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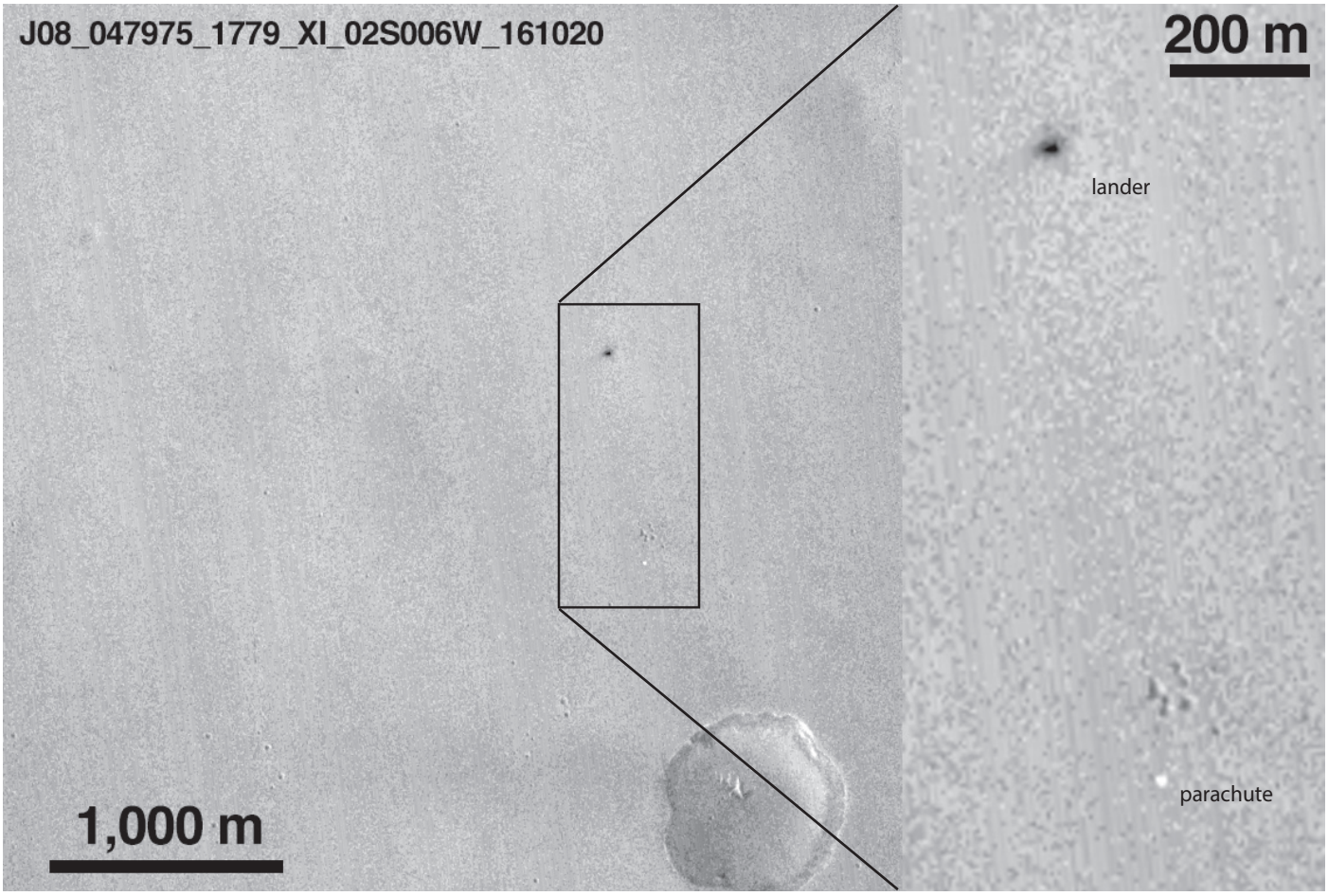
Computing glitch may have doomed Mars lander

Researchers sift through clues after Schiaparelli crash in hopes of averting mistakes in 2020 mission



NASA's Mars Reconnaissance Orbiter has identified new markings on the surface of the Red Planet that are believed to be related to Europe's Schiaparelli test lander, which arrived at Mars on 19 October.

The new image shows a bright spot that may be Schiaparelli's parachute, and a larger dark spot interpreted as resulting from the impact of the lander itself following a much longer free fall than planned, after thrusters switched off prematurely. It was taken by the Context Camera (CTX) on NASA's Mars Reconnaissance Orbiter and is available online, as a before-and-after comparison with an image from May 2016, at:

http://mars.nasa.gov/multimedia/images/?ImageID=8131

Image: NASA
www.jpl.nasa.gov

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Editor: Mike Bryce | President: David J Shayler | Secretary: Dave Evetts

Honorary Member: Helen Sharman OBE

space news roundup

Cover Story...
Photos of a huge circle of churned-up Martian soil leave few doubts: a European Space Agency (ESA) probe that was supposed to test landing technology on Mars crashed into the red planet instead, and may have exploded on impact.

Mars-probe loss is a chance for ESA to learn
The events of 19 October may be painful for ESA scientists to recall, but they will now have to relive them over and over again in computer simulations. The lander, called Schiaparelli, was part of ESA's ExoMars mission, which is being conducted jointly with the Russian Space Agency Roscosmos. It was a prelude to a planned 2020 mission, when researchers aim to land a much larger scientific station and rover on Mars, which will drill up to 2-metres down to look for signs of ancient life in the planet's soil. Figuring out Schiaparelli's faults and rectifying them is a priority, says Jorge Vago, project scientist for ExoMars. "That's super important. I think it's on everybody's mind."

Anatomy of a crash
Unlike the British-led and ESA-operated Beagle 2 mission, which disappeared during its landing on Mars on Christmas Day 2003, Schiaparelli sent data to its mother ship during its descent. Preliminary analysis suggests that the lander began the manoeuvre flawlessly, braking against the planet's atmosphere and deploying its parachute. But at 4 minutes and 41 seconds into an almost 6-minute fall, something went wrong. The lander's heat shield and parachute ejected ahead of time, says Vago. Then thrusters, designed to decelerate the craft for 30 seconds until it was metres off the ground, engaged for only around 3 seconds before they were commanded to switch off, because the lander's computer thought it was on the ground.

The lander even switched on its suite of instruments, ready to record Mars's weather and electrical field, although they did not collect data. "My guess is that at that point we were still too high. And the most likely scenario is that, from then, we just dropped to the surface," says Vago.

The craft probably fell from a height of between 2 and 4 kilometres before slamming into the ground at more than 300 kilometres per hour, according to estimates based on images of the probe's likely crash site, taken by NASA's Mars Reconnaissance Orbiter on 20 October.

The most likely culprit is a flaw in the craft's software or a problem in merging the data coming from different sensors, which may have led the craft to believe it was lower in altitude than it really was, says Andrea Accomazzo, ESA's head of solar and planetary missions. Accomazzo says that this is a hunch; he is reluctant to diagnose the fault before a full post-mortem has been carried out. But if he is right, that is both bad and good news.

European-designed computing, software and sensors are among the elements of the lander that are to be reused on the ExoMars 2020 landing system, which, unlike Schiaparelli, will involve a mixture of European and Russian technology. But software glitches should be easier to fix than a fundamental problem with the landing hardware, which ESA scientists say seems to have passed its test with flying colours. "If we have a serious technological issue, then it's different, then we have to re-evaluate carefully. But I don't expect it to be the case," says Accomazzo.

The ExoMars team will try to replicate the mistake using a virtual landing system designed to simulate the lander's hardware and software, says Vago, to make sure that scientists understand and can deal with the issue before redesigning any aspects of ExoMars 2020.

2020 vision
The rover mission has already been delayed by two years, owing to hold-ups on both Russian and European sides, but Vago believes that making tweaks to its design will not push the mission back. "At this point, no one wants to think about flipping to 2022. It was painful enough to go from 2018 to 2020," he says.

The full story can be found in Nature: http://www.nature.com/news/computing-glitch-may-have-doomed-mars-lander-1.20861

New Horizons Returns Last Bits of 2015 Flyby Data to Earth

NASA's New Horizons mission reached a major milestone this week when the last bits of science data from the Pluto flyby – stored on the spacecraft's digital recorders since July 2015 – arrived safely on Earth.

Having traveled from the New Horizons spacecraft over 3.4 billion miles, or 5.5 billion kilometers (five hours, eight minutes at light speed), the final item – a segment of a Pluto-Charon observation sequence taken by the Ralph/LEISA imager – arrived at mission operations at the Johns Hopkins Applied Physics Laboratory (APL) in Laurel, Maryland, at 5:48 a.m. EDT on Oct. 25. The downlink came via NASA's Deep Space Network station in Canberra, Australia. It was the last of the 50-plus total gigabits of Pluto system data transmitted to Earth by New Horizons over the past 15 months.

"The Pluto system data that New Horizons collected has amazed us over and over again with the beauty and complexity of Pluto and its system of moons," said Alan Stern, New Horizons principal investigator from Southwest Research Institute in Boulder, Colorado. "There's a great deal of work ahead for us to understand the 400-plus scientific observations that have all been sent to Earth. And that's exactly what we're going to do—after all, who knows when the next data from a spacecraft visiting Pluto will be sent?"

Because it had only one shot at its target, New Horizons was designed to gather as much data as it could, as quickly as it could – taking about 100 times more data on close approach to Pluto and its moons than it could have sent home before flying onward. The spacecraft was programmed to send select, high-priority datasets home in the days just before and after close approach, and began returning the vast amount of remaining stored data in September 2015.

"We have our pot of gold," said Mission Operations Manager Alice Bowman, of APL.

Bowman said the team will conduct a final data-verification review before erasing the two onboard recorders, and clearing space for new data to be taken during the New Horizons Kuiper Belt Extended Mission (KEM) that will include a series of distant Kuiper Belt object observations and a close encounter with a small Kuiper Belt object, 2014 MU69, on 1 January 2019.

NASA
www.nasa.gov

Mission Complete: Rosetta's Journey Ends In Daring Descent To Comet

ESA's historic Rosetta mission has concluded as planned, with the controlled impact onto the comet it had been investigating for more than two years.

Confirmation of the end of the mission arrived at ESA's control centre in Darmstadt, Germany at 11:19 GMT (13:19 CEST) with the loss of Rosetta's signal upon impact.

