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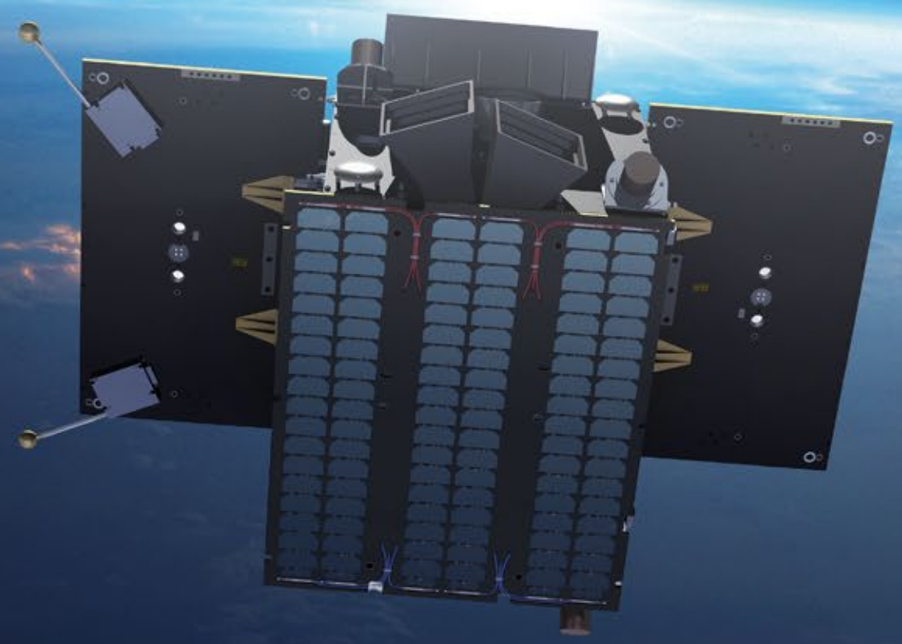
Postcards from Space

APRIL 2021



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www.QinetiQ.com/space/postcardsfromspace

Contents

QINETIQ

DEEP SPACE COMMUNICATIONS

ION THRUSTERS

DEEP SPACE EXPLORATION

TRUSTED TO DESIGN AND DELIVER MISSION SUCCESS

Over 100 mission-years in orbit delivering observation, platforms, science, navigation, propulsion, and secure communications support across military, security and civil space sectors

SCIENCE EXPERIMENTATION

SMALL SATELLITE DEVELOPMENT AND MANUFACTURING

BERTHING AND DOCKING MECHANISM

SPACE

PROGRAMME AND MISSION ASSURANCE

SOFTWARE DEFINED MULTIFUNCTIONAL LIDAR (SDML)

SECURED NAVIGATION

SPACE SITUATIONAL AWARENESS

CYBER ASSURANCE & SECURITY

TEST, EVALUATION AND MANUFACTURING FACILITIES

SPACE LAUNCH RANGE SERVICE

EARTH

POSTCARDS FROM SPACE

Welcome

Jim Graham

Managing Director, QinetiQ's space business

Over the past few years, colleagues from across QinetiQ's space business have produced a series of blogs describing our ever-increasing range of space programmes. The popularity of our 'Postcards from Space' blogs has prompted us to publish the full collection in a special compendium for the first time.

This new publication provides a glimpse of the specialist skills and breadth of expertise that has underpinned our success in the space sector over the past six decades. It also gives an indication of the passion and great sense of personal pride that shines brightly in every corner of the business as we rise to new challenges that are truly at the cutting edge of space technologies, research and exploration.

A common thread through all of the 'Postcards' is how much can be achieved through effective partnership and collaboration. Whether it's extending the capabilities and possibilities of human space exploration, improving the performance and potential of satellite technology or the development of increasingly sophisticated systems integration and space experimentation, QinetiQ is proving it really is a trusted partner for mission-led innovation and operational capability that delivers mission success for our customers, time and time again.

Indeed, we are committed to mission-led innovation; our specialist teams work closely with a growing list of like-minded partners, aiming to deliver the best possible operational outcomes for customers. The postcards from space provide some highlights that are close to our hearts; they also help to explain why everyone here at QinetiQ is looking to the future with a great deal of enthusiasm and excitement as we continue to combine our passion for space with engineering expertise and innovation.

Capitalising on the Data Revolution

Not since the space race in the last century has the space domain experienced such an exciting and dramatic change. As late as the 1990s, space launches were considered a national event, but with the advent of technological innovation, cost reductions and relaxing of the rules governing space access, commercial satellite constellations are now being launched with little fanfare or mainstream coverage. This is taking the total number of space platforms in Low Earth Orbit (LEO) to nearly 2000, including a host of commercial providers offering a range of valuable services.

Many different sectors are benefiting from this significant market development. In the earth observation market alone, environmental monitoring, smart agriculture, meteorological survey and the energy sector are areas that have been revolutionised by the advent of commercial space-based data collection. From a defence and security perspective, nations and their relevant intelligence organisations are also developing how commercial space-based 'Intelligence, Surveillance and Reconnaissance' (ISR) can support them, including how the collection of vast data sets – including imagery and geospatial information – can be consumed and used effectively.

This is where we see a significant challenge. How do we convert this deluge of data from multiple satellite and sensor providers into something useable? The question of handing the 'volume, velocity, variety and ubiquity' of data is starting to have profound effects on the role of humans tasked with engaging with this data. In the defence and security domain, this includes the intelligence analysis community. These skilled people are tasked with taking data and converting it into usable information and insightful intelligence – but they can only deal with so much data effectively. The former head of the United States' National Geospatial Intelligence Agency (NGA), Robert Cardillo said that without technical tools and support, an extra 8 million analysts would be required to analyse all of the data coming from new data sources – including commercial space-based collection. Given how unlikely hiring 8 million extra analysts is likely to be, and the monumental challenge of processing and organising this data – another solution is needed.

This is where space technology meets Information Advantage back on earth – what the UK MOD describes as 'the advantage gained through the continuous, adaptive, decisive and resilient employment of information' - this means that there is not an end game to be won – but a continuous, ever faster cycle of exploiting data effectively and supporting decision-making. In order to deal with the data and to move quickly enough – this is going to take a significant shift in the way humans interact with their technology. Concepts such as Human-Machine teaming and the insertion of machine intelligence into day-to-day operations is well documented but it is now, with the quantity of data that is available, will these technological innovations be so essential – especially when combined with the vast amounts of Publically Available Information (PAI) collected via the internet every day. This represents another challenge - if this data is available to us, then it is available to everyone. Regardless if you are the United States government or a teenager in their bedroom, we all potentially have access to everything. Only by moving at the pace of relevance – machine speed – can we hope to keep our edge with understanding the data that is out there.

So how do we move faster? There is no doubt that technology holds the key to managing the flood of data, but technology cannot be integrated in isolation. Over the next 10-15 years, there will be transformational change in the way we engage with data, including large, complex data sets from space sensors – how it is collected, processed, fused, stored, organised, assured, trusted, analysed and visualised are all likely to see major developments. Our interaction with systems and processes will mean that Agile Software Development and IT Operations (DevOps) approaches will be commonplace, with system changes made daily and algorithmic updates hourly depending on mission requirements. We will be in a world where the boundaries between operations, experimentation and training become blurred. Data Scientists will train machines – analysts will be supported by machines – machines will help develop analysts – and all in a constant cycle of improvement, integration and action. In turn, this will improve how we manage, task and ultimately collect further data whilst refining the next generation of space collectors and look to fuse the data they provide with the widest possible sources that are available.

The data revolution is here. Our people, our wider organisations and our ambition need to be ready to realise the challenges and the limitless benefits that this revolution will provide.

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Joris Naudet
PROBA Systems Engineer

September 2019

A Proven Record for Delivering Data

On 22 October 2001, the PROBA-1 satellite was launched into space in a low Earth orbit. Although it was originally planned as a one-year mission, the satellite has provided data successfully ever since its launch ….and it is still going strong!

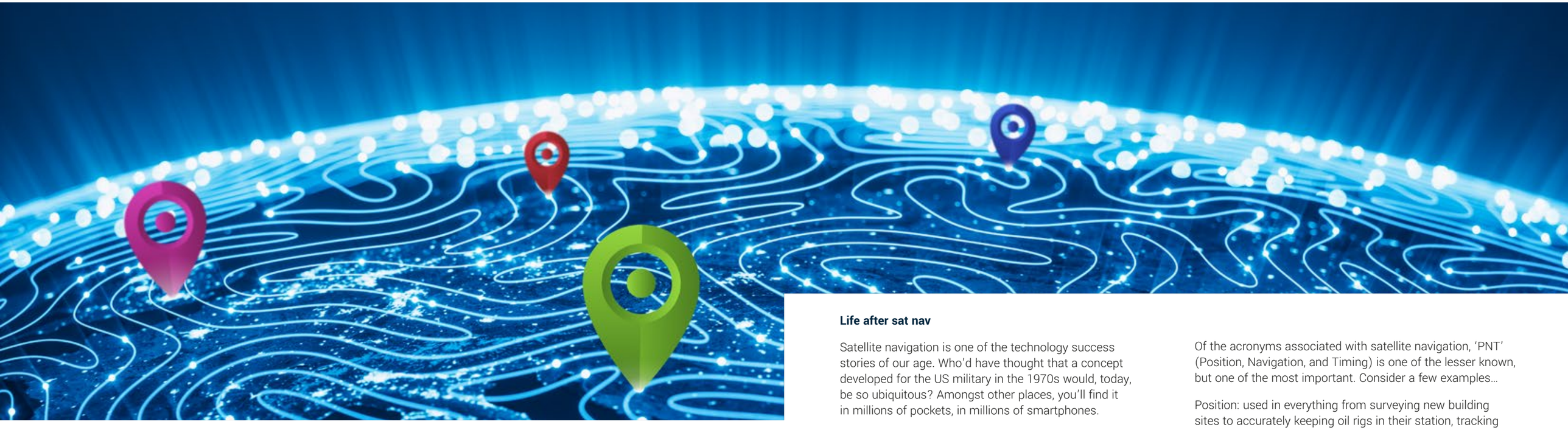
Manufactured by QinetiQ, PROBA-1 is one of the smallest satellites launched by the European Space Agency (ESA) and is less than a cubic metre in volume.

PROBA stands for PRoject for On-Board Autonomy, and is a series of micro-satellites that can fulfil a variety of requirements. PROBA-1, for example, hosts a couple of Earth Observation instruments including a state-of-the-art hyperspectral imager.

PROBA's sister and brother - PROBA-2 and PROBA-V - came in 2009 and 2013 respectively and they are still orbiting around the Earth in perfect condition. They are tracked from our station at Redu in Belgium and, every time they pass over the station, they receive their instructions and then proceed to carry out their tasks autonomously. The PROBA-V mission is mapping the vegetation around the globe on a daily basis - anyone who is curious to see how that looks can see for themselves here.

While the first two satellites in the 'PROBA' series were a combination of demonstration and application missions, the latest generation has evolved the platform to be fully autonomous. After its successful commissioning, PROBA-V now serves as an operational mission satellite and, today, it is supplying data to a huge community of over 1500 users - from universities, companies and institutions to research organisations all over the world. What is remarkable about PROBA-V is that it was originally a gap-filler. However, we were able to build a very innovative and state-of-the-art satellite that has proved to be as resilient as it versatile.

PROBA-V has become part of the overall capacity for Earth Observation (EO) to support weather forecasting, track biodiversity and wildlife and to monitor and respond to natural disasters such as bush fires, floods, earthquakes, and tsunamis. This insight and data is also invaluable in helping us to predict and adapt to climate change, to manage natural resources and to improve agricultural practices by monitoring such factors as soil moisture. Put simply, space technologies are helping us take care of spaceship Earth!



You Are Here

The peril of convenience

With such dependence across a wide spectrum of activities, continued access to reliable PNT is a growing national security issue. The appeal of undermining a technology is proportionate to the reliance upon that technology- and today, satellite based PNT is a very appealing target indeed. In fact, a report by London Economics estimates the economic impact to the UK of a five-day disruption to the global navigation satellite system (GNSS) at £5.2bn. Such disruption is quite possible, as satellite navigation systems exhibit a number of vulnerabilities.

On the intentional side: jamming (deliberate RF interference designed to deny a user's access to PNT), spoofing (deliberate RF interference, where an attacker transmits synthetic signals that may appear real, but seek to mislead or deny PNT) and cyber attacks are perhaps three of the best known. Spoofing is the newest threat; Google searches for 'GPS spoofing' saw a 100 fold increase in July 2016, coinciding with the release of Pokémon Go. Why? Faking a phone's position allows players to collect the virtual characters hidden at specific, real-world locations in the game.

The knowledge of these vulnerabilities (plus the tools to exploit them) are increasingly available. Broadband GNSS jammers can be bought for less than £50 online. Elementary spoofers can be found for little more, or built with open source designs. The signal specification of the open GNSS services is in the public domain, as is information on how to disrupt it.

And then there are unintentional threats. For instance, space weather events can deny service and, in some cases, even damage terrestrial or orbital hardware. A report from the Royal Academy of Engineering anticipates that a solar super storm (…and a big one is long overdue) could render GNSS partially or completely inoperable for one to three days. Such a space weather event could impact all the satellite navigation systems, and so represents a common mode of failure.

