

Angie then cleverly made the link between the imagination and vision of Sir Arthur and the reality of Tim Peake's 'Principia' mission to the ISS and the excitement it caused amongst the children at her school. Then, with the wonders of science and the support of the Internet, Tim miraculously appeared on the massive screen behind her, all the way from Houston.

After a quick "Hi Tim" Angie handed over the lectern to Lord David Willetts, who as Space Minister had made 'Principia' happen. He presented Tim with his well-deserved Special Award for Individual Outreach which magically appeared on screen to be warmly accepted by him. Tim then announced the winners of the Education and Outreach Award which unsurprisingly went to the UK Space Agency Principia Education Team and the Media Award which went to BBC News' David Shukman for his reporting of Tim's mission to the ISS, from start to finish. Lord Willetts presented both these awards and then announced the winner of the Special Education Award, Mike Grocott for founding the UK's first Space Studio School in Banbury.

Helen Sharman, the UK's first astronaut, was then invited to present the Awards for

the Industry/Project Team which, won by the SSTL Galileo Team, was collected by Elizabeth Rooney, a leading figure within the SSTL team and the In-Orbit Test/ Operations manager for the Full Operational Constellation. Helen followed this by presenting the Industry/Project Individual Award to Dave Honess for his leadership of the Astro Pi project that put two Raspberry Pis on to the International Space Station.

Mark Hempsell, President of the British Interplanetary Society, then took to the stage to announce the winner of the Academic Study/Research award and present it to Dr Harry Ward and his LISA Pathfinder team, mostly kilted, from the University of Glasgow for the development of the LISA Optical Bench Interferometer and the Student Award to Joseph Dudley, Chair of UKSEDS, for his long and dedicated service to UKSEDS.

Finally, the moment many had been waiting for: Walda Roseman, Chair of the Sir Arthur C. Clarke Foundation Board, presented the Lifetime Achievement Award to Pat Norris for his 50 years' service to the Space industry and the International Achievement Award to David Hartshorn, Secretary General, the Global VSAT Forum for its support to, and promotion of, the Satellite industry. Walda took the opportunity to tell the audience about the 100th anniversary of the birth of Arthur C. Clarke in 2017 and the Foundation's plan for a year of celebrations. To end the evening Alistair Scott, Past President, BIS, announced the date of the next Awards Ceremony at the UK Space Conference Dinner in Manchester on 1 June 2017 and asked everyone to get their nominations in early.

Alistair Scott

Rockets in Droitwich

Just some of the Rocket Flight audience at Droitwich on 26 November 2016. *Mark Perman*

On Saturday 26 November the West Midlands Branch held its latest event, a showing of the rarely seen, 1946 Royal Air Force film "Rocket Flight" at the Gardeners Arms pub in Droitwich. A few of us had lunch at the pub beforehand and then Robin Brand head of BIS Technical Projects gave us a fascinating overview of the current projects after which we settled down to enjoy the film.

The film had been compiled mainly from captured footage and detailed the work done on rockets and missiles in Germany before and during the Second World War. It started with a look at the early days of heavier than air flight then showed the rocketry enthusiasts' work from the 1920's and 1930's and made comparisons between the two.

Some mention was made of the German armed forces interest in solid rocket motors, however the main focus of the film was liquid propellant rocket and missile development. The hydrogen peroxide systems of the Walter company both cold (catalysed hydrogen peroxide) and Hot (bipropellant) were covered in some detail including propellant handling.

BMW's involvement in rocket propulsion, namely their work on bipropellant systems using nitric acid as the oxidiser was covered along with film of BMW test facilities which unsurprisingly look very similar to those built at the Rocket Propulsion Establishment at Westcott shortly after the war.

The V2 was covered but interestingly not in great detail. Most of the missiles in development at the end of war in Germany were described, the most notable exceptions being the ground-to-air Taifun and the Natter rocket powered interceptor! Oddly there was quite a long sequence on the German version of the bouncing bomb!

The final section of the film speculated on the future of rocketry for space travel and included sequences from Fritz Lang's *Frau im Mond*.

"Rocket Flight" is a fascinating review of the progress made during the period. After the film John Harlow, West Midlands Branch Chair, led a lively discussion on what we had seen.

Do keep a look out for future West Midlands Branch events via the BIS Website or the Branch Group Page on Facebook.