Rosetta carried out its final manoeuvre, setting it on a collision course with the comet from an altitude of about 19 km. Rosetta had targeted a region on the small lobe of Comet 67P/Churyumov–Gerasimenko, close to a region of active pits in the Ma'at region.

Pits are of particular interest because they play an important role in the comet's activity. They also provide a unique window into its internal building blocks.

The information collected on the descent to this fascinating region was returned to Earth before the impact. It is now no longer possible to communicate with the spacecraft.

"Rosetta has entered the history books once again," says Johann-Dietrich Wörner, ESA's Director General. "Today we celebrate the success of a game-changing mission, one that has surpassed all our dreams and expectations, and one that continues ESA's legacy of 'firsts' at comets."

"Thanks to a huge international, decades-long endeavour, we have achieved our mission to take a world-class science laboratory to a comet to study its evolution over time, something that no other comet-chasing mission has attempted," notes Alvaro Giménez, ESA's Director of Science.

"Rosetta was on the drawing board even before ESA's first deep-space mission, Giotto, had taken the first image of a comet nucleus as it flew past Halley in 1986.

"The mission has spanned entire careers, and the data returned will keep generations of scientist busy for decades to come."

Comet landing sites in context

"As well as being a scientific and technical triumph, the amazing journey of Rosetta and its lander Philae also captured the world's imagination, engaging new audiences far beyond the science community. It has been exciting to have everyone along for the ride," adds Mark McCaughrean, ESA's senior science advisor.

Since launch in 2004, Rosetta is now in its sixth orbit around the Sun. Its nearly 8 billion-kilometre journey included three Earth flybys and one at Mars, and two asteroid encounters.

The craft endured 31 months in deep-space hibernation on the most distant leg of its journey, before waking up in January 2014 and finally arriving at the comet in August 2014.

After becoming the first spacecraft to orbit a comet, and the first to deploy a lander, Philae, in November 2014, Rosetta continued to monitor the comet's evolution during their closest approach to the Sun and beyond.

The decision to end the mission on the surface is a result of Rosetta and the comet heading out beyond the orbit of Jupiter again. Further from the Sun than Rosetta has ever journeyed before, there would be little power to operate the craft.

ESA
www.esa.int

US State of Florida Boosts' SpaceX's Mission to Fly US Astronauts from US Soil

SpaceX's preparations to launch astronauts from Kennedy Space Center received a $5 million boost from the state on Wednesday.

During a special meeting, Space Florida's board of directors agreed to provide the money to help SpaceX install an access arm at historic pad 39A that astronauts will use to board Dragon capsules bound for the International Space Station, possibly in 2018.

Officials said SpaceX, which must at least double the state's contribution, planned to invest $25 million in the project, creating 130 construction jobs.

"Obviously an important project, and moving to Commercial Crew is both exciting and an important part of the future of the spaceport," said William Dymond, chairman of Space Florida's board.

The project represents the second phase of SpaceX's renovations to pad 39A, a former Saturn V and shuttle pad that the company is outfitting to support launches of Falcon 9 and Falcon Heavy rockets, including astronaut flights in Dragon spacecraft being upgraded under NASA's Commercial Crew Program.

Space Florida had already contributed $5 million to the first phase of renovations, which included construction of a large hangar at the pad's base and systems to roll Falcon rockets up the pad and lift them into a vertical position.

Officials said SpaceX had spent more than $75 million and created 90 jobs to complete that work, and was "going gangbusters" to ready for crew launches, hence the need for a special meeting to consider the new funding before one scheduled in late November.

"The urgency is to get the pad up and ready so all the certification can be done on all systems that support that," said Jim Kuzma, Space Florida's operations chief.

The state's support came nearly two months after a Falcon 9 rocket exploded during a countdown rehearsal at nearby Launch Complex 40 at Cape Canaveral Air Force Station.

SpaceX continues to investigate the cause of a breach in the helium system used to pressurize the upper stage's liquid oxygen tank. The company initially said it hoped to return the Falcon 9 to flight in the "November timeframe" from either Florida or California, but there is no target date yet.

Any near-term launch from Florida was expected to use pad 39A at KSC rather than pad 40, which was damaged by the explosion.

Along with SpaceX, state funding is also helping Boeing, NASA's other Commercial Crew partner, to renovate a former shuttle hangar and launch pad where Starliner crew capsules will be assembled and launched to the ISS on United Launch Alliance's Atlas V rockets.

Space Florida each year picks projects to receive money from the state Department of Transportation for upgrades of spaceport infrastructure.

Florida Today
www.floridatoday.com

Scientists solve mystery of Beagle 2 Mars lander

Scientists may have solved the mystery of what happened to the ill-fated Mars lander Beagle 2 thanks to an innovative research technique.

The probe was discovered on the Red Planet in November 2014 but uncertainty surrounded what had caused its failure to communicate with Earth.

Now, a collaboration between De Montfort University Leicester (DMU) and the University of Leicester has used 3D modelling technology to reveal for the first time that Beagle 2 did not crash land as previously thought.

Instead analysis by DMU's visualisation specialist Teodora Kuzmanova found Beagle 2 deployed at least three of the solar panels it was supposed to after touching down on the planet's surface.

It may be that the antenna may have been transmitting as planned - but the signal could not get through because the fourth panel had not opened properly.

Beagle 2 was successfully ejected from ESA's Mars Express spacecraft on 19 December 2003 but failed to send a signal on Christmas Day - its scheduled landing day on Mars.

It was presumed lost until over a decade later when the mystery of what happened to the mission was solved when images taken by NASA's Mars Reconnaissance Orbiter (MRO) recorded it on the surface of the planet.

However, because of the MRO camera resolution and the size of Beagle 2 it was not clear what had happened to it.

Professor Mark Sims, former Beagle 2 Mission Manager and Professor of Astrobiology and Space Instrumentation at the University of Leicester came up with the concept of "reflection analysis" - of matching simulated and real images of Beagle 2.

The technique is based on simulating possible configurations of the lander on the surface and comparing the light of the Sun reflected by the simulated lander with the unprocessed images available from the HiRISE camera at a number of different sun angles.

Professor Sims turned to a team at DMU to realise his concept. Commercially available software used for 3D modelling, animation, visual effects and simulation design was adapted to enable this analysis.

Nick Higgett leader of the DMU simulation team said: "This has been an exciting collaboration with the University of Leicester's Space Research Centre.

"The De Montfort team were responsible for all the 3D simulation work to test the reflection analysis concept.

"In order to do this, our visualisation specialist Teodora Kuzmanova had to create a physically accurate 3D model of the Beagle 2 Mars Lander with surfaces that would accurately reflect virtual sunlight.

"The angle of the sun had to be simulated along with position of a virtual camera that could take pictures equivalent to NASA's Reconnaissance Orbiter. Finally these images had to be pixelated to match the resolution of the Orbiter's images.

"We are delighted to say that we have gone way beyond this original plan to reach this exciting conclusion that Beagle 2 did not crash but landed and probably deployed most of its panels. Hopefully these results help to solve a long held mystery and will benefit any future missions to Mars."

Professor Mark Sims praised the DMU team for making his idea a reality.

He added: "The work shows frustratingly that Beagle 2 came so close to working as intended on Mars.

"This unique University collaboration between space scientists and digital designers allowed this reflection analysis concept to be put into practice and tested and ultimately produce these exciting results."

This work confirmed that antenna transmission would probably have been hampered by one of the panels failing to unfold correctly, confirming the previously supposed theory.

Mr Higgett said it was as close to a definitive explanation as would be possible without landing on the planet itself.

Beagle 2, a collaboration between industry and academia, would have delivered world-class science from the surface of the Red Planet. It was sent there to search for signs of life by analyzing soil for organic molecules.

Many UK academic groups and industrial companies contributed to Beagle 2. Its enthusiastic leader was Professor Colin Pillinger from the Open University who died in May 2014 before the fate of the lander was revealed.

Others who also died in 2014 and provided major contributions to Beagle 2 were Professor George Fraser of the University of Leicester and Professor David Barnes of Aberystwyth University.

De Montford University
http://www.dmu.ac.uk

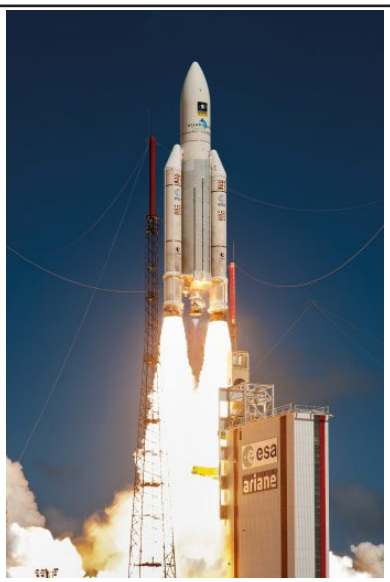
Ariane 5 Update

For its fifth Ariane 5 launch from the Guiana Space Center in French Guiana, Arianespace successfully orbited two satellites: Sky Muster™ II for the Australian operator NBN (National Broadband Network), and GSAT-18 for the Indian space agency ISRO (Indian Space Research Organization). Sky Muster™ II and GSAT-18 are the 542nd and 543rd satellites to be launched by Arianespace.

For its sixth Ariane 5 liftoff, Arianespace orbited four more satellites for the Galileo constellation. The mission was performed on behalf of the European Commission under a contract with the European Space Agency (ESA).

For the first time, an Ariane 5 ES version was used on 17 November, to orbit 4 satellites in Europe's own satellite navigation system. At the completion of this flight, designated Flight VA233 in Arianespace's launcher family numbering system, 18 Galileo spacecraft will have been launched by Arianespace.

Arianespace
www.arianespace.com



Astronaut News

By Rob Wood

New Chinese Space Mission

China's sixth manned spaceflight began on 17 October 2016 with the launch of Shenzhou 11. It contained a crew of two taikonauts for a mission to the Tiangong 2 space station. As I write the two taikonauts are on the 27th day of their flight which is due to last about 33 days.

Jing Haipeng (Major-General, People's Liberation Army) was born on 24 October 1966 near Yuncheng City, Shanxi Province. He is the holder of two undergraduate degrees. In 1984 he registered for an aviation examination but was not accepted at that time due to failing his medical. He passed his medical the following year and joined the People's Liberation Army in June 1985.