So, it's clear that satellite-derived PNT is vulnerable. What is being done? A 2018 report by the Government Office for Science concludes that 'there has been insufficient attention among policy makers to ensuring resilient PNT for CNI'. Thankfully, there's a growing understanding in government and amongst critical infrastructure operators around the risks from satellite-derived PNT.

This doesn't mean that we completely do away with satellite-derived PNT, which has proven itself to be both extremely practical and economical. Instead, it's about a move towards diversification, so that when a satellite PNT service is disrupted, there are other means to fall back on.

There is good news here. The need for continuously available, reliable PNT and the vulnerabilities associated with sat nav is increasingly being recognised - especially by governments and critical national infrastructure.

Life after sat nav

Satellite navigation is one of the technology success stories of our age. Who'd have thought that a concept developed for the US military in the 1970s would, today, be so ubiquitous? Amongst other places, you'll find it in millions of pockets, in millions of smartphones.

Navigation has gone from map reading and sextants, to a GPS-enabled pervasive knowledge of where we are within metres. All of this is provided by signals transmitted from 20,000 km in space with roughly the power of a 60W lightbulb.

Since the launch of GPS navigation services, and the proliferation of low-cost receiver chips that can be built into all kinds of devices, our dependence upon satellite navigation has grown exponentially. Now, almost every aspect of consumer, civil and military life relies upon sat nav - which is critical not only for navigation and positioning, but also for timing.

Of the acronyms associated with satellite navigation, 'PNT' (Position, Navigation, and Timing) is one of the lesser known, but one of the most important. Consider a few examples…

Position: used in everything from surveying new building sites to accurately keeping oil rigs in their station, tracking shipping containers and electronic offender tagging.

Navigation: by ground, air and sea – including driving the hugely complex global logistics chains that support low-cost, next day delivery for millions of online purchases every day.

And Timing: used, for example, in applications as diverse as synchronising communications and computer networks, the electricity supply grid, and time stamping financial transactions to ensure that the flow of money and other assets is properly accounted for.

A multisensory solution

The truth is that there isn't currently a single technology that can provide PNT 24/7, anywhere in the world as conveniently as sat nav. However, a range of existing and maturing technologies are being identified as alternatives (or add-ons) to space-derived PNT.

Ensuring service availability and resilience requires a broad, holistic approach. This is described as a 'PNT architecture' or 'system of systems' - it's the key to spreading the risk and allowing solutions that can meet the needs of different users. For example, navigation in a city can be quite different to navigation on the high seas.

Such an architecture could take the form of an integrated suite of sensors, operating in different parts of the spectrums to provide redundancy. Applicable technologies include a wide range of sensors that provide relative measures. This includes accelerometers, magnetic heading sensors, gyroscopes, quantum gravity sensors, and stable oscillators, (such as atomic clocks or miniaturised chip-scale atomic clocks).

New infrastructure, such as terrestrial radio navigation systems like eLoran (a recent development derived from navigation technology with roots in World War II) are being considered, especially for coastal and maritime navigation. A new UK initiative called the National Timing Centre (NTC) is looking at how accurate absolute time can be distributed to users that are critically dependent on it. We might also expect next generation 5G communications networks to offer PNT services.

There are also a number of complementary forms of navigation under review. These include navigation via 'signals of opportunity' - referencing signals that are broadcast from known locations for other purposes (like wifi networks and radio stations), and harnessing them for navigation. Optical flow navigation, radar and LIDAR (laser radar) can also be used to measure progress through an environment, or relate features to a location database. The ancient art of celestial navigation is also seeing a resurgence!

Such innovative technology developments and the smart integration of those technologies will be key to delivering the always available, resilient and reliable PNT that we all rely on.

Dr Nigel Davies CEng FIET
Chief Engineer, Secured Navigation

December 2020

The Importance of Secure Communications

With ever-increasing connectivity and digitalisation, the need for resilient, robust and secure information processing, situational awareness and communications is not just important. It's absolutely vital - especially in mission-critical and highly sensitive environments such as defence and critical national infrastructure as well as all areas of commerce and highly regulated areas of public service. The threats to a digitally enabled and digitally dependent society are very real, very significant and are constantly evolving.

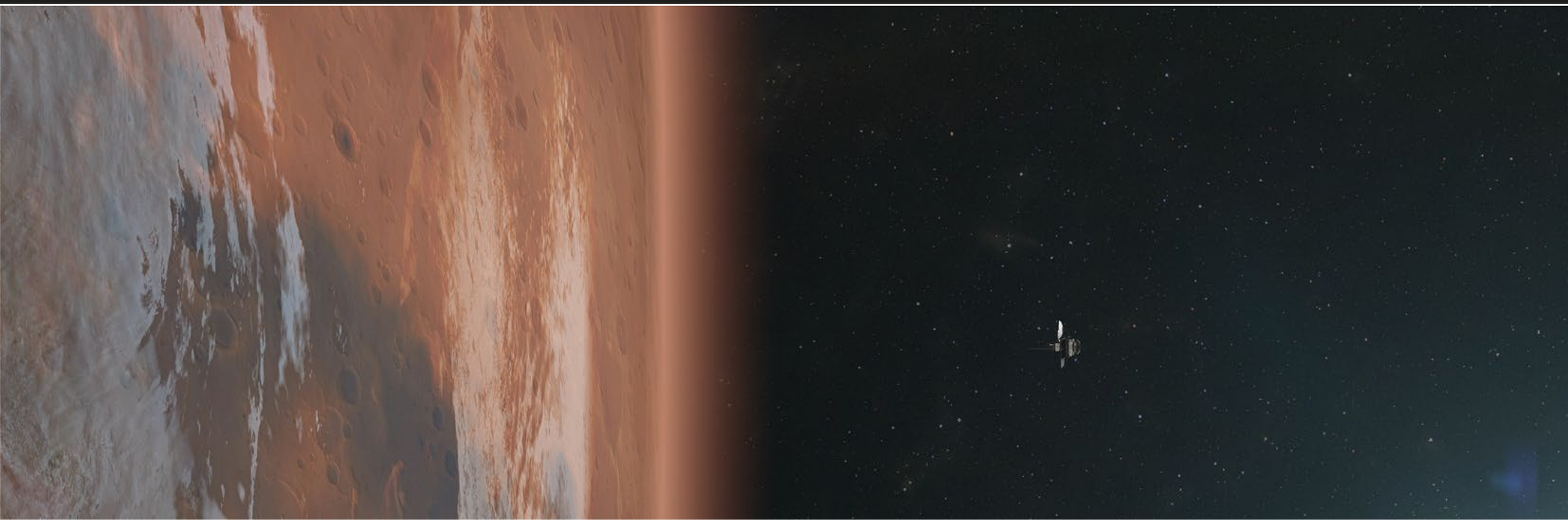
One area where operational resilience and threats to national security are currently in very sharp focus is in relation to Position, Navigation and Timing (PNT). Here, our expertise and experience in global navigation satellite systems (GNSS) has been well documented. It's not just the satnav on your car and an app on your mobile phone, though. Such information is of critical importance for the military, critical national infrastructure (CNI), emergency services as well as countless other organisations, and we provide a range of technologies to provide such mission-critical users with continuously available, resilient and highly accurate PNT.

Significantly, such technologies provide operational assurance in the face of threats to defence and national security from the most highly resourced, capable and determined adversaries including criminal and state actors. Building on our expertise in GNSS and GPS receivers and multi-sensor integration, we are able to provide navigation resilience from interference, jamming, spoofing and cyber attacks in even the most dynamic and demanding environments including those where satellite navigation sources are degraded or denied.

Our award-winning Q20HD high dynamics GPS receiver, for example, provides a unique capability that underpins a number of advanced high dynamics complex weapon systems to improve their effectiveness and to minimise collateral damage. We are also in the process of developing a new family of secured GNSS receivers to provide high-integrity satellite navigation solutions that mitigate against the wide range of threats. The new Q40 generation of receivers use multiple GNSS constellations, multi-frequency reception as well as special RF, digital signal processing and navigation processing to mitigate interference, spoofing and cyber threats. There can also be integrated with anti-jam antennas and other sensors (including inertial, magnetometers, barometric sensors etc) to increase resilience. Consequently, they will offer enhanced resilience and accuracy in defence, critical national infrastructure, autonomy and other high value industrial/ commercial applications and will also address the unique challenges of low signal and highly dynamic environments.

Here in the UK, the Government is now developing a new PNT strategy that will consist of a system-of-systems PNT architecture using a mix of technologies to deliver the required resilience for different users. We are contributing to this new thinking with our continuing work on advanced satellite navigation receivers as well as the development of new GNSS-free technologies to complement existing systems and deliver even more resilient PNT solutions. These will include navigation using signals of opportunity, celestial navigation and the innovative use and integration of new sensor technologies.

Knowing where you are, where you're going, how to get there and when you'll arrive has never been as precise as it is today …. and it's all thanks to increasingly sophisticated capabilities derived from space. However, delivering and maintaining security, reliability and resilience for any PNT solution at all times is the only way to protect such invaluable information from malicious attacks. We are using our know-how and insight to do just that.



Small and Mighty: The Triumph of the Small Satellite

Since the beginning of the ‘space race’, there has been a growing market for satellites. But it’s small satellites – with a mass of under 1000kg - that have truly ‘taken off’ over the last few years.

Today, new constellations of over 1,000 such satellites have been proposed. By the next decade, the number of them in orbit could increase ten-fold - from about 2,000 to 20,000, according to the World Economic Forum. But why?

High risk, high return?

Technology breakthroughs have driven costs down, opening the market to new commercial players, such as SpaceX, who haven’t traditionally had a presence in space.

Typically operating in low Earth orbit (LEO) of 1100-1300km above the Earth’s surface, these small satellites can be built for a tiny fraction of the price of a traditional spacecraft, largely due to advances in miniaturisation and commercial off the shelf (COTS) technology. But the operational lifetimes of these small satellites is short: one to five years, compared to a traditional 10 to 15.

Nevertheless, their proximity to the surface means that LEO-to-Earth communication can be achieved in 20% of the time (latency) of what is achieved via geostationary satellites. A constellation of satellites at this altitude offers shorter revisit times and greater coverage for the same mission costs. And the defence industry has its own connectivity challenges, being heavily reliant on the more traditional radiofrequency spectrum, which has much slower transmission rates.

The opportunities afforded - whether that be building a space-enabled Internet of Things (IoT) network, global broadband access, or your own Earth observation system - allows companies to tap into the ‘NewSpace’ phenomenon. Never before have organisations had so much control over the process, from the design of a system all the way through to its orbital operations.

The age of optical mesh

While accelerating Earth-to-satellite signals is undeniably promising, perhaps a more significant development will be the possibility of cross-linking (or ‘meshing’) thousands of satellites with lasers that can send and receive information - in order to form global optical mesh networks. This is provided by the transmission of light (visible or infrared) in free-space, where there is no need for optical fibres.

Today the use of optical technology via fibre-optic cables connects much of the world. But such ground-based cables aren’t always best. A digital signal over a standard fibre-optic link between New York and London is a 76 millisecond round trip. The same signal routed through a space-based optical mesh network could theoretically do this in 50 milliseconds, according to research from University College London.