Mark Perman

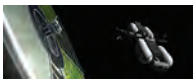
New BIS Members

Giuseppe Mattia, Italy
Simon Pipe, Hampshire
Anthony Newland, Fife
Walter Stroud, Cornwall
Michael Churchouse, Essex
Sebastian Hill, Hampshire
Jessica Attard, Australia
Kerry Sanz, Ruislip
Marianne Schuldt, Germany
Emanuele Bedetti, Italy
Guilia Cammarata, Italy
David Germroth, USA
Adam McSweeney, Kent
Rajesh Kulkarni, Birmingham
Toby Prudden, London
Patrick Mahon, Buckinghamshire
Calum Ryan, Ayrshire
Charlotte Morrison, Essex
Fred H. Francis, USA
Sergio Abbatiello, Belgium

BIS Lectures and Meetings

Future Histories and Forecasting

25 January 2017



Following the successful session at the BIS Space Conference, the British Interplanetary Society is staging a one-day symposium on the subject of hypothetical future histories and technical forecasting in both science fiction and space programme planning.

Space Law and the UN Treaty

31 January 2017

Speakers: Michael Franks, Adam Manning, Mike Leggett and Jerry Stone

The SPACE Project is a BIS study to re-examine and update the space colony plans from the 1970s. Unlike most BIS projects this covers many topics beyond the engineering aspects. These include the legal situation regarding the use of material from the Moon or asteroids, and how a space colony might be governed. The UN Treaty on the Peaceful Uses of Outer Space prohibits governments from claiming celestial bodies, but what about a private company or consortium that wants to use lunar material?

The evening will include the following topics: What law would apply to a space colony? Would it be necessary to draw up articles of association between the colonist like the 19th Centaury Pirate articles; What are the Treaty's implications for private organisations seeking to mine asteroids or build settlements on the Moon or Mars? Is Space Law's concept of the common heritage of mankind appropriate in the age of SpaceX, Blue Origin, Deep Space Industries and Planetary Resources?; What is the technical and commercial potential of the utilisation of extraterrestrial resources?

Call for Papers

Cosford V

18-19 March 2017

The next 'Cosford' conference event is being organized by the BIS West Midlands branch in conjunction with the BIS History group and is to be held over the weekend 18/19 March 2017. This will be the 5th in the series and as before will be held at the Royal Air Force Museum facilities at Cosford, Shifnal, Shropshire.

Presentations and papers are being sought and current proposals show a broader subject matter and coverage than on previous such events. Thus, the programme promises something for everyone. There will also be an opportunity to hear from members of the History Committee themselves about the results of their on-going research and current initiatives.

Further information will be published in the next issue of *Spaceflight*.

Call for Papers

37th BIS Soviet/Chinese Technical Forum

3-4 June 2017

During the weekend of 3rd and 4th June 2017 the BIS will be holding its annual Soviet/Chinese Technical Forum at the Society's Headquarters in London. The Society is now accepting proposals for papers from former and new speakers to be included at this year's Forum.

The Soviet/Chinese Technical Forum is one of the most popular and longest running events in the Society's history. This year will mark the 37th Forum since its inception in 1980 and will continue the tradition of featuring a wide ranging agenda. Details of the programme are being finalised but will feature presentations, films and debates on the history, current activities and future plans of both the Russian and Chinese space programmes.

Speakers are invited to provide a short biography and synopsis of their paper. Updates to the programme will be published over the coming months and a selection of papers from the Forum will be published in a special edition of *Space Chronicle*.

With a traditionally varied and exciting programme planned we encourage members to support the event, visit the heart of the BIS and take the opportunity to meet old friends and establish new contacts.

Speakers are asked to send details of their papers via the BIS - events@bis-space.com - to Dave Shayler, Coordinator of the 2017 Soviet/Chinese Forum.

Readers are reminded that these Notices contain only a reduced description of the event. Full details can be found on the website at www.bis-space.com/whats-on, where any updates are also carried.

Lectures

Venue: BIS HQ, 27/29 South Lambeth Road, London, SW8 1SZ, unless otherwise stated.

Members can attend free of charge. Places must be booked in advance, online or by post. Each member may also obtain a free ticket for one guest subject to availability of space.

Non-Members are able to attend the Society's lectures for a fee. You can order a ticket online or by post (please make cheques payable to the British Interplanetary Society). If oversubscribed Society Members will be given priority.

If applying via our website the confirmation receipt is your entry ticket.

If, for reasons outside its control, the Society is required to change the date or topic of a meeting, every effort will be made to avoid inconvenience to attendees either by notice of change in ***Spaceflight/JBIS***, on our website or by special advice to each participant.

Readers are reminded that these Notices contain only a reduced description of the event. Full details can be found online:

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