He trained as a fighter pilot and graduated from flight school in 1990. He has flown a variety of aircraft including the iconic Shenyang J-6 (NATO designation 'Farmer'), which was China's version of the Soviet Union's Mikoyan-Gurevich MiG-19. He logged 1,200 safe flying hours and was appraised as a pilot of the first-grade of the air force.

He was selected as a taikonaut on 5 January 1998 (China Group 1). He was the first taikonaut to make a second spaceflight and the first to fly three times. He was one of six taikonauts who trained for China's second manned spaceflight, Shenzhou 6, and served as a member of one of the two back-up crews for the flight which launched on 12 October 2005.

He made his first spaceflight on Shenzhou 7 (25-28 September 2008) as descent module pilot. The flight was China's third manned spaceflight and its crew conducted China's first extravehicular activity (EVA) operations. During the EVA he remained in the pressurized descent module from where he supported the two taikonauts in the orbital module. Jing was awarded the title 'Hero Astronaut' following the flight.

China's first space station, Tiangong 1, launched on 29 September 2011, was visited by the unmanned Shenzhou 8 in November 2011. Jing's second spaceflight was as commander for Shenzhou 9/Tiangong 1 (16-29 June 2012). This was China's first manned space station mission.

China's second space station was launched on 15 September 2016 and would be the destination for Jing's third spaceflight. He was the commander for Shenzhou 11, launched on 17 October 2016. Docking with Tiangong 2 took place on 19 October 2016. He is married with one son.

Chen Dong (Lieutenant Colonel, People's Liberation Army) was born in 1978 in Luoyang, Henan Province. He joined the People's Liberation Army in 1997. He achieved the level of first-grade pilot of the air force and had logged 1,500 hours of safe flight time when he joined China's taikonaut corps. He was selected as a taikonaut in March 2010 (China Group 2). He was the co-pilot for the Shenzhou 11 mission to the Tiangong 2 space station. This is his first spaceflight. He is married with twin sons.

Too Tall Gets Extreme - Again

I mean extreme, as in adventuring. Having braved the heights of space and Mount Everest, Scott Parazynski turned to the other direction in the early summer of 2016 and plumbed the depths. In the first half of June 2016, he took part in an expedition to study the shipwreck of 'Andrea Doria'.

SS Andrea Doria was an Italian ocean liner that collided with another ocean liner, the MS Stockholm, about 40 miles southwest of the island of Nantucket, part of the USA state of Massachusetts. Although there was thick fog the two ships had radar so were aware of each other. The exact cause of the collision is still argued about today with both misinterpretation of the radar image and the more basic seamanship error of turning in the wrong direction having supporters.

Andrea Doria was carrying 1,706 people, 1,134 passengers and 572 crew and Stockholm carried 742 people with 534 passengers and 208 crew. A total of 51 people died, 46 passengers from the Andrea Doria including two resulting from injuries sustained in the evacuation of the ship and one from a heart attack after rescue, and 5 crewmembers from the Stockholm.

The collision occurred at just after 11pm on 25 July 1956. Despite serious damage to the bow of the Stockholm measures were taken to avoid the ship sinking. However, the Andrea Doria was less fortunate and quickly listed to starboard beyond its design capacity for survivability. Nevertheless, it still took 11 hours to sink and despite problems caused by the severe listing most of the surviving passengers and crew were evacuated safely.

Almost immediately, the wreck became a target for divers. Pictures of the ship on the bottom soon appeared in Life magazine that were taken as soon as the day after the sinking and it has continued to be a draw for divers. The ship's depth, together with sea conditions where it lies, puts it well beyond the scope of your average fun divers and even median level divers.

Diving to the ship was a real test of diving skills and there were casualties. Over the years the Andrea Doria has continued to cost lives. At least 16 divers have died either during dives or as a result of health complications immediately following dives (such as decompression sickness - otherwise known as the bends).

Parazynski certainly likes undertaking adventures with a record of danger. He has climbed Mount Everest which has seen the deaths of well over 200 climbers including another retired astronaut, Karl Heinze, who succumbed to high altitude pulmonary oedema, a complication of altitude sickness, on 5 October 1993. The profession of astronaut itself has seen 18 deaths on actual spaceflights plus another five during ground based training incidents and another two on test flights of spacecraft that were not actual spaceflights. Parazynski certainly likes excitement with a significant element of danger.

So why SS Andrea Doria, Parazynski says it is a "huge bucket list thing," although he also talked about the synergy between ocean exploration and space exploration. He explained about how, as well as the exploration benefits on Earth, the experiences can be used on other planetary bodies. "'We can take these types of technologies to explore extremophile life in the oceans," adding, "What might lie in the waters under the icy crust of Europa? If we can someday drop a submersible through the ice and swim around there, would we find extremophile life there as well?"

He was the co-pilot of Cyclops 1, the five-crewed submersible used for the expedition to the Andrea Doria in June 2016. Cyclops 1 has depth capabilities to 500 meters so the dive to the Andrea Doria, 60 to 80 metres, was well within its capabilities. Cyclops 1 is a joint project by OceanGate Inc., a subsea research, development and exploration company, and the University of Washington's Applied Physics Laboratory.

There were other partners in the exploration: iXBlue, providers of the underwater navigation equipment; Teledyne BlueView, who provided the multi-beam sonar hardware and software for capturing images; Boston Harbor Cruises, who supplied the support vessel 'Warren Jr.' that was the base for dive operations; and the University of Delaware's College of Earth, Ocean and Environment, who are involved in mapping the site of the wreck.

A submarine was used instead of divers for the expedition to enable more time underwater and better assessment of the wreck. Because of the depth and conditions divers can normally spend only about

20 minutes at the wreck site and usually with lousy visibility. They therefore cannot explore the full wreck. Unfortunately, even with the submarine, things did not go according to plan.

Surface weather conditions did not cooperate. There was low visibility due to fog, high winds and heavy seas. The expedition had to be curtailed. It was not a total loss as the submarine did manage 4 hours underwater and performed 17 sonar scans, although these were mainly focused on the bow. More visits are planned by OceanGate, who hope to mount an expedition in 2017, to continue their work on assessing the current condition of the wreck of Andrea Doria.

Scott Edward Parazynski was born on 28 July 1961 in Little Rock, Arkansas. He has a Bachelor of Science degree in Biology from Stanford University in 1983 and a Medical Doctorate from Stanford Medical School in 1989. Whilst at medical school, he was awarded a NASA Graduate Student Fellowship and conducted research at NASA-Ames Research Center on fluid shifts that occur during human spaceflight.

During his academic period he was also a top US athlete and competed on the United States Development Luge Team. He was ranked in the top 10 competitors in the nation during the 1988 Olympic Trials. Following his medical and astronaut careers, he served as Honorary Captain of the US Olympic Luge Team during the 2010 winter games in Vancouver, Canada.

He served his medical internship at the Brigham and Women's Hospital of Harvard Medical School (1989/90) and went on to complete almost two years as a resident physician in emergency medicine in Denver area hospitals (1990/1992) when he was selected for NASA's astronaut corps.

Years later he said, "My father worked on Apollo, and it was always a dream of mine to go to space. However, it only became tangible when I began my medical training at Stanford Medical School. It was there that I realized, with NASA's Ames Research Center just down the street, I could craft a career that combined my two life-long career aspirations: to be an explorer and physician." His father was an engineer for Boeing during the Apollo era.

He was a NASA astronaut from 1992 (NASA Astronaut Group 14) to 2009, making five spaceflights on the US Space Shuttle. As a crewmember of the shuttle, he visited the Russian space station Mir and the ISS (twice). His flights were STS-66/Atlantis (1994); STS-86/Atlantis to Mir (1997); STS-95/Discovery on which John Glenn at 77 became the oldest person to fly in space (1998); STS-100/Endeavour to ISS (2001); and STS-120/Discovery to ISS (2007).

He accumulated over 47 hours of EVA time over seven spacewalks. His last one, whilst STS-120 was docked to the ISS, included an unplanned repair of a solar array. The astronauts had to jury rig the tools and equipment and the EVA is regarded by many as one of the most challenging and dangerous ever performed. Parazynski was positioned by the space stations robotic arm (Canadarm 2) further away than any orbiting astronaut had ever ventured from the safety of their airlock.

In 1995, he spent several months living and training at the Yuri Gagarin Cosmonaut Training Centre. He had been selected to fly a long duration mission to the Russian Mir space station during the Mir/Shuttle Programme but then the situation occurred that led to him receiving a new nickname, 'Too Tall'. Concerns were raised that because of spinal stretching during spaceflight he would not be able to sit safely in a Soyuz descent module during an emergency evacuation. His Mir expedition training was discontinued.

The Soyuz has been continually upgraded since it first flew in the 1960's and in 2002 a new variant came into service; the Soyuz TMA version. Amongst the upgrades was the ability to take taller and heavier astronauts but this was too late for Parazynski. He did get to visit Mir in 1997 but this was as a Space Shuttle visiting crew member.

NASA's official biography in part records that he "retired from NASA in March 2009 to work in private industry and to pursue other entrepreneurial and exploration interests." His effective leaving date was 13 March. Only two months later, on 19 May 2009, he became the first astronaut to reach the summit of Mount Everest.

In the years that followed he has held many positions in the business, medical and academic worlds including as a director of business development for Wyle's Integrated Science and Engineering Group; Chief Medical Officer and Chief Technology Officer of The Methodist Hospital Research Institute; Chairman of the Board of the Challenger Center for Space Science Education; visiting professor of space medicine at the University of Oxford; University Explorer at Arizona State University; and his latest ventures as Non-Executive Director for Blue Abyss Ltd., an aquatic, aerospace and extreme environment research and training company based in the UK plus his own company Apogee Interests as founder and Managing Director, both from June 2016.

Shuttle Pilot and ISS Astronaut Retires

On 23 August 2016, NASA released the news that Terry Virts was leaving NASA on that day. He had spent 16 years as part of NASA's astronaut squad and made two spaceflights. There was no indication as to what his future plans were.

Terry Wayne Virts (Colonel, USAF) was born on 1 December 1967, in Baltimore, Maryland. Even in kindergarten he knew he wanted to be an astronaut. There, the first book he read was on the Apollo moon landings. All four walls of his bedroom were covered in posters on space and aircraft. His parents also worked for NASA, at the Goddard Space Flight Center, so there was almost a natural progression for him into the space programme. Education and the military would however get in the way first.