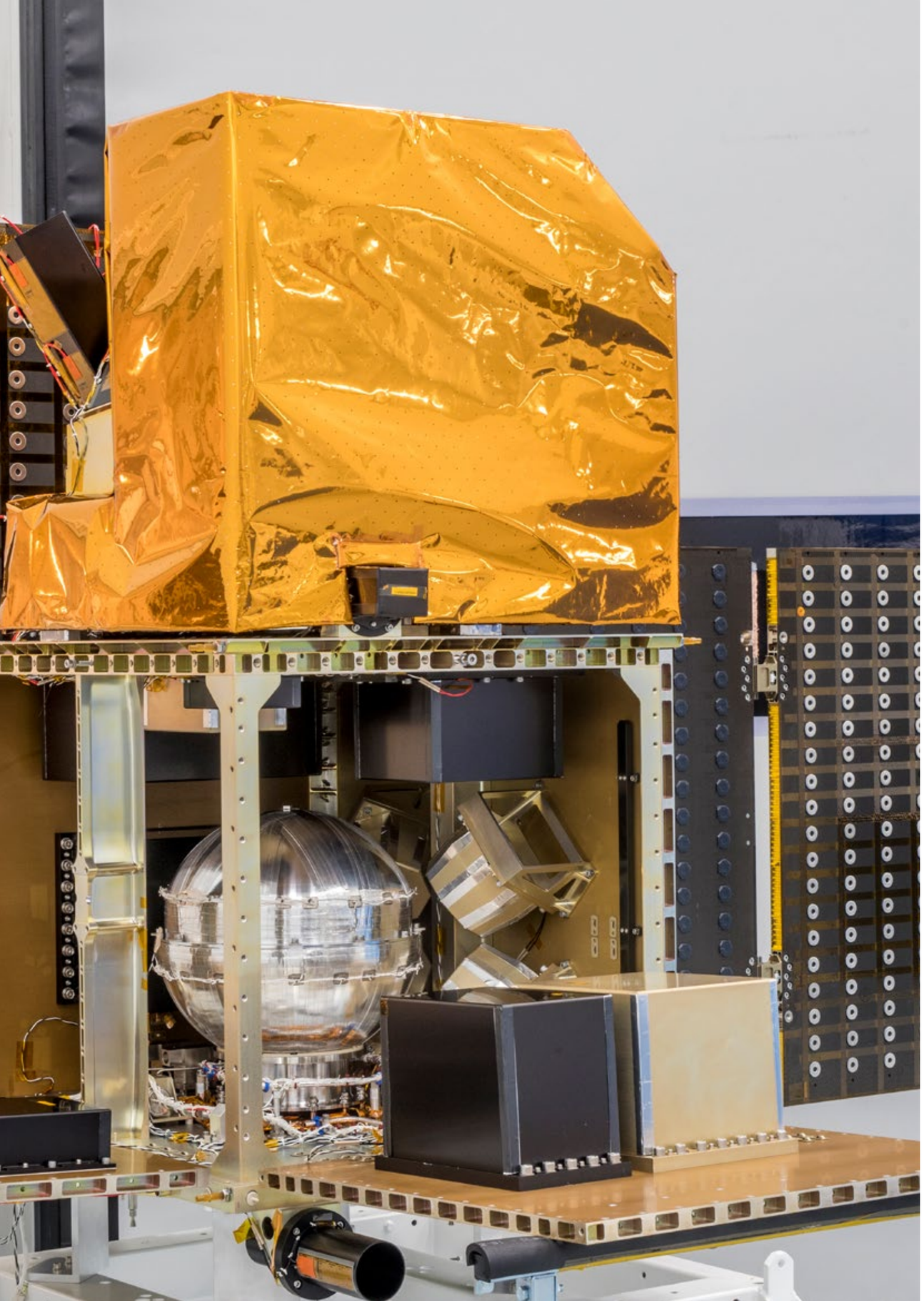
Optical transmissions are virtually impossible to intercept. They also don’t compete for space on the increasingly congested electromagnetic (EM) spectrum, and the optical band is unlicensed, so it’s easy to get going. In fact, the optical communication and networking equipment market was valued at $18.9 billion in 2020, but is set to reach $27.8 billion by 2025, according to Markets and Markets.

Despite all this, meshing between thousands of small satellites across many orbits, whilst connecting to ground-based networks is far from simple, and there are hurdles to overcome.

Co-operation is key

Whilst the business of small satellite constellations is evidently high-risk, high-reward, the story of the bankruptcy of satellite company OneWeb shows the impact of getting it wrong. Even still, faith remains: the UK government and India’s Bharti Global both put $500 million into a joint $1 billion takeover to rescue OneWeb in July 2020.

With the field expanding at such a rate, with such versatility available, the temptation for some operators might be to ‘go it alone’ in order to get ahead. Successful implementation of constellations requires a cohesive effort from a broad range of (often competing) global stakeholders. This won’t happen quickly, but if successful, the outcomes could one day be magnificent.



Dennis Gerrits
Project Manager

September 2019

The Next Generation of Small Satellites

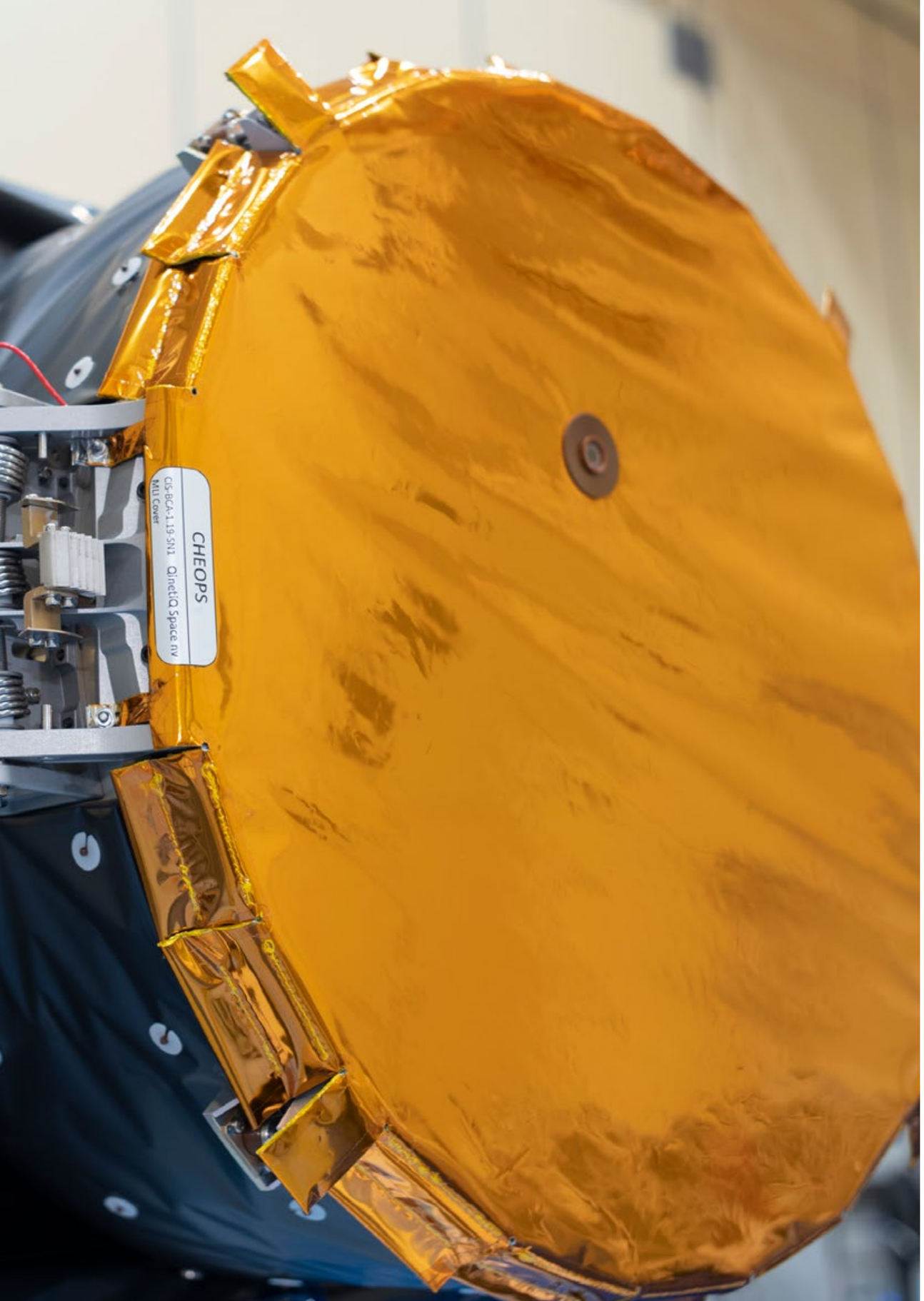
Following the success of the reliable and adaptable PROBA satellites, we designed and developed the next generation of satellites to define the future of PROBA-like missions and spacecraft

The development of the P200 platform aims to create a generic platform for a wide range of missions and studies and features new propulsion and avionics systems. To deliver the best operational outcomes, the platform has been designed to provide a very high level of versatility and will not only carry varying payloads but is also compatible with a wide range of launch rockets.

It has a mass of +/-130 kg allowing it to fly at least a payload and mission-specific hardware of up to 70kg. This leads to a resulting total mass of the satellite as low as 200kg (explaining the name P200). Configuration is also highly flexible so that the platform is easily adapted to meet specific payload requirements. If the payload needs a lot of energy, for example, solar panels for extra electricity can be added.

The P200 platform in its generic configuration consists of a fully redundant spacecraft with two deployable solar panels, two star trackers, and a propulsion system. The hinges of the solar panels — the “articulations” — are also developed and made in-house to high specification.

The qualification model is now in our new clean room facilities in Belgium. Last April, it passed the environmental tests in Toulouse, where it was subjected to vibration tests and thermal vacuum tests to assure the quality of the product before it is sent to space. It is expected that the excellent results obtained will allow the use of the P200 platform for multiple missions to come.



Malika de Ridder
Instruments Portfolio Manager

December 2019

Characterising Exoplanets

CHEOPS is the European Space Agency's CHaracterising ExOPlanet Satellite that will orbit the Earth at around 700 km of altitude to study exoplanets. It is the first mission dedicated to searching for exoplanetary transits by performing ultra high precision photometry on bright stars already known to host planets. Featuring a Ritchey-Chretien telescope, the satellite won't be looking for new planets outside of our Solar System but will be focusing its attention on securing more data for known targets as well as new planets discovered by the next generation of ground-based or space transits surveys.

The support provided by QinetiQ's space business for CHEOPS reflects the company's mission-led philosophy and has focused on two important pieces of hardware for the satellite: a two-stage baffle and a lightweight cover.

Stray light, primarily from the Earth and the Moon, is a major source of optical noise and the telescope must be baffled to minimise its impact. The primary function of the baffle is to absorb light so that stars can be observed without optical disturbances. The CHEOPS baffle has seven accurately aligned vanes to optimise the optical path and also protects the satellite's main scientific instruments as well as acts as a thermal cover. In view of the stringent requirements for cleanliness and to avoid dust contamination, the lightweight cover features a one-shot deployment mechanism to protect the telescope prior to and during commissioning.

Handover of the hardware for the project was completed in September 2016 for further system integration and testing and, following completion of all pre-launch preparations, CHEOPS was launched to space from French Guiana on December 18th.

Using its ultrahigh precision photometry, CHEOPS will observe bright nearby stars that are known to have planets. When the orbit of a planet takes it in front of its host star, there is a dip in the light emitted by the star. The scale of this dip - known as the depth of the transit - relates directly to the size of the planet in relation to the size of the star. Put simply, a larger planet will block more of the emitted light from the host star than a smaller planet. CHEOPS will focus on exoplanets ranging from the size of the Earth to the size of Neptune, and the data it gathers will enable scientists to calculate the bulk density of target planets - the first step towards characterising such planets.

CHEOPS has been a great project to work on. Communications with the customer and the science teams were really good so that any minor issue arising from the system testing process was resolved without delay. I can't wait to see what science CHEOPS reveals about exoplanets. However, I'll have to be patient as the satellite has to go through some further testing and calibration in orbit before it starts to produce scientific data.

Update – October 2020

Photometric precision and stability are key requirements for CHEOPS to fulfill its objectives. Following almost three months of in-orbit commissioning, the satellite's performance and operation was confirmed to be "impeccable" by the CHEOPS Project Manager at ESA, and routine science operations commenced in April.

The first of many new findings was a nearby planetary system that contains one of the hottest and most extreme extra-solar planets known to date – a so-called 'ultra hot Jupiter' called WASP-189 b. With a scorching dayside temperature of 3,200°C, here even metals such as iron turn to gas so this particular planet is clearly uninhabitable. But who knows what exciting new discoveries will be made in the months and years ahead, as CHEOPS sets its sights on other alien worlds orbiting nearby stars in the universe?

Ryuichi Dunphy
Project Manager

February 2020

Planetary Defence

HERA is a European Space Agency (ESA) mission to characterise the binary asteroid Didymos – comprising a 780m diameter main body that is orbited by a 160m moon called Didymoon. The prime contractor for the mission, OHB, is leading an industry consortium of specialist companies including QinetiQ's space business, GMV, Spacebel, and OHB Italy.

QinetiQ is responsible for the design and development of the On-board Data Handling subsystem based on the company's dedicated on-board computer for satellites, spacecraft, and space robotics - the Advanced Data and Power Management System – 3 (ADPMS-3).