In 1985 he was accepted into the United States Air Force (USAF) Academy. On graduation in 1989 he received a Bachelor of Science degree in Mathematics with a minor in French and was commissioned as a second-Lieutenant in the USAF.

He entered flight school at Williams Air Force Base from where he earned his pilot wings in 1990. Basic jet fighter training at Holloman Air Force Base followed, before commencing advanced training at MacDill Air Force Base on the Lockheed Martin F-16 Fighting Falcon single-engine supersonic multirole fighter aircraft. It was in this aircraft that he spent most of his operational career.

He served with several squadrons before a posting to the 22nd Fighter Squadron at Spangdahlem Air Base in Germany led to him flying 45 combat missions in the F-16 to supress Iraqi air defences during the US wars against Iraq.

In 1997 he received a Master of Science degree in Aeronautics from the Embry-Riddle Aeronautical University and was accepted for the USAF Test Pilot School at Edwards Air Force Base. He graduated from the test pilot school in 1998 and was assigned to the F-16 test squadron at the USAF Test Center also at Edwards.

He was the Chief Test Pilot for the F-16 HARM Targeting System as well as the Multi-Mission Computer Programme, the largest upgrade package in the long history of the F-16. Although his flying career was very much linked to the F-16, he has actually flown more than 40 aircraft and logged over 4,300 flight hours through to 2013.

Whilst he was still going through test pilot school he heard that NASA was recruiting for a new astronaut class. He discussed this with others and was told to wait for the next selection because he was too young and not experienced enough; after all he was only still a student test pilot. He decided to reject their advice and let the USAF or NASA say no. He applied through the Air Force (serving military personnel have to apply through their parent service). He passed their checks and they forwarded his application to NASA.

In January 2000 he was called for a week long series of interviews and tests with NASA in Houston. He was told the applicants would hear by March. But March came and went with no contact. Finally on 20 July 2000 Charles Precourt, the Chief of the Astronaut Office, called him and asked the usual question about was he still interested in becoming an astronaut. As if...

He was named as a pilot astronaut candidate on 26 July 2000 (NASA Astronaut Group 18) in a press release issued on that date. His first crew assignment was as a support astronaut for ISS Expedition 9 which flew in 2004. He worked as a CapCom for numerous ISS Expeditions and Space Shuttle missions through 2004 to 2009.

He served as pilot for STS-130/Endeavour (8-21 February 2010) on a mission that carried the Tranquility and Cupola modules to the ISS. These were the final US pressurized modules for the space station. As well as his pilot responsibilities Virts was also the lead robotic arm operator and as such worked with the shuttle's Canadarm 1 and the ISS's Canadarm 2 during the installation of the two new modules.

He was back-up for Soyuz TMA-13M/ISS Expeditions 40/41, which launched on 28 May 2014 before making his second spaceflight on Soyuz TMA-15M/ISS Expeditions 42/43 (24 November 2014 – 11 June 2015). He was a flight engineer for Soyuz and ISS Expedition 42, and commander for ISS Expedition 43. He was involved in many experiments and projects, and made three spacewalks during his stay on the station.

Cosmonaut Divorce from Spaceflight

On 2 September 2016, the second most experienced space traveller stood down as an active cosmonaut. Yuri Malenchenko had spent 827 days in space over six missions. Only Gennady Padalka with 878 days in space is ahead of him at present. He has flown on Soyuz and Space Shuttle spacecraft and conducted tour of duties on two space stations, Mir and the ISS. He has not left the Yuri Gagarin Cosmonaut Training Centre but has taken up a senior management position as a departmental chief.

Yuri Ivanovich Malenchenko was born on 22 December 1961, in Svitlovodsk, Kirovograd Oblast, Ukrainian Soviet Socialist Republic (now Ukraine). After service in the Soviet air force as a fighter-pilot he was accepted for cosmonaut training in 1987. He holds a unique record in that he is the only human to get married whilst in space. On 10 August 2003 he was on the ISS and his bride was in Houston. Fortunately, the State of Texas allows wedding ceremonies in the absence of one of the partners.

His sixth and last spaceflight ended in June 2016 after an 185 day mission to the ISS. His spaceflight time started with a 125 day mission to Mir in 1994. This was followed by five visits to the ISS, initially as a mission specialist on the US Space Shuttle followed by four ISS Expeditions. First up was a stint as back-up for Soyuz TM-18/Mir-15 launched on 8 January 1994 before he made his inaugural spaceflight as commander of Soyuz TM-19/Mir-16 (1 July – 4 November 1994). During the mission he performed two spacewalks.

He was then assigned to ISS training from 1997 and from October 1998 trained to fly on the US Space Shuttle. He was MS-4 for STS-106/ Atlantis (8-20 September 2000) on its visit to the nascent ISS to help prepare the station for its first resident crew due in November 2000. As part of this process he conducted his third EVA overall, helping to connect electrical, communications and telemetry cables between the recently arrived Zvezda Service Module and the Zarya Control Module.

At regular intervals, ISS residencies followed: Soyuz TMA-2/ISS Expedition 7 (26 April – 28 October 2003); Soyuz TMA-11/ISS Expedition 16 (10 October 2007 – 19 April 2008); Soyuz TMA-05M/ISS Expeditions 32/33 (15 July – 19 November 2012); and Soyuz TMA-15M/ISS Expeditions 46/47 (15 December 2015 – 18 June 2016). Apart from the first of these he also served on back-up crews shortly before his flights. He always commanded the Soyuz part of the missions but his only ISS command was his first expedition, ISS-7. He made one spacewalk on each of his last three spaceflights to bring his total to six.

On Soyuz TM-19 in 1994, Malenchenko's flight engineer was Talgat Musabayev who was also making his first spaceflight on a two-person crew making it an unusual, all-rookie crew. They were the first Russian vehicle all-rookie crew launch since Soyuz 25 in 1977 and since Soyuz TM-19, there has only been one other, Soyuz TMA-12, in 2008. On-board Soyuz TMA-12 was Yi So-yeon, South Korea's first flown astronaut. She made a short visit to the ISS and with one of those coincidences that often occurs, she returned to Earth on Soyuz TMA-11 with Malenchenko.

Also in the descent module of Soyuz TMA-11 was US astronaut Peggy Whitson. This was a very different team to the one that Yi had launched with. None of Sergei Volkov, Oleg Kononenko and Yi had been in space before. Not only had she now spent 10 days in space but Malenchenko was returning at the end of his fourth flight including three long duration missions and Whitson was at the end of her second long duration flight. Between the three of them they had accumulated 900 days in space.

China's first three manned missions in 2003, 2005 and 2008 were all rookie crews but these were exceptions to the norm. The US Space Shuttle saw 135 missions between 1981 and 2011 and only the second in November 1981 had an all-rookie crew. Regular all-rookie crews had launched from 1961 to 1977 but from then they became a rarity.

September Sees Two More

The Russian cosmonaut team saw even more contraction in September 2016. Following Malenchenko's retirement on 2 September 2016, two more left on 23 September 2016. This followed elections to the State Duma of the Federal Assembly of the Russian Federation (part of Russia's Parliament – lower house of the Federal Assembly) on 18 September 2016 which saw two active cosmonauts elected as deputies. This meant they had to relinquish their active status as cosmonauts and this was confirmed by the chief of the Yuri Gagarin Cosmonaut Training Centre on 23 September 2016.

The two cosmonauts were Elena Serova and Maksim Surayev. This leaves 33 active cosmonauts. Most are attached to the main squad based at the Yuri Gagarin Cosmonaut Training Centre but two remain at the S P Korolyov Rocket-Space Corporation Energiya, Aleksandr Kaleri and Pavel Vinogradov, but they are considered still active.

Serova was the only active Russian female cosmonaut who had flown in space and her departure leaves just one rookie female in the group, Anna Kikina. The Soviets/Russians have only flown four female cosmonauts: Valentina Tereshkova (1963); Svetlana Savistkaya (1982 and 1984); Yelena Kondakova (1995 and 1997); and Serova (2014/2015 - one flight spread over the new-year).

Elena Olegovna Serova was born on 22 April 1976 in the small town of Vozdvizhenka, in Russia. She became interested in aviation and astronomy as a child and this led her to the Moscow Aviation Institute (MAI). She was studying there when she met her future husband Mark Serov. They were both interested in cosmonautics and it was this joint interest that led their paths to cross. They would both apply successfully to the S P Korolyov Rocket-Space Corporation Energiya for employment, Mark in 1998 and she followed after graduation from the MAI.

In 2001 she graduated from the MAI with a degree in Engineering. The same year she joined Energiya. In 2003 she received a degree in Economics from the Moscow State Academy of Instrument Engineering and Information. In December 2004 she was assigned to the Lead Operations Control Team at the Mission Control Centre in the city of Korolyov.

Her husband had successfully applied to join Energiya's cosmonaut ranks in 2003 and had passed his basic training in the summer of 2005. The same summer she applied to join Energiya's cosmonaut team. On 26 February 2006 she passed the Chief Medical Commission for fitness to proceed to cosmonaut training. She was the first candidate for the 2006 group to pass this medical stage. On 11 October 2006 she was formally accepted as a candidate cosmonaut by the State Interdepartmental Commission.

Basic training ran from 26 February 2007 to 2 June 2009 and she was officially confirmed as a 'Test Cosmonaut' by the Interdepartmental Qualification Committee on 9 June 2009, making her eligible for advanced training, for taking on ground positions associated with actual space missions and eventual assignment to a space crew. The following year her husband's hopes of flying in space were dashed when he was removed from the active list due to medical considerations.

At this time she was part of the Energiya cosmonaut detachment but as part of a reorganisation by the Russian Federal Space Agency and

their move to create a single cosmonaut corps she resigned from Energiya in 2011 to join the cosmonaut squad at the Yuri Gagarin Cosmonaut Training Centre.

On 15 December 2011 she was assigned to a prime crew for an ISS mission. Prior to this she would also serve as a flight engineer on the back-up crew for ISS Expeditions 39/40 and Soyuz TMA-12M, which launched on 26 March 2014. Her only spaceflight was as a flight engineer for Soyuz TMA-14M/ISS Expeditions 41/42 (26 September 2014 – 12 March 2015). The mission lasted for 167 days.