Named after the Greek goddess of marriage, the HERA mission is the European contribution to the Asteroid Impact and Deflection Assessment (AIDA) programme being undertaken in collaboration with NASA, and is scheduled for launch in January 2024. The mission has three key objectives:

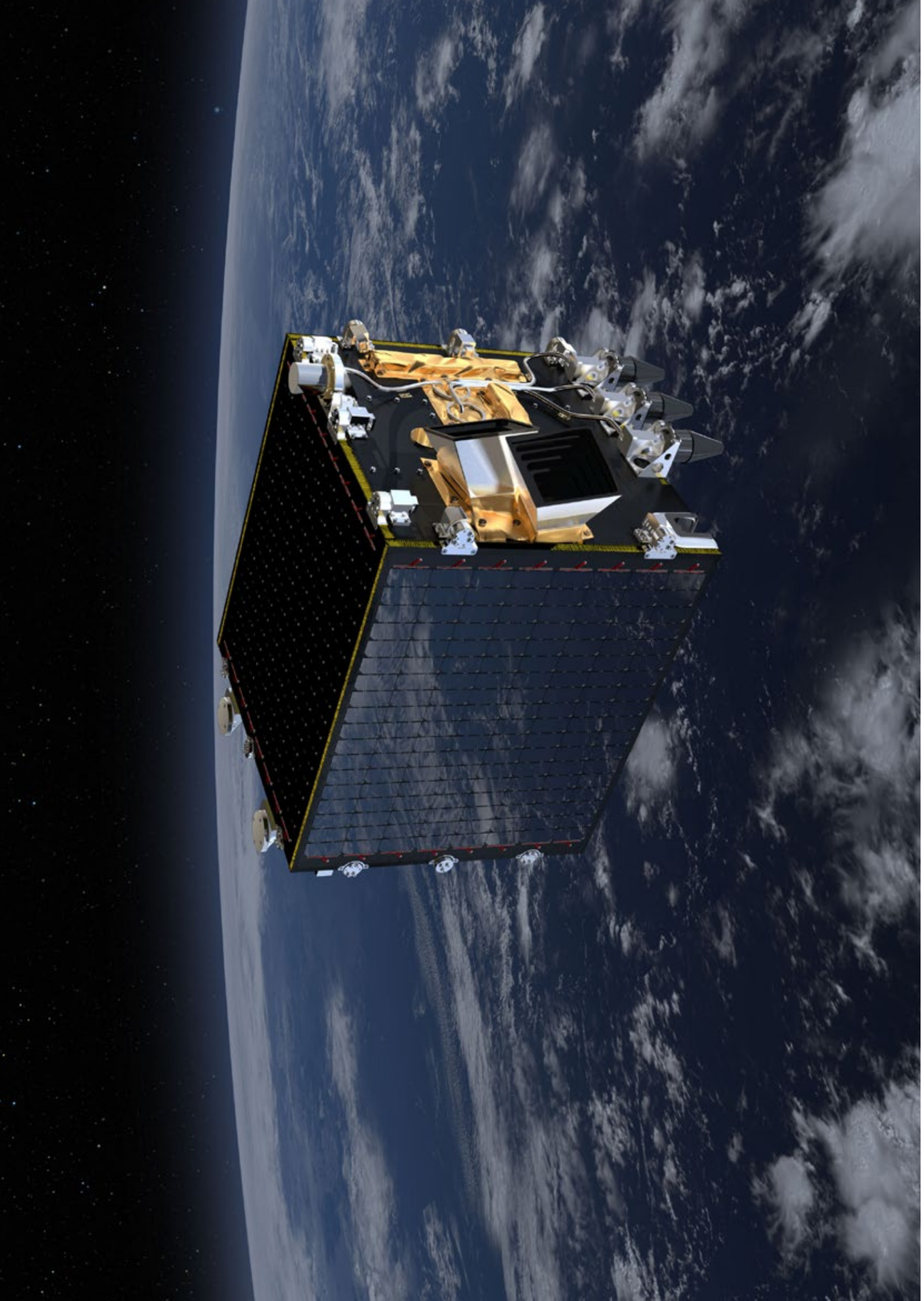
1. To contribute to the planetary defence of Earth by testing and validating impact models that will help to determine whether a spacecraft could successfully deflect an asteroid on a collision course with our home planet. In July 2021, NASA will launch a large impactor spacecraft - the Double Asteroid Redirection Test (DART) - that is planned to impact Didymos in 2022. ESA's HERA spacecraft will arrive in 2027 to observe the DART impact crater and measure the effect of the impact on the binary system orbit.

2. To investigate the surface properties and composition of a binary asteroid system and help increase our scientific understanding of such mysterious, airless and rocky worlds.

3. To demonstrate the effectiveness and performance of multiple novel technologies, including autonomous visual navigation around the asteroid and cutting-edge space hardware such as QinetiQ's ADPMS-3.

The first phase of the project began in September 2018, with the industry team focusing on the preliminary design of the spacecraft and the operational priorities of this new ESA mission. This work was completed in July 2019. A second preliminary phase is now underway to determine the payload interface baseline and critical technology developments. This has included a recent workshop at QinetiQ's primary space facility in Belgium, where 30 representatives from the industry team joined all of the payload providers to discuss the current status of the payload development and key technologies for the mission. The workshop also presented an opportunity for QinetiQ to highlight the current status of the ADPMS-3 system.

We look forward to reaching new milestones on the HERA mission.



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Dennis Gerrits
Project Manager

April 2020

Remembering the Launch of PROBA-V

It is often said that the second spacecraft a company builds is the hardest. In our case the third one, PROBA-V, is competing with the second one (PROBA-2) for being most challenging.

It started with the name - PROBA-V. This left a lot of people wondering what ever happened to PROBA-4? Well, the 'V' actually stands for the vegetation imaging instrument carried by this miniature satellite, that is only slightly larger than a washing machine. Despite its small size, PROBA-V is tasked with a full-scale mission to map land cover and vegetation growth across the entire globe every two days. Such imagery is vital for important applications such as climate impact assessments, water resource management, agricultural monitoring and food security estimates.

PROBA-V also became the first of its kind to step out of the technology demonstration background and enter the operational missions arena. One of the beauties of a PROBA-like project is that it involves relatively small teams on all sides that work collaboratively together in an integrated and supportive way to achieve a common goal. This spirit of collaboration is in evidence from the customer to the systems integrator and from the instrument manufacturer right up to the end user and scientific community.

Prior to launch, the main focus is getting the whole space and ground segment tested and calibrated to ensure that it will fulfill operational requirements once in orbit. This involves weeks and months of intensive test campaigns at various locations.

The launch is always an exciting step in each project. Preparing the satellite in a remote location on the planet and putting it on top of the launcher is the most memorable stage of the project, and it certainly puts team spirit to the ultimate test. During the launch you think of so many things that could go wrong, but everything is now out of your hands.

When a first signal is received from the satellite and when all experts have had a chance to go through the first telemetry received and confirmed that the spacecraft is healthy, the relief in the ground station is huge.

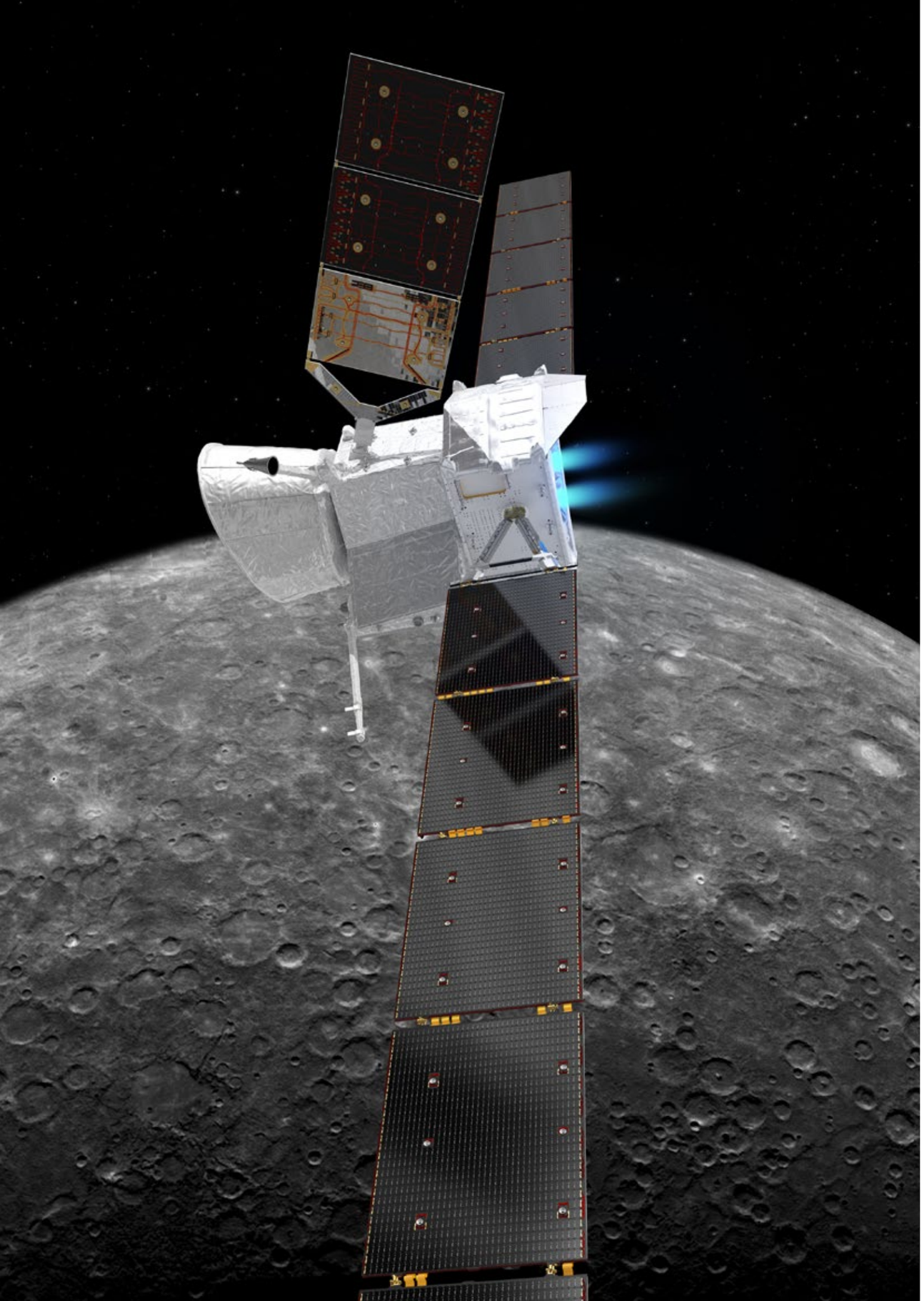
Systems are carefully and precisely checked step by step, and the platform is prepared for taking its first image. Belgium would have been an excellent first target for an image but, unfortunately, we are not always so lucky to have a blue sky with little clouds! Nevertheless, receiving the first image is a thrilling time in the test sequence of the satellite as it confirms the primary goal of having a healthy instrument in orbit that will provide much needed data and insight for the scientific community. It also allowed VITO, the company processing PROBA-V's images, to complete the tests of their ground segment and set the way for a successful operational mission.

One of the images we took later on during the commissioning phase has remained as my computer wallpaper for many years – a stunning image of the moon that was obtained when testing the automated moon calibration built into the system.

For the team at QinetiQ, the contact with the PROBA-V mission reduced after the handover to the customer. However, we still remained involved by providing support to the routine and less routine operations, investigating and solving anomalies when they popped-up and expanding image acquisitions and calibrations based on various interests.

In the meantime, other PROBA-like missions are under development at QinetiQ that will build on the heritage and experience gained from earlier missions. PROBA-V has been an important building block in that development as it demonstrates the maturity and value of this type of platform for Earth observing satellites.

You can see more special images and read stories in connection with PROBA-V at **www.proba-v.be.**



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Elaine Greaney
Chief Engineer

April 2020

Ion Thrusters

When developing truly pioneering technologies, the ability to rise to new challenges is just half the story. Painstaking research, the application of scientific insight and exhaustive testing are all prerequisites for turning a bright idea into a practical reality. This is especially true in the area of space exploration and research where technologies are constantly evolving to deliver new capabilities and new possibilities. However, the real sense of achievement comes with the successful application and performance of advances in ground-breaking technology and mission-led innovation.

Following our initial development of the ground-breaking T1 ion thruster in the late sixties, QinetiQ is now a world leader in electric propulsion systems. It is with a sense of great pride, therefore, that we see our ion thrusters being used for a mission that will study the mysteries of the Solar System's innermost planet.

The QinetiQ-engineered Solar Electric Propulsion System (SEPS) is powering the BepiColombo spacecraft as it makes its way across the solar system to Mercury following its launch in October 2018. This is the most powerful electric propulsion system ever flown. The QinetiQ T6 thrusters accelerate the joint ESA/JAXA spacecraft with a propellant of charged particles from xenon gas, powered by electricity generated by solar panels. This advanced form of propulsion minimises fuel consumption and addresses key mission challenges – such as the enormous gravitational pull of the Sun – while also maximising the quantity of scientific equipment being transported to Mercury.

A total of 23 ion thrust arcs are planned to ensure the spacecraft follows the correct interplanetary trajectory to arrive at Mercury in late 2025. This will entail no less than nine flybys of Earth, Venus and Mercury and 18 loops around the Sun. On arrival, the Mercury Planetary Orbiter and the Mercury Magnetospheric Orbiter will be deployed from the Transfer Module to gather unprecedented data and insight of the least explored inner planet during a year-long mission.

Significantly, the in-flight performance of the propulsion system is continuing to fulfil all objectives and the second thrust arc for BepiColombo has now been completed successfully. Having stayed dormant for eight months, two of the ion thrusters were switched back on to complete the manoeuvre and take the spacecraft from its furthest point from the Sun on the correct trajectory to achieve an Earth flyby in April 2020. It was gratifying to receive congratulations from the customer on the stable performance of our thrusters during such a critical stage in the mission.

To commemorate this success we sent delegates to last year's International Electric Propulsion Conference in Vienna, with presentations on the qualification and early flight data of the BepiColombo T6 electric propulsion system. The team who attended the event also took the opportunity to highlight the latest system developments including our smaller T5 thruster and larger T7 thruster, which are expected to feature prominently in a diverse range of space missions in the coming years. There can be no doubt that electric propulsion is set to transform the efficiencies and capabilities of space transport in the years ahead.

© ESA

Jim Graham
Managing Director, QinetiQ's space business

March 2020

Looking Back to Fly Forward

Recently I wrote about the state-of-the-art instrumentation we have provided for material science experiments on the International Space Station and the recent launch of a new satellite to search for new exoplanets.

As it continues its journey to the innermost planet of our Solar System, the BepiColombo spacecraft is also benefiting from our advanced solar electronic propulsion system.