Maksim Viktorovich Surayev (Colonel, Russian Air Force, Ret.) was born on 24 May 1972 in Chelyabinsk, Russia. In 1994 he graduated from the Kachinsky Higher Military Aviation School as a pilot-engineer and served as a fighter pilot in the Soviet then Russian Air Forces. He flew the Sukhoi Su-27 jet-fighter aircraft. In 1997 he graduated from the Zhukovsky Air Force Engineering Academy.

Following graduation from the Zhukovsky Academy he was selected as a cosmonaut candidate by the Russian Ministry of Defence. Following completion of medical tests, this decision was confirmed by the State Interdepartmental Commission. He commenced basic training in January 1998 and took his final exams in November 1999. He was officially confirmed as a 'Test Cosmonaut' by the Interdepartmental Qualification Committee in December 1999.

He commenced advanced training for the ISS in January 2000. From 2001 to 2002 he was the Yuri Gagarin Cosmonaut Training Centre's Director of Operations at the Johnson Space Center in Houston, Texas. In July 2005 he was assigned to a group of cosmonauts to prepare for assignment to ISS Expeditions 15, 16 and 17, and the following month began training as part of this group. From 2006 his training was specifically aimed at ISS Expedition 17.

In 2007 he graduated from the Russian Presidential Academy of National Economy and Public Administration with a Law degree. Perhaps this was a useful degree for someone who was possibly harbouring political ambitions.

He was the back-up commander for Soyuz TMA-12, which launched on 8 April 2008. As part of this assignment he was also the back-up commander for ISS Expedition 17. After the launch of Soyuz TMA-12 he began training for another back-up assignment. He was again in the role of Soyuz commander for the launch of Soyuz TMA-14 on 26 March 2009. He was also the back-up ISS commander for ISS Expeditions 19/20. From April 2009 he began full time preparations for his maiden spaceflight.

In total he made two spaceflights accumulating 334 days in space. His first was Soyuz TMA-16/ISS Expeditions 21/22 (30 September 2009 – 18 March 2010). He served as Soyuz commander and an ISS flight engineer. His second and last spaceflight was Soyuz TMA-13M/ISS Expeditions 40/41 (28 May – 10 November 2014). Again he served as Soyuz commander and was a flight engineer for ISS 40 before he took over command of the station for ISS-41. He conducted one spacewalk during each of his two missions.

His history between the two spaceflights makes for interesting reading. Even before his first flight ended it was reported he had received another assignment and would fly again to the space station in 2012 as part of ISS Expeditions 33/34. However, by June 2010 he had been removed from the crew. No official reason was given but unofficial sources suggest it was a medical problem that required surgery. In November 2010 it was indicated he had passed the Chief Medical Commission and had regained his flight status.

On 18 February 2011, a NASA press release confirmed Surayev's appointment to the crew of ISS Expeditions 36/37 scheduled to start in May 2013 using the Soyuz TMA-09M spacecraft. He conducted training with Luca Parmitano and Karen Nyberg for the flight but on 15 December 2011 the Interdepartmental Commission for the selection of cosmonauts and crews removed him from the crew. His replacement was Fyodr Yurchikhin.

In February 2012 it became known he was on the prime crew for ISS Expeditions 40/41 although this was not confirmed until the Interdepartmental Commission meeting of 15 March 2012. This position had been vacant since the previous December when Yurchikhin had moved to replace Surayev. The two cosmonauts had seemingly swapped positions but no reason was ever officially made known.

This is only my speculation but Surayev had been involved in politics with the United Russia party of Vladimir Putin and stood unsuccessfully in the elections for the State Duma on 4 December 2011. It is possible his involvement in the elections led him to fall a little behind in the training or perhaps alternatively the Interdepartmental Commission thought his priorities were elsewhere and therefore moved him down the line in the flight schedule.

In 2012 the Yuri Gagarin Cosmonaut Training Centre was put under civilian control and it was no longer considered a posting for serving military personal. They were given the option of resigning from the military or re-assignment to another place. Serving military cosmonauts were also allowed to leave the military and join the cosmonaut team as civilian specialists. Surayev chose to remain a cosmonaut and in the summer of 2012 he retired from the Armed Forces of the Russian Federation.

He continued to be involved in politics and worked for the election office of Andrey Vorobyov during his successful campaign in the Moscow Gubernatorial Election of September 2013. However, this time there were no further delays in his spaceflight preparations. He served as the back-up commander for Soyuz TMA-11M, which launched on 7 November 2013 for its ISS Expeditions 38/39 mission. Surayev was also a back-up flight engineer for the ISS expeditions. He then moved full time into preparations for his second spaceflight.

Where Are They Now - Ex-Astronaut Movements in the Private and Public Sector

Ex-NASA astronaut Daniel Tani has joined the faculty at The American School in Japan in Tokyo from the 2016 autumn term. A MIT graduate in mechanical engineering Tani served as a NASA astronaut from 1996 to 2012 and made two spaceflights. He was MS-2 on STS-108 (2001) and then completed an ISS expedition, STS-120/ISS-16/STS-122 (2007/2008).

Bonnie Dunbar has been elected the first female president of the Association of Space Explorers during their annual Planetary Congress in Vienna held over 3-7 October 2016. Dunbar was a NASA astronaut from 1980 to 2005, completing five Space Shuttle flights: STS-61A (1985), STS-32 (1990), STS-50 (1992), STS-71 (1995) and STS-89 (1998). Her last two flights visited Russia's Mir space station and she also trained as the reserve astronaut to the first NASA astronaut on a Mir residency crew (Norman Thagard's mission of 1995). She is currently a Distinguished Research Professor in the Department of Aerospace Engineering at Texas A&M University.

New Astronaut Selections Update:

Canada

As noted in the July/August 2016 issue of CapCom Canada opened up a new astronaut recruitment exercise on 17 June 2016 with applications being accepted to 15 August 2016.

As of 15 August 2016, there had been 3,722 applications completed. Those that met basic requirements were invited to take an online Public Service Entrance Examination. Of these, 1706 reached the cut-off score required to be considered further.

The Canadian Space Agency is looking for two new astronauts who will join NASA's 22nd class of astronaut candidates for training. The two successful candidates will be announced by August 2017. In August 2017, they will relocate to Houston, Texas, and the same month report to the Johnson Space Center to commence astronaut candidate training.

ESA

The next ESA astronaut recruitment is expected to take place in 2019. It is not clear if the UK's recent human spaceflight funding will continue and allow for a potential second UK ESA astronaut following Tim Peake. Watch this space (pun intended).

Robots or Humans continued

In the last issue I discussed the opposite views of Astronomer Royal Martin Rees and ESA's British astronaut Tim Peake on the robotic versus human space exploration argument. Lord Rees had said that human spaceflight should at best be carried out by private ventures, "only as an adventure and spectator sport." Peake said, "It's important that we have humans working in space." Peake considered that it will probably be 100 years before robots have sufficient artificial intelligence to do them properly.

Not long after I had written that item for the last issue that I found details of Scott Parazynski's expedition to the Andrea Doria, which I detail in an earlier story in this issue. He made some comments relating to the human v's robot argument.

"My firm belief is that the best exploration takes place as a human-robotic partnership," said Parazynski. "It's like having MacGyver in the loop; it's about real-time problem solving that really can save the day when it comes to extreme exploration."

For the uninitiated MacGyver was a popular US TV programme (1985-1992) with Richard Dean Anderson in the lead role. He was later Colonel Jack O'Neill in the long running science-fantasy series Stargate SG1 (1997-2007). MacGyver was a secret agent who relied on an encyclopaedic knowledge of science and how to turn that knowledge into practical use using whatever is available to solve the tricky situations he gets into rather than the normal American way of shooting their way out of trouble.

To be fair to the argument I should note that it would be expected that astronauts would take the side of human exploration over robots. I should also declare my own bias towards human spaceflight as should be obvious from my scribblings.

UK Astronaut Sightings

Brief details on UK astronaut sightings follow. For full details see Collect Space and their Sightings section - http://www.collectspace.com/sightings/sightings-unitedkingdom.html This is kept updated by many in the space community and is always more up to date than any printed material.

Chris Hadfield: Lecture tour in January 2017 at venues in Bristol, Edinburgh, Dublin and London.

Scott Altman: 31 March - 1 April 2017 with Space Lectures events in Pontefract.

Kenneth Cameron, **Gregory Chamitoff** and **Charles Walker**: 12-14 May 2017 at the Autographica Autograph Show in London.

NB: If anyone wants to know more about these or other sightings and they do not have access to Collect Space on the Internet please contact me either through the Midlands Spaceflight Society or by email at - **RobandJill@blueyonder.co.uk** - I often find out about visits at too short notice to put in CapCom. But, a word of warning. It is always best to check in advance of travelling that an event is taking place as planned. I travelled all the way to London a number of years ago to meet a cosmonaut only to discover he had cancelled because of work commitments. I had not phoned before travelling. I have no involvement in the organisation of the above astronaut events and therefore no liability is accepted for any changes that occur.

Bits & Pieces

1/ On 16 August 2016, former astronaut Timothy Creamer completed his first shift on console as a certified ISS Flight Director. His call-sign is 'Saber Flight'. See previous story in March/April 2016 edition of CapCom.

2/ On 16 September 2016, Montclair's Mt. Hebron Middle School was renamed the Buzz Aldrin Middle School. Aldrin, an alumni of the school, said his experience at the school had fuelled his interest in science and mathematics.

3/ Ex-NASA astronaut Mike Massimino has his own website from 2 October 2016 http://www.mikemassamino.com

BREAKING NEWS/UPCOMING IN THE NEXT ISSUE OF ASTRONAUT NEWS

Changes in ISS crewing including reduction in crew numbers. It had been rumoured for some months that Russia intended to reduce its crew number on the ISS from three to two for a temporary period and on 28 October 2016 this was confirmed. More on this story next time out.