Although our achievements over the past few years and decades certainly bear close scrutiny, I do believe they have also helped to consolidate our leading role in space exploration and research – both as a trusted partner and as an industry pioneer. And working in collaboration with a diverse community of stakeholders, partners and suppliers, there is no doubt we are helping the UK to build on its pedigree, expertise and influential role in constantly evolving space technology and science.

So I was delighted, therefore, to accept an invitation to a special event to mark the 50th anniversary of the launch of the Black Arrow rocket, where a highlight was a talk from the only surviving member of the construction team detailing how they made the fuel tank. Developed during the 1960s, this satellite carrier rocket was the culmination of a concerted development programme led by scientists at the Royal Aircraft Establishment in Farnborough and led to the successful launch of the Prospero satellite into a low earth orbit in 1971. This was the first (and, to date, only) all-British mission – with the satellite and its carrier rocket both designed and built in the UK.

The R3 Black Arrow rocket that carried the Prospero satellite into space was launched from a launch pad in Woomera in Australia and the first stage of the rocket landed in the Australian desert. An impressive statement of pioneering British space technology at the height of the so-called space race, this section of the rocket has finally returned to its original home. It was unveiled at the 50th anniversary celebration to mark the first successful launch of the Black Arrow rocket in 1970. The event was held at the Cody Pavilion at the Farnborough Air Sciences Trust Museum on Wednesday 4th March, close to home for us here at QinetiQ, and where a model of our T5 Ion Thruster is on display.

One can only wonder at the immense sense of pride felt by the Black Arrow scientists and engineers from the rocket's first successful launch and, a year later, when the Prospero satellite entered orbit and clicked into life. Space technology has come a long way over the past 50 years, but we all feel the same sense of achievement with every step forward we make in space exploration and research. Certainly, when one considers the versatility, specification and the advanced propulsion and avionics systems of our latest generation of satellites, it is clear that QinetiQ's space business is about to enter a very exciting new era. Not only is that a credit to every member of the team, but it also opens a new chapter in the UK's role as a space pioneer.

Ruben Willems
Electronics Systems Engineer

December 2020

Continual Evolution for our ADPMS 3rd Generation

Using innovation to deliver the very best operational outcomes for customers lies at the very core of our business. One area where this has been clearly demonstrated is with the development of an Advanced Data and Power Management System (ADPMS3) for small satellites. Our ADPMS3 system includes three products: an on-board computer (OBC), a power control and distribution unit (PCDU), and a remote terminal unit (RTU). In this blog though, I am going to talk about our OBC.

Our first ADPMS OBC was originally developed for the European Space Agency's (ESA) PROBA 2 satellite and it has worked perfectly since the launch of the satellite eleven years ago. The second generation of the system was also used on the PROBA-V, as well as other missions, and has been modified to meet the specific power and production demands for the two spacecraft of ESA's pioneering PROBA-3 mission that will see two satellites flying in precision formation together for the very first time.

We're now building on the system's proven resilience, agility and operational performance with the introduction of the latest evolution of our redundant on-board computer – included in the ADPMS3 product gamma. As has been the case with its predecessor, this new system balances the same need for cost-effectiveness and simplicity with even greater functionality to provide a dedicated, highly versatile and modular platform controller for the new generation of satellites, space vehicles and space robotics technologies.

The development of ADPMS3 is now at a Qualification Model level. Our objective has been to improve reliability, performance and flexibility in a more compact form without compromising the benefits of using plug and play architecture to integrate an easily configurable and adaptable mix of units. We're well along the road – or should that be flight trajectory!? - to achieving this goal.

The system can be used as a non-, cool- and hot-redundant platform controller. At its heart is a dual core processor that runs at 80Mhz (delivering 112.7DMIPS in single core operation and 171 DMIPS in dual core operation) in conjunction with a large scale, reconfigurable field-programmable gate array (FPGA). Great care has been taken to provide a comprehensive range of dedicated interfaces, including ECSS (European Cooperation for Space Standardisation) compliant spacecraft platform communication interfaces – and to ensure all components meet low Earth orbit, geostationary orbit and deep-space requirements.

This commitment to quality, reliability and versatility is helping to maximise the system's functionality and capabilities and, subsequently, its application potential. We have no doubt that our ADPMS3 products will continue the successful track record of their predecessors and make a significant and measurable difference to an ever-growing number of future space missions.

Staying Alive: Life Support Systems for Future Space Travel

Life support systems ensure that astronauts can live in a comfortable and safe environment, with conditioned air, oxygen, food, water and waste control systems. There are steps that can be taken to make the environment conducive to greater recycling and resource exploitation, all culminating in a closed loop system. This could be, literally, life-changing.

Current life support systems rely on a react and resupply process – for instance, astronauts on board the ISS have to take a limited amount of water with them, because bringing the required amount is impossible, so they rely on regular resupplying; they also depend on packaged food for nutrition as opposed to cultivating food.

Recognising that elements traditionally considered 'waste' are in fact resources, will undoubtedly enable longer-term space travel, at a long distance, to enable exploration of the moon and mars.

Space to breathe

Traditional space systems rely on physico-chemical processes, requiring a lot of energy, occurring at particularly high pressures and temperatures. Replacing them with biological processes increases effectiveness and builds the foundation of an entire closed loop system.

Take the air that we breathe as an example. It's easy to forget that we need 78% nitrogen in the air to avoid ignition of random fires. Research shows that there is extremely little nitrogen on the moon or mars. Producing it through human waste containing high levels of nitrogen is currently an untapped method but a vast resource pool.

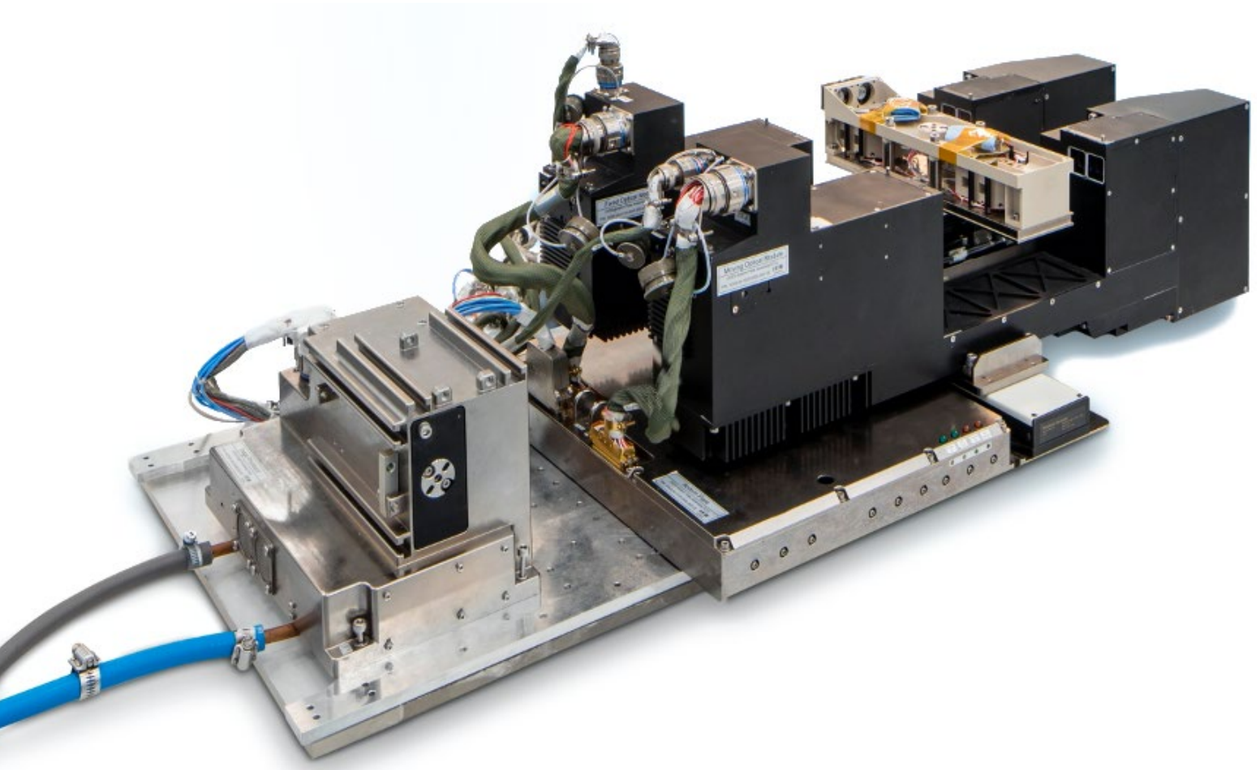
This is where micro-organisms come in. Bacteria can produce nitrogen out of human waste in a much more sustainable, long-lasting manner. Nitrogen is required for growing plants and algae as food, or can be converted to nitrogen gas to create an atmosphere. Micro-algae provide a great amino acid source for the astronauts' diet, replacing the proteins in meat. So, what's the merit in growing micro-algae?

Both algae and ordinary plants of course produce oxygen through photosynthesis and biomass as well. Many would opt for growing plants to eat, to eventually extract nitrogen from waste, but often this can mean waiting for a couple of months before the plant is ready to eat. With algae, the amount of biomass can double in just a couple of days. Being grown in bioreactors, they are also much more controllable, reacting to light, temperature and nutrient conditions. Aside from this, they are far less prone to disease or being infected by fungi. With plants, avoiding a whole spectrum of diseases is tricky when the slightest variation in conditions can instigate them. The recovery time for plants remains much longer as well.

Bringing the value back to Earth

The value from making improvements to systems in space can be brought back down to Earth, so that everyone can reap the benefits. Bioreactors, containing microalgae, to improve air quality in space can be used for indoor spaces, like offices and meeting rooms. As the CO2 level exceeds optimal amounts, those in the room can begin to fade away and feel their energy alertness sap. Algae can control the CO2 from ambient air to maintain the optimum threshold. The reactors can also be designed into furniture, further contributing to overall wellbeing and becoming part of an office or meeting experience.

Though this may appear niche, already hundreds of people globally are dealing with this expertise and technology. This is despite the fact that the budget for operational, short-term missions is greater. Clearly, the opportunity for longer-term, full-circle scenarios in space is where we are going to find immense, unexploited value, stimulating a chain reaction of benefits across the universe that everyone can enjoy.



Marc Dielissen
Engineering Manager

October 2019

SODI – A Decade in Orbit

The Selectable Optical Diagnostics Instrument, or SODI for short, is a scientific instrument to study fundamental fluid science in weightlessness made by QinetiQ's team in Belgium.

The science that SODI studies has some applications on Earth. For example, for defining amounts of crude oil in underground oil wells, for explaining and predicting diffusion models, and for understanding the formation of colloids and crystals in liquids (potential use in super-fast light computers).

It was launched in 2009 to the International Space Station (ISS) and is located in the Destiny module. It was expected to operate for two years but it is still going strong today. During these ten years in orbit, SODI has been a reliable instrument for the European Space Agency.

After a series of experiments during this last decade, SODI is now ready for a new experiment. In 2020 there is an experiment called T-PAOLA from the UK Space Agency. In preparation for T-PAOLA, the vibration mechanism and the bottom plate of SODI will come back to QinetiQ on a SpaceX Dragon flight for some parts to be refurbished, and some parts will be preventively replaced. Once this is complete, they will be flown back to the ISS ready to go again.

After a decade in space, SODI has been through a lot (and round the Earth a lot too). For example, back in 2014, the launch vehicle Cygnus exploded with a cell array and a Flash Disk for SODI inside. The hardware was returned to our team here at QinetiQ and was found to still be operational. That unit is on display at our facilities in Kruibeke, Belgium. Another challenge SODI managed to come through was when a faulty processing unit needed replacing. We managed to get the unit returned to Earth (in the US Space Shuttle no less), fully repair it and upload to the SODI unit on the Space Station, all within 4-months' time. Extremely fast even by this industry's standards!

From QinetiQ in Belgium, we want to celebrate the 10-year anniversary of SODI on orbit and we are working on delivering more reliable and long-lasting hardware for the ISS.

Dries Demey
Senior Systems Engineer

October 2019

Life Support Technology to Support Long-distance Space Travel

Long-distance crewed space missions for exploration of new habitats might be a reality within just a few decades. These challenging activities require the development of effective solutions for spacecrafts, energy supply, communication systems and, of course, Life Support Systems to ensure astronauts can live in a comfortable and safe environment with conditioned air, oxygen, food, water, and waste evacuation. Advanced Life Support Systems consider waste as a resource and aim to recycle air and water after appropriate treatment and conditioning.

QinetiQ's space business is helping to develop and demonstrate new Life Support Systems technology. Current projects include the Waste Compartment and Microbial Electrolysis Cell (WC-MEC) and support for the exploitation of the water production and recycling system at the Princess Elisabeth Research Station.

Microbial Electrolysis Cell

Production of bio-hydrogen has the potential to be a renewable energy alternative to current technology. A Microbial Electrolysis Cell (MEC) is a bio-electrochemical system capable of producing hydrogen gas at a much better energy efficiency rate when compared to conventional electrochemical hydrolysis. In fact, MEC systems consume hardly any energy at all as bacteria are the catalyst for the reactions.

In collaboration with the Center for Microbial Ecology and Technology at Ghent University's Faculty of Bioscience Engineering, QinetiQ's space team has developed and constructed a fully automated pilot installation to demonstrate the technology and to quantify the processes. Based on the experiments, it will be possible to establish the hydrogen production rates in relation to the converted organic contaminants. The work is performed for the European Space Agency in the framework of the MELISSA program that is focusing on innovative technologies for Life Support Systems.

Drinking water at the Princess Elisabeth Research Station

QinetiQ is also supporting the International Polar Foundation in the operation and exploitation of the water treatment and production facilities at the Princess Elisabeth Station near Utsteinen on Antarctica.

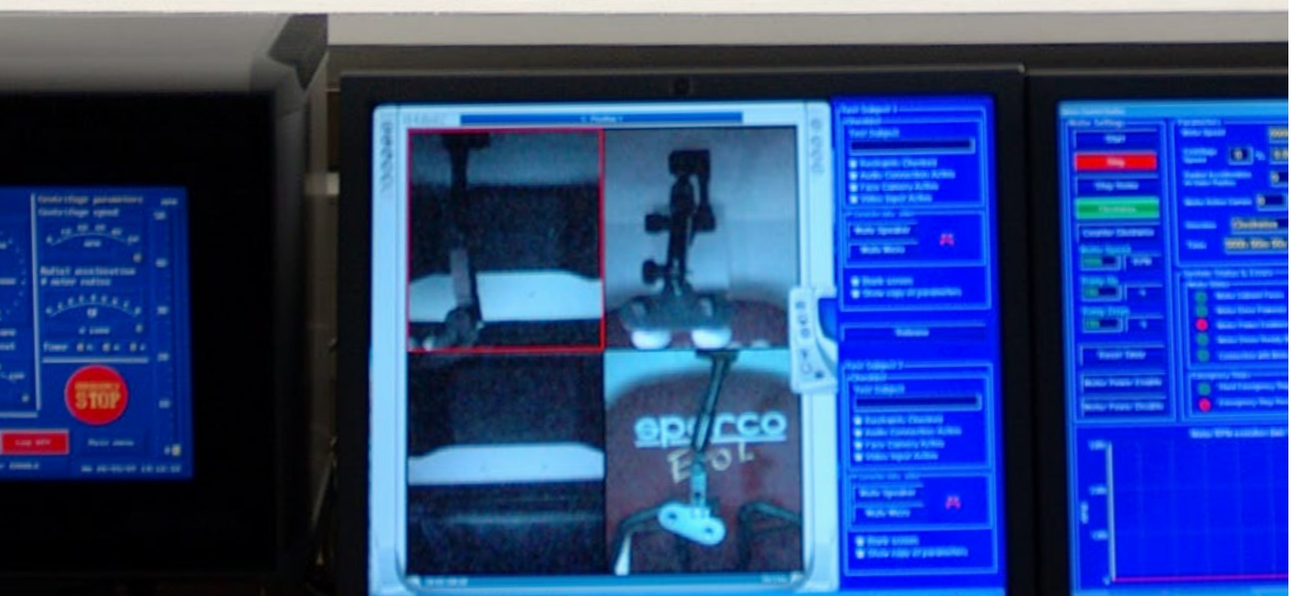
The Station was constructed about 10 years ago on the initiative of the International Polar Foundation. In accordance with the Antarctic Treaty, the "zero-emission" concept of the station limits the impact on the environment with renewable energy generated by solar panels and wind turbines and all waste and wastewater is treated and reused.

The design and implementation of the technical systems to achieve this was particularly challenging due to the hostile environment and the constraints on available space, energy supply and logistics - demands that are very comparable with the requirements of space systems. Consequently, a partner agreement was established with the objective to promote the Station as a reference platform for future Life Support Technology for Human Space Exploration.

At the start of every season, snow is melted to produce potable water and is conditioned, stored and distributed to the kitchen, showers, toilets, and laundry. The wastewater treatment system combines biological and physical-chemical treatment technology comprising. In the anaerobic bioreactor, fermenting bacteria degrade the particles into smaller soluble molecules in the absence of oxygen and at high temperature (55°C) – a process that also ensures elimination of pathogenic microorganisms.

After filtration, the filtrate is forwarded to the aerobic treatment system where soluble organics are biodegraded and converted to CO2 and N2 and the water is separated from the bacteria by a flat sheet membrane filtration unit. The effluent is finally polished in an activated carbon column and, after chlorination, is stored in the distribution tank for reuse.

After completion of a refurbishment and expansion of the units in 2018/19, a treatment efficiency of about 90% was achieved of all the wastewater. Melted snow still provides drinking water for human consumption, but treated water was reused as toilet flush and shower water. The actions for season 2019-2020 include an improvement of the start-up and shut down procedures and further automation to allow the systems to work at full capacity as soon as possible. New analyzers to measure the water quality will provide additional feedback for advanced control algorithms that support operator decision-making and to provide early warning of any anomalies.



©CNES–Rachel Barranco, 2010

Joachim Senft
Project Engineer

November 2019

Human Centrifuge Receives an Upgrade

For many years, QinetiQ has been supporting increasingly ambitious and pioneering human space exploration programmes. In 2005 and 2007, the QinetiQ space team in Belgium was given the task of building two short arm human centrifuges (SAHC) for the European Space Agency (ESA).

Centrifuges are used to create centrifugal acceleration on a body – or what could also be called “artificial gravity”. They are vital pieces of equipment for astronaut training and for understanding and minimising the potential health issues and physiological risks posed by space travel - such as bone loss and muscle mass reduction, deterioration of the immune system, sight impairment, and orientation problems. Such risks increase in tandem with the length of time spent in space. However, studies have shown that the artificial gravity created by a SAHC could help counteract the effects of microgravity.

The two QinetiQ-built centrifuges – at the Institute of Space Medicine and Physiology (MEDES) in Toulouse, France, and at the DLR (German Space Agency) facilities in Cologne - have proved to be extremely reliable and resilient, delivering excellent results day after day.

In Germany, the SAHC has been used for training of European astronauts and provides the capability to train individuals (with their associated equipment) to very accurate acceleration profiles. This centrifuge is now being upgraded to become an active centrifuge. Previously, it has only been possible for trainees to lay or sit during a centrifugal period but, significantly, the mission-led upgrade will deliver improved operational outcomes for ESA and provide the option for individuals to undertake exercise while experiencing artificial gravity.

The SAHC arrived QinetiQ at the beginning of 2020 and will stay in our facilities for approximately six months. Once the upgrade programme has been completed, the SAHC will be moved to the Jožef Stefan Institute at Planica in Slovenia where ESA plans to carry out detailed studies of bed rest. Such research has been shown to be an excellent way of testing potential measures to counteract the negative effects of microgravity.

The upgraded SAHC:

- Measures almost 6 metres in diameter
- Weighs 3.5 tons
- Runs at 43 revolutions per minute and results in 2.5 g at the centre of gravity of the test subject.
- Can accelerate a total weight of 550 kg to a maximum of 6.5 g

Ellen De Cock and Jeroen Peeters
Project Manager and Systems Engineer

November 2019

ICAPS Experiment is Great Success!

Friday November 15th saw the successful launch of the Interaction in Cosmic and Atmospheric Particle System (ICAPS) from Sweden, part of the TEXUS 56 flight campaign in the Esrange Space Center. The launch was carried out jointly by the DLR (German Space Agency), Airbus Defence & Space, OBH System, and the Swedish Space Corporation, with financing provided by the European Space Agency (ESA).

QinetiQ's space business built the ICAPS experiment which performed very well during this sounding rocket flight and provided invaluable information to scientists studying planetary science. We relayed this news back to the team at QinetiQ's space business in Belgium and, naturally, they were delighted with the success.

What is ICAPS?

The main goal of the experiment is to simulate the early stages of protoplanetary matter formation as planet precursors and to study the mutual interactions of micron-sized dust particles and their agglomeration. In simpler terms, this means that ICAPS is studying dust-dust and dust-gas interactions to provide new insight and answers to fundamental questions, such as:

- What is the nature of initial growth processes of planets?
- What is the mass, structure, and motion of small dust aggregates?
- How did the planets form in the early solar system?

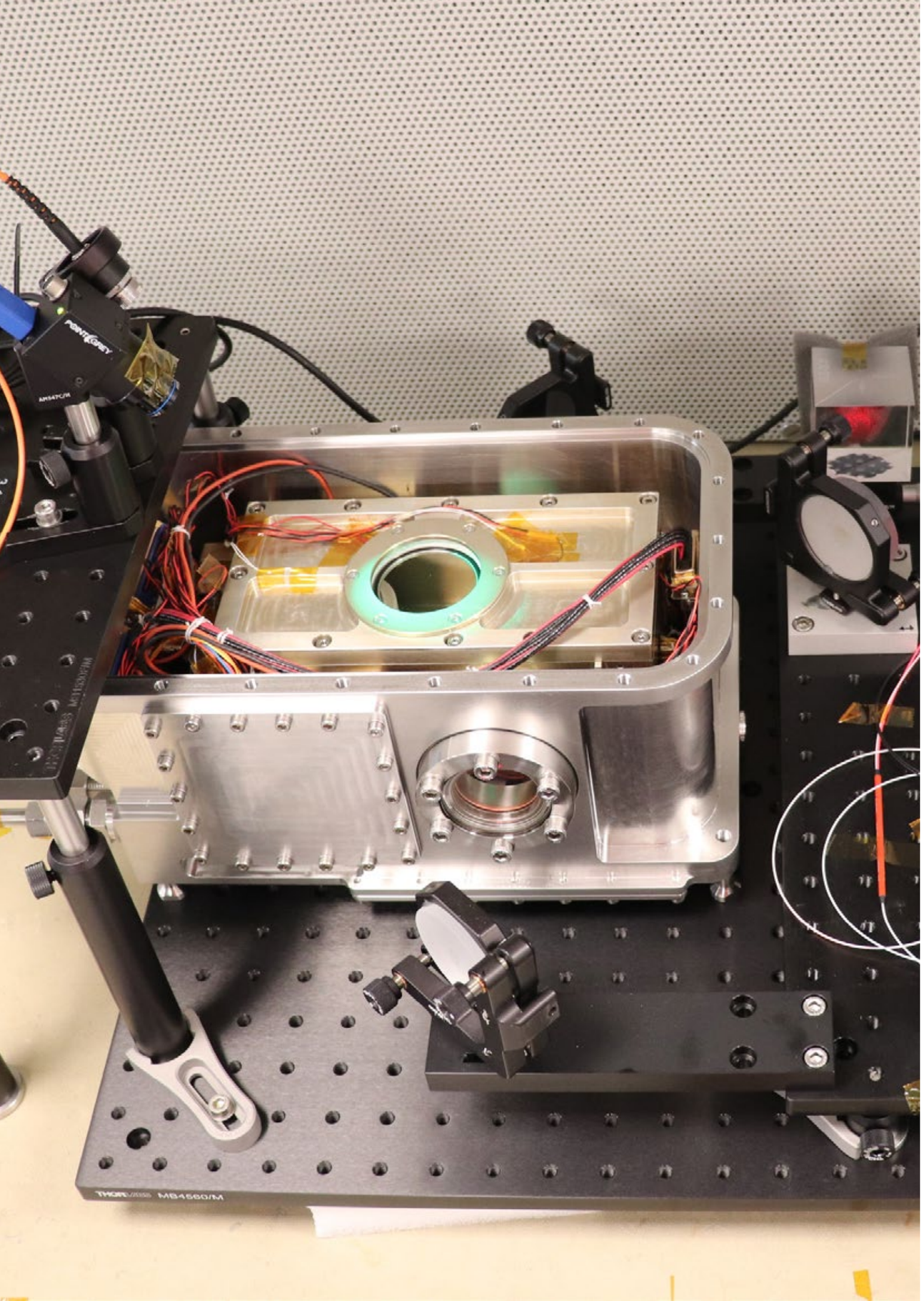
Given the success of the mission and the significance of such findings, it is hard to imagine a better example of our commitment to deliver exceptional operational outcomes for our customers… and the wider space community!

What is a sounding rocket and how does it help scientists study planetary science?

The ICAPS experiment is a 1.2 metre-long module that houses a vacuum chamber, a silica particle injector, and cameras. Silica dust particles are injected into the vacuum chamber and then scientists use the cameras to observe how these particles interact while in microgravity. This is basically a re-creation of the ideal conditions for the formation of planets.

The microgravity is achieved thanks to the sounding rocket. This carries instruments designed to perform scientific experiments and take measurements. It does not go into orbit, as it only needs to provide a few minutes (in this case, six) of microgravity before it returns to Earth. The vehicle performing the launch was a VSB-30 - a two-stage solid propellant launcher, with a diameter of 557mm - that can reach an altitude of 259km.

There are many more experiments planned which we look forward to supporting.



Ingmar Lafaille
Satellite Portfolio Manager

October 2019

Taking Heat Transfer Research to a New Level

QinetiQ's latest experiment facility for space is the European Space Agency's Heat Transfer Host 2 – a programme that has now reached a significant development milestone.