Acknowledgements and sources:

ABC News; Asij.ac.jp; Association of Space Explorers; Astronaut.ru; Autographica; Bostonglobe.com; Canadian Space Agency; CapCom (previous issues); Chinadaily.com; China Manned Space Engineering Office; Collect Space; Gerhardkowalski.com; Google; Imdb.com; Linkedin; Manned Spaceflight Log II 2006-2012 ©2013 by David J Shayler and Michael D Shayler; NASA and its various centres; NASA Astronaut Selections ©2003 AIS Publications; NASASpaceflight.com; Nationalgeographic.com; Novosti Kosmonavtika; Parazynski.com; Pbs.org; Praxis Manned Spaceflight Log 1961-2006 ©2007 by Tim Furniss and David J Shayler with Michael D Shayler; RussianSpaceWeb.com; Scubadiving.com; Smithsonianmag.com; Spacefacts; Spaceflight (magazine publication of the British Interplanetary Society); Space Lectures; Twitter; Who's Who in Space ©1999 by Michael Cassutt; Wikipedia; Wrecksite.eu; xconomy.com; Xinhua News Agency; Yuri Gagarin Cosmonaut Training Centre.

NASA Updates 2017 ISS Crew Assignments

NASA and its international partners have updated the assignments for several crew rotations to the International Space Station in 2017. The changes reflect a switch in assignments for some NASA astronauts, as well as a reduction in the number of Russian cosmonauts on some missions.

Expedition 51/52 crew members NASA astronaut Jack Fischer and cosmonaut Fyodor Yurchikhin of the Russian space agency Roscosmos will launch in March 2017. Yurchikhin will be the Expedition 52 commander.

In May 2017, **Expedition 52/53** will launch with NASA astronaut Randy Bresnik, ESA (European Space Agency) astronaut Paolo Nespoli and Russian Cosmonaut Sergey Ryazanskiy. Bresnik will be the Expedition 53 commander.

Expedition 53/54 will launch in September 2017. NASA astronaut Mark Vande Hei and Roscosmos cosmonaut Alexander Misurkin will make up that crew, with Misurkin commanding Expedition 54.

Expedition 54/55 will launch with NASA astronaut Scott Tingle, Japan Aerospace Exploration Agency astronaut Norishige Kanai and Russian cosmonaut Alexander Skvortsov in October 2017. Expedition 55 will be commanded by Skvortsov.

The International Space Station is a convergence of science, technology and human innovation that enables us to demonstrate new technologies and make research breakthroughs not possible on Earth. It has been continuously occupied since November 2000 and, since then, has been visited by more than 200 people and a variety of international and commercial spacecraft. The space station remains the springboard to NASA's next giant leap in exploration, including future missions to an asteroid and Mars.

NASA
www.nasa.gov

ISS Mission Update

By George Spiteri

Expedition Forty-Nine is underway following the safe return to Earth in early-September of American Jeff Williams, and Russians Oleg Skripochka and Alexei Ovchinin. The International Space Station (ISS) is currently under extended three person operations following the delay of the next Soyuz launch and is manned by its latest Commander, Russian cosmonaut Anatoli Ivanishin and Flight Engineers, American Kate Rubins and Japan's Takuya Onishi. *

The International Docking Adapter-2 (IDA-2) was removed from Dragon's trunk by ground controllers using the 57 foot long Canadarm2 with the Special Purpose Dexterous Manipulator (SPDM) or "Dextre" attached to it during the early hours of 18th August and manoeuvred IDA-2 three feet away from its installation position ahead of the upcoming spacewalk by Williams and Rubins.

Williams and Rubins exited the Quest airlock at 1304 BST on 19th August to begin the mission's first EVA and the 36th US ISS spacewalk. Together with ground controllers, the astronauts successfully installed IDA-2 to Pressurised Mating Adapter-2 (PMA-2) in front of the Harmony Module. IDA-2 is the first of two docking ports which will allow future US commercial spacecraft such as SpaceX's crewed Dragon and Boeing's Crew Space Transportation-100 (CST-100) Starliner to dock at the ISS. Several "Get Ahead" tasks were cancelled after Williams reported degraded communications following a problem with the right ear piece of his communication cap. The spacewalk lasted 5 hours 58 minutes when the crew returned to Quest at 1902 BST.

On 19th August NASA denied an RIA Novosti report that a fire alarm was triggered by smoke coming from one of the Merlin freezers in the Station's US Segment.

Just before 1000 BST on 24th August, Jeff Williams surpassed Scott Kelly's US cumulative record of time spent in space, having logged 520 days 10 hours 30 minutes on his four missions.

Canadarm2 released the Dragon unmanned commercial spacecraft at 1111 BST on 26th August and packed with over 3000 pounds of scientific experiments and hardware splashed down in the Pacific Ocean over five and a half hours later at 1647 BST (0847 local time) 326 miles South West of Baja, California.

Williams and Rubins left the Quest airlock for a second time at 1253 BST on 1st September to begin another EVA. The astronauts successfully retracted a thermal radiator, installed two enhanced high definition cameras on the Station's Truss and tightened bolts on a joint that enables one of the Station's solar arrays to rotate. They returned to Quest after six hours 48 minutes at 1941 BST to complete the 195th EVA dedicated to ISS assembly and maintenance totalling 50 days 17 hours 34 minutes.

Williams relinquished command of the ISS to Ivanishin in the traditional Change of Command ceremony on 6th September. Williams then joined Skripochka and Ovchinin aboard Soyuz TMA-20M/46S and undocked their spacecraft from the Poisk Module at 2251 BST later that day to officially signal the start of Expedition Forty-Nine. Soyuz landed near the remote Kazakh town of Dzhezkazgan at 0213 BST (0713 local time) on 7th September to complete a mission of 172 days 3 hours 47 minutes with Williams accumulating a total time of over 534 days in space.

The first pair of eight Planet Lab Dove Satellites were launched from the ISS at 1625 BST on 14th September. Rubins Tweeted that they resembled "skydivers soaring towards the earth". The next two pairs were deployed at 0015 BST and 0335 BST on 15th September respectively.

The crew continued with their retinue of scientific experiments and maintenance throughout late September and early October, confirming what Rubins described in a "Meet the Press" interview on 28th September that "you get to be a "Jack of all Trades" up here" on the ISS.

Progress MS-02/63P was undocked from Zvezda at 1037 BST on 14th October and burned up in the Earth's atmosphere as planned later that same day.

As of 14th October, Ivanishin, Rubins and Onishi have been in space for 100 days and Rubins celebrated her 38th birthday the same day.

Update:

Returning on Soyuz MS-01 spaccraft, U.S. astronaut Kate Rubins of NASA, Russian cosmonaut and Expedition 49 Commander Anatoly Ivanishin of Roscosmos and Japanese astronaut Takuya Onishi landed near Kazakhstan at 0358 GMT on 31 October.

Expedition 50 Launches from Baikonur

Three crew members representing the United States, Russia and France are on their way to the International Space Station after launching from the Baikonur Cosmodrome in Kazakhstan on 17 November.

MSS

Launch Of New Galileo Navigation Quartet

An Ariane 5 rocket has launched four additional Galileo satellites, accelerating deployment of the new satellite navigation system.

The Ariane 5, lifted off from Europe's Spaceport in Kourou, French Guiana on 17 November 2016 at 13:06 GMT carrying Galileo satellites 15–18. The first pair was released 3 hours 35 minutes and 44 seconds after liftoff, while the second separated 20 minutes later.

The Galileos are at their target altitude, after a flawless release from the new dispenser designed to handle four satellites.

This mission brings the Galileo system to 18 satellites. The satellites already in orbit will allow the European Commission to declare the start of initial services, expected towards year's end.

The previous 14 satellites were launched two at a time using the Soyuz–Fregat rocket.

Two additional Ariane 5 launches are scheduled in 2017 and 2018. The full system of 24 satellites plus spares is expected to be in place by 2020.

ESA
http://www.esa.int

THE AGE OF AQUARIUS – NEEMO 21

ROB WOOD

As with London buses, human space anologue missions also come close together. No sooner had CAVES 2016 ended (see last issue – The Cavenauts of Sa Grutta) that we moved on to NEEMO 2016. Well, not quite, in fact NASA give their NEEMO operations a chronological number of the mission rather than the year it occurs.

Within two weeks of the cavenauts from CAVES 2016 returning to the surface on 8 July 2016, aquanauts were diving towards the Aquarius Reef Base on NEEMO 21. For the second issue of CapCom running we are looking in detail at another human spaceflight analogue mission or human spaceflight simulation experiment conducted on Earth. I could have said experiments conducted on terra firma but that would not have been totally accurate. Some do take place on terra firma such as the Mars Society's Mars Desert Research Station simulations or the Russian Academy of Sciences' Institute of Bio-Medical Problems Mars-500 project but for ESA's CAVES and NASA's NEEMO, they are anything but on terra firma.

The acronym NEEMO stands for 'NASA Extreme Environment Mission Operations'. The missions are conducted using the Aquarius Reef Base, located at Conch Reef, about nine miles south of Key Largo, in the Florida Keys, at an ocean depth of 62 feet below the surface of the Atlantic Ocean. The centerpiece of the Aquarius Reef Base is the Aquarius Underwater Research Habitat: a research station where scientists live for days and weeks beneath the sea. The Habitat is nine feet in diameter, 43 feet long, with approximately 400 square feet of living and laboratory space; it sleeps up to six people and is located next to a coral reef.

Those that take part in NEEMO missions are known as aquanauts, linking aqua (Latin for water) with astronaut. To distinguish those that have flown in space, they are also known as aquastronauts. To receive these titles, 24 hours have to be spent underwater. Saturation diving techniques allow the aquanauts to remain underwater for extended periods while postponing decompression requirements until the end of the mission. Each day the Aquanauts can spend 8-9 hours in the water working. This is an order of magnitude more time than is possible using surface oriented diving techniques.

The Aquarius Reef Base is run under the auspices of the Florida International University (FIU). The FIU took over Aquarius in January 2013 following funding issues. In 2014, the Medina Family Foundation gave $1.25 million to establish the Medina Aquarius Programme (MAP) at the FIU. MAP is dedicated to the study and preservation of marine ecosystems worldwide and as part of the FIU Marine Education and Research Initiative to enhance the scope and impact of FIU on research, educational outreach, technology development, and professional training.

The aim of the NEEMO activities is to provide a convincing analogue to space exploration. They provide astronauts with some of the same challenges underwater as they would face in space. International crews representing various space agencies test technologies and research crew behaviour in what is an extreme environment.

Training for NEEMO 21 began at the Johnson Space Center (JSC) in Houston, Texas, in June 2016, where the participants learned about the mission experiments. They moved to Florida on 11 July 2016 for water training as well as continuing working with the experiments.

The aquanauts were taught basic SCUBA drills, including mask flooding and clearing, buddy breathing and navigation skills. They trained on the Kirby Morgan 37 stainless steel helmet that would be used for dives out of the Aquarius Underwater Research Habitat. The helmet has air supply, communications and video through an umbilical hose that runs back to the habitat.

Dawn Kernagis, one of the aquanauts, talked about a training dive in her blog. She noted that "The photos and video I have seen of the habitat don't do it justice." She continued by describing what she saw, "the coral-covered structure stands proud against a back drop of aqua and the marine life and colours around the entire site are stunningly vibrant. We were all grinning ear to ear as we descended upon our soon-to-be undersea home!"

But What About the Weather

The aquanauts were ready to go on 18 July 2016 but as NASA's Facebook entry reported, "The crew is ready. The habitat is ready. The weather is not." After a three-hour hold to monitor weather and sea conditions, the decision was taken to stand down and put the mission on hold for 48-72 hours.

Three days passed and they were ready to go again. The official NEEMO 21 Splashdown or start time was 10:28am Eastern Daylight Time (EDT) on 21 July 2016. At that moment the aquanauts dived to the undersea habitat with the intention to live and work there. A new feature for this mission was that it would include a mid-mission decompression, partial crew rotation and change of command.

The crew make-up and who they represented for the first half of the mission was Megan Behnken-McArthur (NASA Astronaut), Matthias Maurer (European Astronaut Centre, ESA engineer), Marc O'Griofa (Veterans Administration & Noninvasive Medical Technologies Principal Investigator), Reid Wiseman (NASA Astronaut), and two FIU habitat technicians, Sean Moore and Hank Stark. Wiseman was the mission commander for this leg of the dive.

"This feels very similar to Day 1 on the space station," said Wiseman on arrival in the habitat. "There are so many incredible views outside I can't decide between working and taking it all in." Following lunch and unpacking they did quick 40 minute excursions in 2-person teams to learn how to exit and enter the undersea habitat and manage the umbilicals. In turn those that remained inside worked with the radios and laptops that will be used on the main excursions in the following days.

As they completed the days programme, thoughts turned to food. They were hungry and as Wiseman said, "you could hear a pin drop during dinner… No witty banter, just food consumption." After dinner they had the opportunity to phone home and then with sunset Hank Stark turned on the outside lights, "and the world outside came alive," commented Wiseman. He continued, "We had huge fish, tiny fish, and unidentifiable fish all coming to say hello. It was impossible to pull oneself away from the view ports to head to bed. I'm sure this will all become the norm soon, but for now it is sensory overload and it is awesome!"

Day two saw the beginning of work on the many experiments for

the mission, which would continue through the mission, involving in-habitat and extravehicular activity objectives, including DNA sequencing, sensorimotor testing, nutritional assessment, optical communication testing and coral nursery tree construction.

The second day also saw the surprise visit of Chief of the Astronaut Office Chris Cassidy. As part of his tour, he made dives to the Aquarius habitat to see in-water operations. As an ex-Navy Seal he was no stranger to water. Cassidy has flown twice in space himself including an ISS Expedition in 2013. Also on day two was a live link-up with the ISS from the habitat. The aquanauts spoke with orbiting astronauts Kate Rubins, Jeff Williams, and Takuya Onishi (all NEEMO aquanauts from previous missions).

On 28 July 2016, Wiseman handed over command to Behnken-McArthur. The official time of the change of command ceremony was 16:09 EDT. O'Griofa and Wiseman splashedup on 29 July 2016. The same day, their replacements took the opposite route: Noel DuToit (Naval Postgraduate School Principal Investigator) and Dawn Kernagis (Naval Sea Systems Command & Institute for Human and Machine Cognition Principal Investigator). DuToit and Kernagis had made dives throughout the mission but these were from the surface until now. The programme of experiments continued with the new crew working both inside and outside the habitat.

But What About the Analogue

How does living under water relate to spaceflight? Similar to ESA's caving experiences there is confinement, minimal privacy, technical challenges and psychological issues. Similarities are even greater when considering that outside their living quarters is an environment that like spaceflight requires complete body suits and equipment to keep them alive. When leaving the habitat, the similarities to spacewalks are very strong. Simulations can also be carried out providing challenges and experiences that are similar to those faced during a spaceflight.

During NEEMO 21 some of the operations were conducted with a 15-minute time delay for communications to simulate missions to Mars. O Griofa described this as like, "you are almost chasing the past, present & future all at the same time." Also, by using buoyancy control, simulations of working in a Martian gravity field could be conducted.

A Free-Space Optical Communication (FSOC) system was evaluated, which has relevancy to underwater and planetary exploration. Traditional radio frequency communication systems require large amounts of power and are bandwidth-limited. FSOC systems have the potential to allow for less power hungry, more reliable, and faster data and voice communication links during extravehicular activities. There is a weight saving potential which is very important to spaceflight requirements. Not everything is rosy for FSOC as it is limited in distance to a few hundred meters and requires a direct line-of-sight between transmitter and receiver so part of the evaluation is about do the benefits outweigh the disadvantages.

Samples were collected for analysis just as they would during off-world exploration. Sampling procedures, tools, techniques, contamination mitigation strategies, storage and transport of equipment and samples all provide close similarities to spaceflight.

Although the coral nursery tree construction project is very much about the regeneration and preservation of coral reefs there can still be found links to spaceflight. The work conducted is analogous to assembling supporting infrastructure when landing on another planetary body for the first time. In respect of the basic aim of the experiment, the corals are grown on the tree structures and are later transplanted to a reef with the goal to get them to reproduce on their own and repopulate an area.

The DNA (deoxyribonucleic acid) research included microbial identification for crew and vehicle health assessments. This involved the NEEMO 21 crew, using a spaceflight-compatible process, collecting swab samples from Aquarius, extracting the DNA, amplifying and modifying that DNA, and, finally, collecting the DNA sequences. In conjunction with these undersea efforts NASA astronaut and molecular biologist Kate Rubins was due to be sequencing prepared samples in space during her ISS mission to test the feasibility and quality of the same procedures and technology.

NEEMO operations provide a unique real-mission environment on Earth to perform research through its combination of extreme conditions, realistic scientific exploration and the ability to perform lengthy partial gravity extravehicular type activities.

The Astronauts of NEEMO 21

Megan Behnken-McArthur (Ph.D.) was born on 30 August 1971 in Honolulu, Hawaii but does not consider she has a home town as such because as a child she lived all over the world. She describes herself as a 'military brat'. Her father was a naval aviator and she notes that she "was born in Hawaii and we moved through California to Japan to England, Rhode Island, back and forth to California over the years." Her family now live in California and she does consider it to be her home state.

She was interested in aviation and the space programme from an early age. She grew up surrounded by airplanes due to her father's service and during one posting she lived at Moffett Field Naval Air Station in California. This was close to NASA's Ames Reseach Center and she often saw astronauts parking their Northrop T-38 Talon training jets. The whole thing, flying in aviation and space, looked like a neat job to her.

She attended the University of California, Los Angeles, from where she graduated with a Bachelor of Science degree in Aerospace Engineering in 1993. She then conducted postgraduate research at the University of California, San Diego's Scripps Institution of Oceanography. Whilst conducting this research she applied to join NASA's astronaut corps and was called for interview and examination in September 1999.

She was selected as an astronaut candidate in July 2000 (NASA Group 18). She reported to the JSC in August 2000 to begin basic training. This was successfully concluded two years later and she was assigned to technical duties for the Astronaut Office. Also in 2002, she received a Ph.D. in Oceanography from the University of California, San Diego.

In October 2006, she was assigned to STS-125. This would be the fifth and final Space Shuttle servicing mission to the Hubble Space Telescope. The mission took place as STS-125 Atlantis (11-24 May 2009). She was the flight engineer (MS-2) and assisted the commander and pilot on the flight deck during launch, rendezvous with the telescope and landing. She also operated the shuttle's robotic arm (Canadarm1) and placed Hubble in the shuttle's cargo bay. The telescope then underwent an overhaul to improve the telescope's capabilities and extend its life.

She is married to another astronaut, Robert Behnken, who has flown twice on the Space Shuttle, is a former Chief of the Astronaut Office, and is currently in training to fly on a debut mission of one of the commercial crew vehicles currently in development.

Although his initial name is Gregory he prefers to be named Reid Wiseman. Currently a commander in the United States Navy (USN), he was born on 11 November 1975 in Baltimore, Maryland. He was not one of those kids who grew up wanting to be an astronaut. He wanted to be a pilot and fly military aircraft off ships. The call of space in his own words "just kind of came about."

Speaking just before his spaceflight in 2014, he described succinctly his passage to space, "I flew in fighters and landed on ships, it was great. And then it just became this steppingstone approach. I kind of want to fly into space so I'll go to test pilot school and become a test pilot. I did that and then it became a reality. NASA's looking for applicants and I kind of want to fly into space so let me try that. And sure enough, here I am and just a few weeks away from launch and it's like Wow!"

He attended the Rensselaer Polytechnic Institute of Troy, New York. His studies were partially funded by a military scholarship under the Reserve Officer's Training Corps (ROTC) programme. He started his college course as an ROTC student but initially without the scholarship funding support. If he did well, then the navy would provide help. He did well and then received a navy scholarship (in return for funding the student has to agree to active military service following graduation). He received a Bachelor of Science degree in Computer

and Systems Engineering from Rensselaer in 1997.

Following graduation he was commissioned as an Ensign in the USN and reported to Naval Air Station Pensacola in Florida for flight training. He was designated a Naval Aviator in 1999 and was assigned to Naval Air Station Oceana, Virginia, for training on the Grumman F-14 Tomcat. His first operational assignment was to Strike Fighter Squadron 31 or VFA-31 'Tomcatters' based at Oceana. During 2002 and 2003, he made combat deployments on the USS Abraham Lincoln (Nimitz-class aircraft carrier) to the Middle East and Asia in support of the wars against Afghanistan and Iraq.

In 2003 the USN nominated his candidature as an astronaut for NASA's 19th astronaut selection due in 2004. The navy recommended 139 candidates and NASA called 10 of them for interview and medical evaluation but Wiseman was not amongst them.