The design and specification of highly sophisticated and complex experiment facilities for deployment in space demands painstaking attention to detail as well as exhaustive test and evaluation procedures. QinetiQ's latest system is the Heat Transfer Host 2 for the European Space Agency that will provide unprecedented insight into evaporation and condensation processes. Among many other benefits, this new scientific data will help to optimise the performance and efficiency of thermal management devices and various industrial processes. Once the development and integration phases are completed, Heat Transfer Host 2 will be operated in the European Drawer Rack 2 in the Columbus laboratory on-board the International Space Station.

The development of Heat Transfer Host 2 has now reached an important milestone, with the design of the three experiments to be hosted in the facility now completed and all instrumentation and hardware, at large, successfully tested to build confidence on the attainable scientific performance. Test campaigns were held in partnership with the relevant science teams - comprising leading experts in the field of gas-liquid phase change thermodynamics - to reflect on the critical specifications and target performance of each experiment.

Precision optical diagnostics, developed or adopted by Lambda-X, will be used in each of the three experiments to observe in detail the physical phenomena relating to drop evaporation, thermocapillary convection in evaporating liquid films and film condensation on external surfaces - all within a weightless environment.

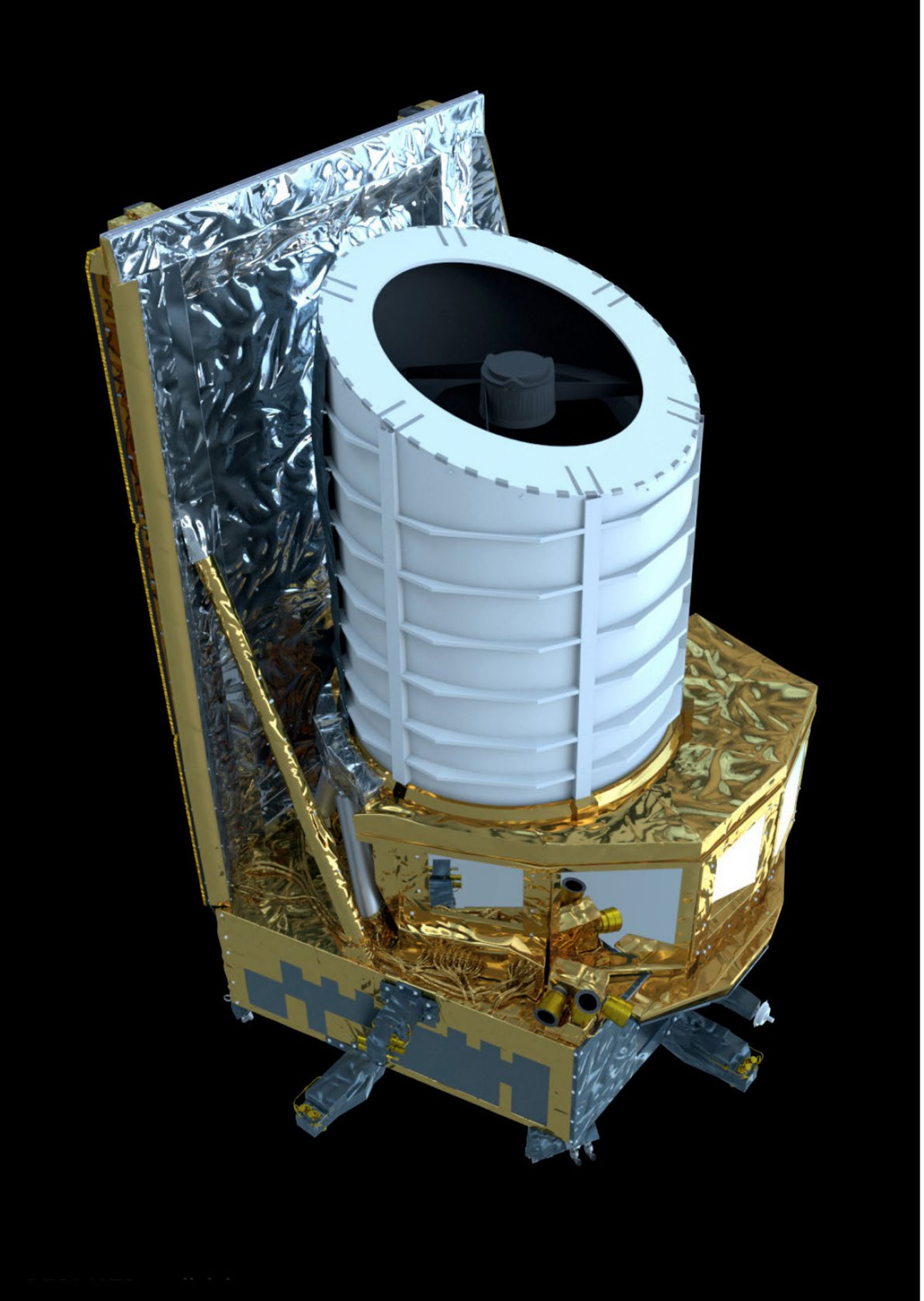
Having obtained reassuring indications on the prospective operational performance of the different experiments and optical systems, the focus of our Heat Transfer Host 2 team is now moving onto the next phase of production – the engineering modelling phase.

The European Space Agency's Heat Transfer Host 2 facility comprises three experiments:

Condensation on Fins aims to reveal the link between the thickness of the condensed liquid film on an axisymmetric condenser finger and the heat transfer characteristics. In weightlessness, a relatively large condenser can be studied as a model of ground-based capillary driven devices. It enables detailed instrumentation and accurate characterisation of the condensate thickness distribution that, together with the heat transfer characteristics, is necessary for the validation of theoretical models. The improved understanding from such experiments is expected to support the development of more efficient and/or more compact condensers - contributing to the conservation of resources, both on ground and for future space missions.

Drop Evaporation will investigate instabilities that form in evaporating liquid droplets sitting on a substrate and the spreading of the vapour away from the droplet, with a range of gas-phase characteristics. It also aims to study the effect of an electric field on the evaporation process. Dropwise evaporation occurs in a wide spectrum of circumstances in nature as well as in technical processes, ranging from printing technologies, nano-coatings, to DNA mapping. If the space experiment allows an accurate characterisation and subsequent modelling of all underlying mechanisms (that gravity will mask during on-ground experiments), it will enable knowledge-based optimisation of existing processes and the establishment of new technologies such as surface functionalisation.

Marangoni in Films pursues a better understanding of the formation of instabilities and the transfer of heat to the surface of an evaporating liquid film that covers a heated substrate with a structured surface. For its success, the detailed and accurate mapping of the liquid film thickness distribution, the thermal stability of the evaporating region as well as the characterisation of the vapour concentration distribution are all key. The fundamental experiment is expected to advance and validate numerical models which can then be applied in the future design of film-wise evaporators. This will help to improve the efficiency of terrestrial thermal control devices and/or enable the realisation of compact evaporators for space applications.



Malika De Ridder
Instruments Portfolio Manager

February 2020

The Dark Side

Euclid of Alexandria was a Greek mathematician who is considered the father of geometry. He lived around 300 BC and his book Elements is one of the most influential works in geometry and mathematics. When the European Space Agency (ESA) decided to build a telescope to map the geometry of the dark universe, that's why they named it Euclid.

Dark matter and dark energy make up most of the energy of the cosmos and Euclid will investigate three extremely dark patches of the sky by measuring shapes and redshifts of galaxies - equivalent to looking-back in time of 10 billion years. This way, scientists will be able to study the period over which dark energy accelerated the expansion of the universe.

The Euclid baffle, which QinetiQ's space team just finished, is a super lightweight structure that will shield stray light from the Euclid telescope. It weighs 58 kg including 24 thermal straps and multi-layer insulation blankets and extreme thin sections (thickness of 0.4mm over half the surface). In addition, it serves as a radiator to control the temperature of the electronics. The baffle has a diameter of 1.8 m and a height of 2.4 m. Even though it's a lightweight structure, it can sustain up to 19 g in 3 different directions. The baffle protects the two main scientific instruments:

- A visible imager (VIS) for shape and photometric redshift measurements of galaxies in the wavelength regime from 550–900 nm.
- A near-infrared spectrograph and photometer (NISP) for photometric and spectral redshift measurements of galaxies from 920 nm to 2100 nm.

The baffle had to be developed under strict cleanliness conditions as any dust particles could interfere with the telescope's observations. Our team made sure everything was as neat and clean as possible by wearing full body suits and cleaning in the dark with a UV light and small swabs. But, that's not all, as we also had to keep everything clean during integration, transport, and testing!

The baffle will now be integrated into the spacecraft and will be further tested as part of the payload. It is expected to be launched from French Guiana in 2022. Euclid will be orbiting the sun at the L2 Lagrangian point – a special location in space where a small body can maintain its position in relation to two bigger bodies (the Earth and Sun in this case) without being pulled into the larger object's orbit.

QinetiQ's space team is looking forward to seeing just what Euclid can discover from the dark side of the universe!

Steven Hens and Malika De Ridder
Project Manager and Instruments Portfolio Manager

February 2020

The Alloys Age

Rocket launches are always special. However, when they carry hardware that you and your team have worked on, they are even more special.

Special pieces of hardware made by QinetiQ were onboard a recent resupply mission to the International Space Station (ISS). Called Transparent Alloys Cartridges (TAC), they flew inside the Dragon spacecraft, on top of the Falcon 9 rocket that marked the 19th mission for SpaceX under its commercial cargo resupply mission to the ISS.

The TAC arrived safely at the Station in December and will now be used in the Transparent Alloys instrument itself (also made by QinetiQ), which is already inside the Microgravity Science Glovebox host facility in the Columbus module on board the ISS. The Transparent Alloys instrument is hosting experiments in the field of material science - more specifically, in the field of alloys – and received high praise from both the European Space Agency (ESA) and the scientific teams working with it.

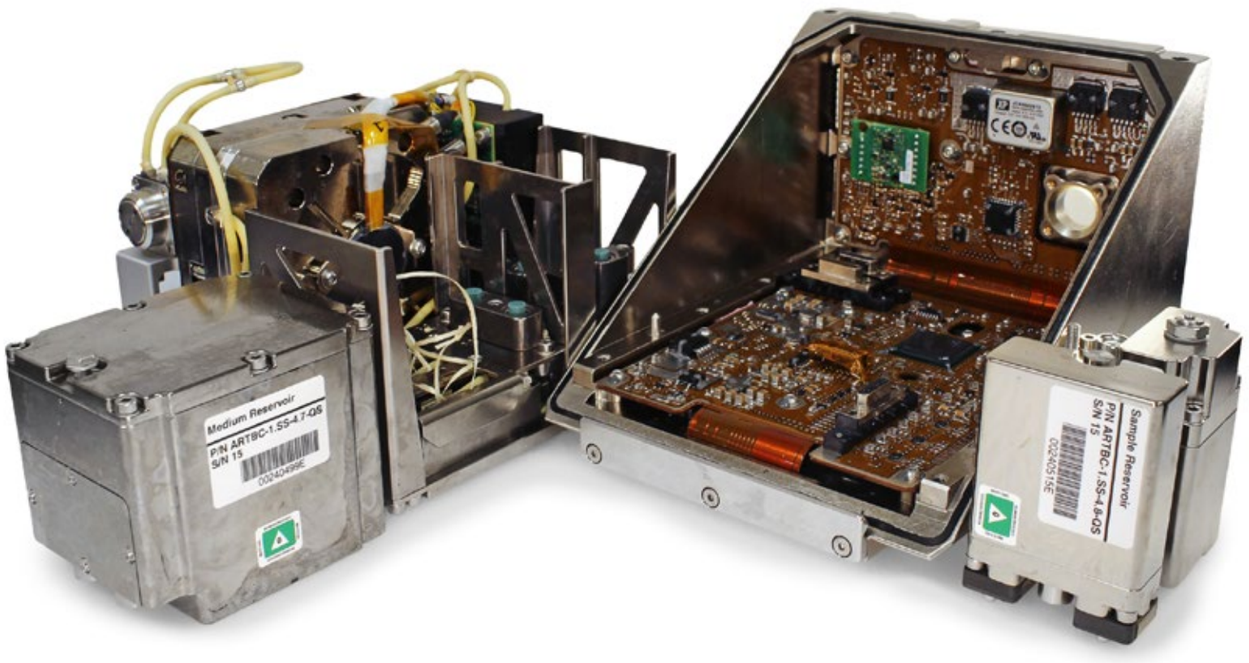
Why does TAC matter?

Alloys are mixtures of various metals. When you mix metals, you'll produce a new material with different properties to the original and, if you happen to find the right combination, you may discover a revolutionary new material. Alloys have been vital in producing lightweight or resistant materials. If we think about humanity's progress, it has often been linked to advances in metallurgy. Just consider the Iron Age and the Bronze Age. With alloys now everywhere we look and in everything we do – from rockets to mobile phones – perhaps we should say that we are now in the Alloys Age!

How does it work?

The Transparent Alloys instrument can be compared to a miniature toaster operating in line with a small freezer, with two microscopes to study what happens in between. This is similar to a conveyor-belt oven found in factories or fast-food restaurants. The cartridges pass from the heating elements into the freezer at an agonisingly slow pace - they take more than two days to travel 1 mm, and the experiment runs on its own for several weeks. During this process it is possible to monitor the dynamics of physical processes during solidification under microgravity.