He qualified as a test pilot from the United States Naval Test Pilot School at Patuxent River, Maryland, in June 2004. He worked on various aircraft as a Test Pilot and Project Officer with Test and Evaluation Squadron 23 at Patuxent River, and also spent time studying for his master's degree. In 2006 he received a Master of Science degree in Systems Engineering from the Johns Hopkins University of Baltimore, Maryland.

Following his tour at Patuxent River, he reported to Carrier Air Wing Seventeen as the Strike Operations Officer, where he completed a two-month deployment around South America in 2006 on the USS George Washington (Nimitz-class aircraft carrier). He then returned to Oceana with VFA-103 'Jolly Rogers', flying the Boeing FA-18F Super Hornet. He sailed on the USS Dwight D Eisenhower (Nimitz-class aircraft carrier) during its 2009 cruise (February to July) and was based in the Persian Gulf where his squadron flew combat missions in support of the USA's wars in the region.

In 2008 the navy recommended Wiseman to NASA again. This time he was called for interview and medical evaluation. He was selected as an astronaut in June 2009 (NASA Group 20). He was still at sea when the announcement was made. He reported to the JSC in August 2009 to commence basic training which he completed in July 2011.

Unlike many astronauts, he did not have long to wait for a flight assignment. In August 2011, he was assigned to ISS Expeditions 40/41. He also trained as a back-up flight engineer for ISS Expeditions 38/39 that launched on Soyuz TMA-11M on 7 November 2013. He flew on Soyuz TMA-13M/ISS 40/41 (28 May – 10 November 2014). He was a flight engineer for the Soyuz spacecraft and the ISS. He participated in many experiments during the mission and conducted two spacewalks.

Non-Astronaut Aquarius Crew Members for NEEMO 21

According to NASA's news release of 22 July 2016 and I quote, "Joining McArthur for the entire 16 days is ESA Astronaut Matthias Maurer." That will come as news for both ESA and Matthias. Despite what NASA said there were no other astronauts living on Aquarius during the latest NEEMO mission other than Behnken-McArthur and Wiseman. I trust that Matthias will be framing that release on the wall of his office at the EAC. Maybe us old space sleuths have a new member for our phantom astronaut/cosmonaut studies?

Matthias Maurer has a Ph.D. in materials science engineering and more than 10 years of related research and development experience. He joined ESA and the EAC in 2010 as Crew Support and EUROCOM (Europe's equivalent of CapCom). He is Head of the EAC Management and Support Office. He was a cavenaut on CAVES 2014 as a last minute replacement for a NASA astronaut.

He is involved in preparing future spaceflight operations with new international partners and starting new EAC projects to extend its expertise in exploration beyond ISS. He has conducted research studies on analogues for preparing robotic and human exploration of the Moon

Marc O'Griofa has a medical degree from University College Dublin and a Ph.D. in Biochemical Engineering from the University of Limerick. He worked as a physician at the Mater Infirmorum Hospital in Belfast. He is qualified in tactical combat casualty care and as an advanced trauma life support instructor. He is also a National Oceanic and Atmospheric Administration (NOAA) trained diving medical officer. He is no stranger to space analogue missions having supported previous NEEMO dives and acted as a flight surgeon for the Mars Society's Mars Desert Research Station field sessions.

He was the principle investigator for Project CASPER (Cardiac Adapted Sleep Parameters Recorder), a sleep study experiment to test and evaluate a method of monitoring sleep disturbance and sleep stability in weightlessness. This was the first Irish experiment to fly on ISS and was sponsored by ESA as part of their Astrolab mission. The astronaut guinea pig was Thomas Reiter during his 2006 spaceflight. He wore a VivoMetrics LifeShirt, the first non-invasive, ambulatory monitoring system that continuously collects, records, and analyses a broad range of cardiopulmonary readings.

He spent 3 years at Kennedy Space Center as part of the Aerospace Medicine and Biomedical Research departments providing medical support for the Space Shuttle programme. He then became the chief medical and technology officer for Noninvasive Medical Technologies doing R&D in developing biomedical technology for civilian and military use.

He is currently the chief trauma and combat casualty care instructor for the Department of Defense and other US Government agencies instructing physicians, medical personnel and Special Operations Forces teams in joint tactical and medical care at Nellis Air Force Base. His latest endeavour sees him as chief medical officer for TeloRegen, another biotech company. A position he took up in 2016.

Dawn Kernagis has a Bachelor's degree in Biochemistry and Molecular Biology from North Carolina State University and in 2012 a Ph.D. in Pathology from Duke University. As a research scientist she has held several positions including in Hyperbaric Medicine and Environmental Physiology at Duke University Medical Center and currently at the Florida Institute for Human and Machine Cognition in the area of human performance optimization and risk mitigation for operators in extreme environments.

She is a vastly experienced diver who went to the ocean for the first time as a nine year old and fell in love with the sea. Her fifteenth birthday present from her parents was scuba diving lessons and she has since conducted over 1400 dives. She has been a diver and dive manager on numerous underwater exploration, research, and conservation projects since 1993, including the deep underwater exploration of Wakulla Springs and surrounding caves in Florida where she directed several world record-breaking deep cave dives. One was the historic connection and swim-through cave dives between Turner Sink and Wakulla Springs in 2007. In 2016, she was inducted into the Women Divers Hall of Fame.

In 2008, whilst at Duke University, she was the first Predoctoral Award recipient from the Office of Naval Research (ONR) Undersea Medicine Programme and she has since received additional research awards from ONR on diving medical research. Amongst the research projects she worked on through the Duke University Medical Center were Immersion Pulmonary Oedema (for the USN), Flying After Diving (for Divers Alert Network) and EVA Oxygen Prebreathe (for NASA). She joined the Florida Institute for Human and Machine Cognition in May 2015.

When the NEEMO 21 programme director, Bill Todd, called her and asked her if she would like to dive on the mission, she thought he meant as a support diver and told him she would do anything, clean, cook and carry. But he then asked about being one of the crew. She said, "I think my jaw hit the floor at that point. I was so excited and not anticipating that." She quickly accepted Todd's offer.

Noel DuToit has a Bachelor degree in Mechanical Engineering (cum lauda) from the University of Stellenbosch in South Africa (2001), a Master degree in Aeronautics and Astronautics from MIT (2005) and a Ph.D. in Mechanical Engineering from Caltech (2010).

He grew up on a rose farm near Pretoria, South Africa. He moved to

the United States in 2003 to attend MIT for his postgraduate studies. His research studies over the years has been on unmanned vehicles including self-driving ground vehicles, aerial vehicles (quad rotors and fixed-wing unmanned air vehicles), surface water vehicles and underwater vehicles.

Following his Ph.D. he was a postdoctoral scholar in control and dynamical systems at Caltech. Since 2012, he has been a research assistant professor at the Naval Postgraduate School in Monterey, specialising in maritime robotic systems such as autonomous underwater vehicles in challenging environments.

The habitat technicians who are living with the crew and as noted by Dawn Kernagis in her blog "keeping us safe and sound during NEEMO 21" are Hank Stark and Sean Moore. Stark is also one of the operations managers as well as the lead habitat technician. He is a 30-year navy veteran and achieved the qualification of USN Master Diver. Moore also has a Navy diving background including four years as a rescue swimmer. He is a qualified scuba instructor and has worked offshore as a commercial diver. He accepted a position to work with the Medina Aquarius Programme in 2015.

Aquarius Reef Base Crew

There are many other who supported the mission as part of the Aquarius Reef Base (ARB) Crew. Dawn Kernagis explains further in her blog, "The ARB crew make the mission run, plain and simple. Crew and staff training, boat operations and dive equipment maintenance, and everything that has to do with the habitat operations is in the hands of the very experienced, very knowledgeable, very hard-working ARB staff." Many wear more than one hat.

There is Programme Director Tom Potts, Operations Director Roger Garcia, Science Manager Otto Rutten and Operations Manager Mark 'Otter' Hulsbeck (Hank Stark is the other operations manager). We have the dive specialists Tom Horn and Ivana Sanchez (Sean Moore is another dive specialist). Elizabeth McNamee is FIU's Assistant Dive Officer and Boating Safety Officer, and Aileen Soto is Director of Education and Outreach. They all have bags of experience in diving operations.

Hulsbeck has an interesting history. As well as spending over 200 days in saturation in the Aquarius habitat himself, including as a habitat technician on several NEEMO missions, he had previously spent five years in the USN as an aviation anti-submarine warfare operator and helicopter search and rescue air crewman. Subsequent to his time with the military, he earned a degree in geology from the University of South Florida and then then joined the NOAA Commissioned Corps, serving on numerous research vessels. He has a United States Coast Guard Captain's 100-ton license and has a variety of other professional qualifications in the diving arena.

Looking at some of the others, Horn lives for the water and can even be found diving in his free time. He is a qualified cave diver as well. McNamee is also Research Coordinator in FIU's Environmental Health and Safety Department. Sanchez has an undergraduate degree in Environmental Science and is working to become a habitat technician. Soto has a first degree in Biological Sciences and a Master's degree in Science Education.

Thanks for all the Fish

The end of the mission came on 5 August 2016 after 16 days in saturation (8 for Wiseman, O'Griofa, Kernagis and DuToit). The night before splashup the aquanauts conducted extensive decompression protocol to allow them to return safely to the surface. The body becomes saturated with nitrogen from the elevated pressure of living underwater and it is not possible to return to the surface at will.

With the NEEMO 21 mission successfully concluded, NASA ended with a most appropriate tweet "So long, and thanks for all the fish!"

Acknowledgements and sources:

Aerospaceonline.com; Airdocs.net; Astronaut.ru; BBC.co.uk; Caltech; CapCom (previous issues); Collect Space; ESA; Facebook; Florida International University; The Free Dictionary; Google; Institute for Human & Machine Cognition; JAXA; .thejournal.ie; Las Vegas Review Journal; Linkedin; NASA and its various centres; NASA Astronaut Selections ©2003 AIS Publications; Naval Postgraduate School; The Open University; Researcggate.net; Spacefacts; SpaceX.com; Sportsvite.com; Twitter; University of Limerick Alumni Association; University of Stellenbosch; Washington Post; Wikipedia; You Tube;

Midlands Spaceflight Society

Contact

Dave Evetts, Secretary,

Midlands Spaceflight Society

124 Stanhope Rd, Smethwick

B67 6HP

Tel. 0121 429 8606

(evenings & weekends only) or

e-mail mss.shop@midspace.org.uk

Web Site:

www.midspace.org.uk

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