The new cartridges – the TAC – are providing mixtures for many new experiments. In fact, they will be used by five different groups of scientists. This multi-user aspect was the main challenge for the design of the instrument as most of the parameters were variable. Working in close collaboration with ESA and the various science teams, we ensured the TAC met all of the target objectives and operational outcomes for the various experiments. Not only did we deliver different sizes of experiment cartridges and cater for specific optical requirements and a large range of temperatures (from -10°C up to +250°C), but we also provided three levels of containment for some of the experiment materials to meet stringent safety requirements.



Steven Hens
Project Manager

March 2020

Artemiss Oxygen Production in Space

How can we make human deep space travel a reality? The challenges and considerations are huge, but the starting point will always be having good quality air to breathe for the duration of the mission.

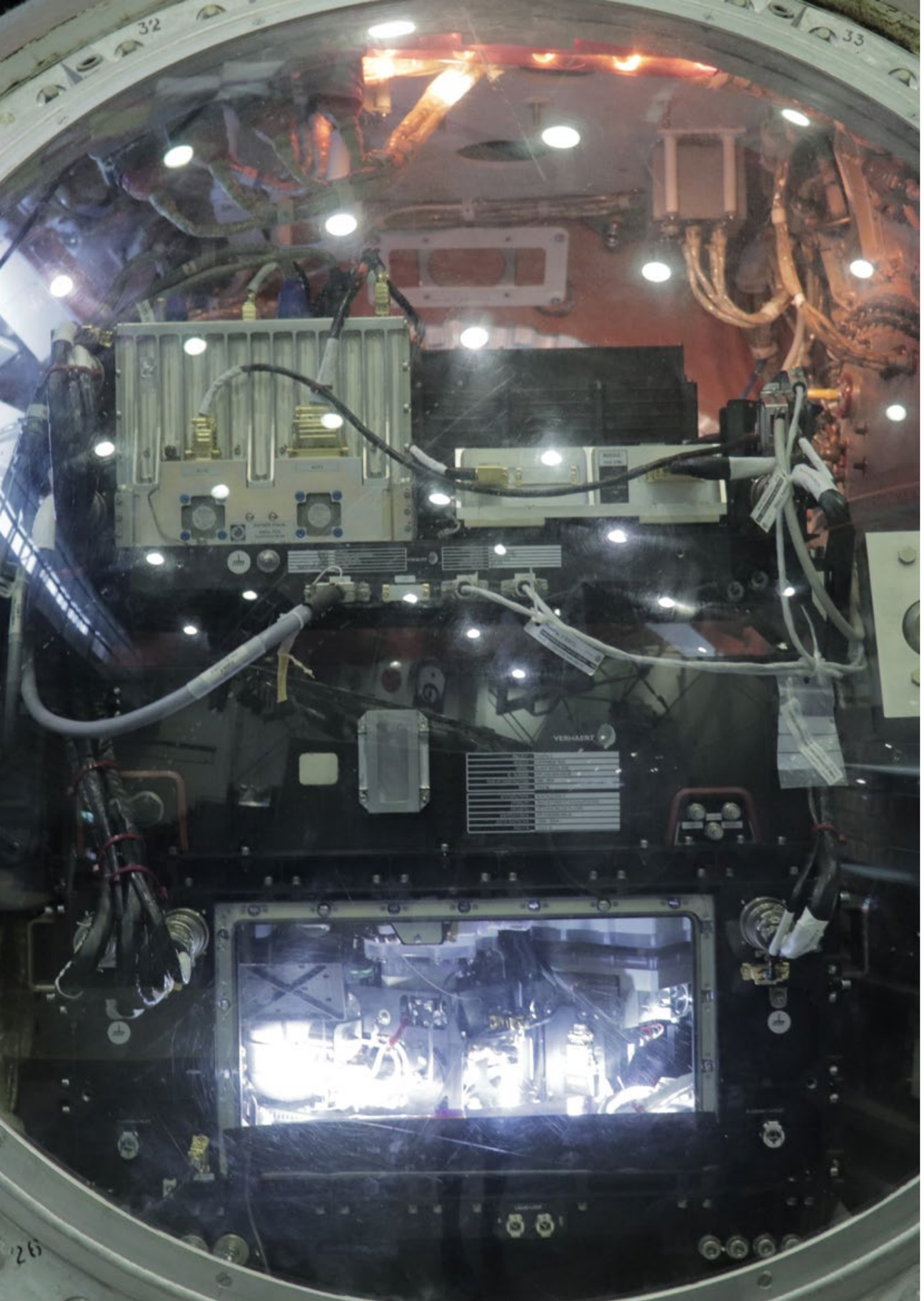
The cyanobacterium Arthrospira sp. strain PCC8005 (commonly known as spirulina) is a candidate for use in spacecraft biological life support systems for carbon dioxide and nitrate removal as well as oxygen and biomass production. The reliability of such a biological life support system is critical, however, so it is necessary to characterise its response to in situ spaceflight conditions. This is where QinetiQ's expertise and commitment to mission-led innovation comes into play.

Artemiss is an instrument (a photobioreactor) built by QinetiQ to help determine the effect of spaceflight conditions - including reduced gravity and increased radiation - on the Arthrospira's morphology, physiology and metabolism.

Artemiss was launched to the International Space Station (ISS) on December 2017 onboard the SpaceX' Dragon spacecraft and stayed onboard and in orbit for five weeks. In this time, the bacterium was cultured in a defined liquid mineral salt medium with constant illumination, temperature, and stirring over multiple generations. By accessing the data provided by Artemiss from space, the science teams were able to monitor all biological changes of the bacterium. The experiment worked successfully so, in every respect, Artemiss produced a breath of fresh air for the astronauts onboard the ISS.

QinetiQ's space business is now planning and developing a second stage to the experiment. In Artemiss B, the bacterium was cultured in a batch regime. In Artemiss C, the bacterium will be cultured in a continuous 'steady state' regime and kept at a constant predefined cell density by imposing a continuous in- and out-flow of the bioreactor at a specific dilution flow rate and with appropriate light intensity.

QinetiQ is the European Space Agency's prime contractor for this project, which is expected to fly back to the ISS by the end of next year. The experiment will give further insights into the adaptation of the bacterium to space conditions and we're certainly enjoying our role in helping humanity to become an interplanetary species! And, just as an added curiosity, did you know that the spirulina is also used to give the M&M's their blue color?



Marta Lebron
Marketing and Communications Officer

March 2020

Our Heritage on Display

Our space team visits the European Space Agency (ESA) – one of our main customers – on a regular basis. ESA has sites in several European countries, but the European Space Research and Technology Centre (ESTEC) at Noordwijk in the Netherlands, is the largest. It was here, on our most recent visit, that the team took some time to take a tour around the facilities.

A real highlight on the visit was seeing one of the projects we delivered in the past: the Foton spacecraft – with one of our instruments on board! Naturally, we had to stop for a picture with the Foton capsule and our hardware inside!

It's not as if we didn't know our hardware was there, but it was a privilege to take the time to appreciate it and, if you look closely at the photograph, you can even see our name stamped on the side of the instrument. It was also fascinating to feel the scorch marks on the heat shield from the capsule's atmospheric re-entry. The Foton is a Russian-made un-crewed capsule based on a similar design to the Vostok spacecraft, which took the first man – Yuri Gagarin – into space. It was used to fly experiments into Earth's orbit for a certain period of time before returning to Earth.

The capsule in the top picture is the Foton 12, which was launched to space in September 1999 carrying one instrument made by us: FluidPac (Fluid Physics Facility). This was a very complex and autonomous facility for fluid physics research in microgravity, which provided scientific data during nearly 15 days that the spacecraft stayed in space.

Subsequently, we have provided further experiments onboard other Foton capsules. The Foton M3 mission, for example, was launched with a Soyuz rocket from the Baikonur launch site in Kazakhstan in September 2007. Carrying 400 kg of European instruments to perform various scientific experiments, it spent 12 days in space before its return to earth and subsequent landing in the Kazakh desert. Three of these instruments were built by QinetiQ - demonstrating our ongoing commitment to drive innovation and deliver new insight at the cutting edge of science:

Soret Coefficient in Crude Oils (SCCO)

The SCCO instrument investigated the diffusion effects in liquids to help determine whether it is worth exploiting an oil reservoir when new oil fields are discovered.

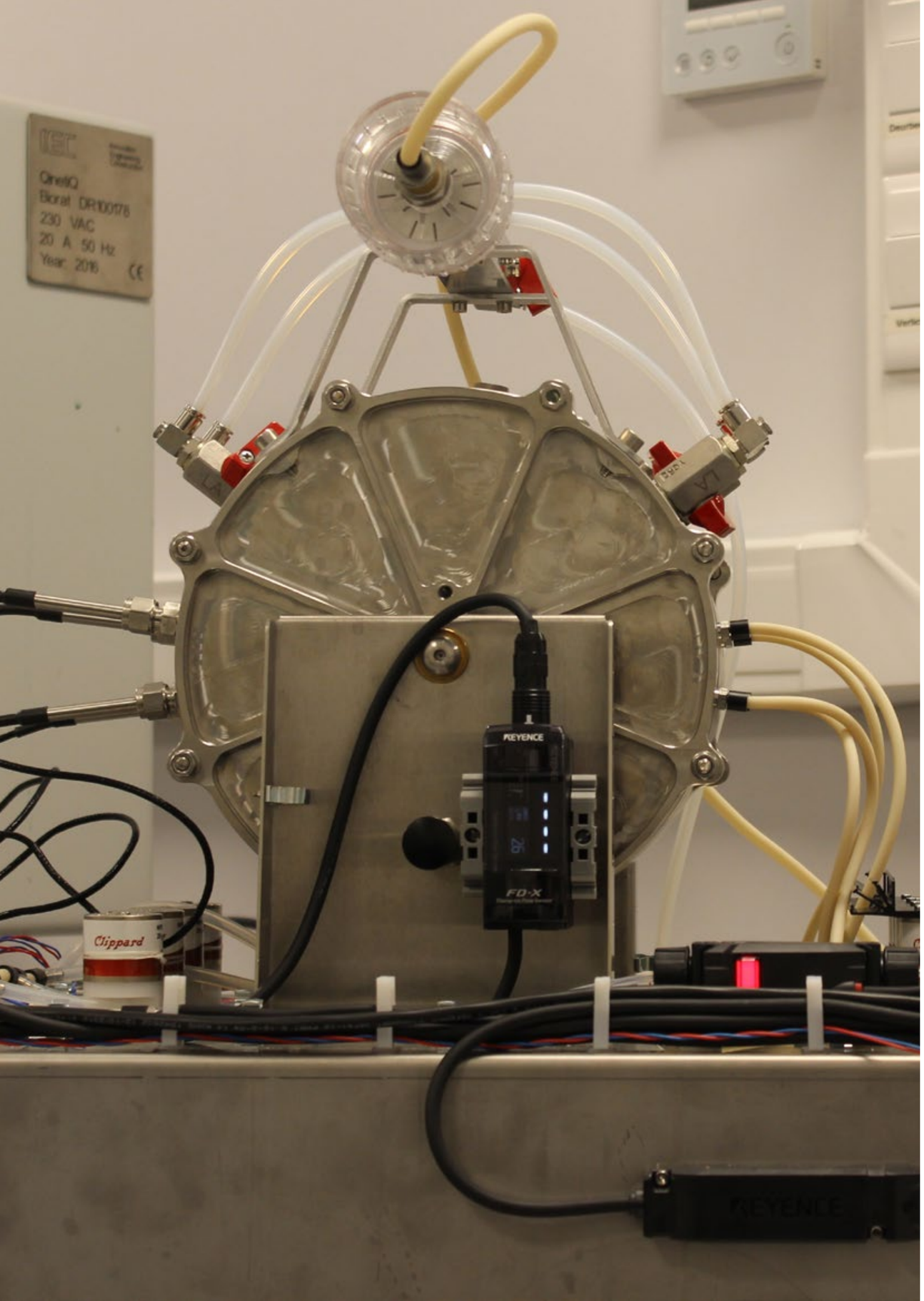
FREQBONE

This biological experiment investigated the decalcification of bones in microgravity. Doctors were looking into more effective ways of combating osteoporosis and this experiment helped to shed some light on what the options would be.

GRADFLEX

This GRADient-Driven FLuctuation EXperiment contained two experiments in fluid science during microgravity.

It's always good to look at the past in search of inspiration and to remind us why we do what we do, and finding one of your projects exhibited at the technological centre of the European Space Agency was certainly an uplifting experience!



Marie Vandermies
Process Engineer

October 2020

BioHarvest, Biorat 1 and GreenLung - Breaking New Ground in Life Support and Air Quality

The Micro-Ecological Life Support System Alternative initiative (MELiSSA), led by by the European Space Agency, aims to supply astronauts on long space missions with oxygen, water and food from waste recycling.

Spirulina is a cyanobacterium recognised for its high nutritional value. This photosynthetic organism feeds on carbon dioxide and releases oxygen as a result. For these reasons, it is studied by a number of MELiSSA projects for its capacity to refresh the ambient air in space installations and to serve as astronaut food.

Following ARTEMISS success (first photobioreactor demonstration on-board the International Space Station), QinetiQ, together with CAPACITÉS SAS and the AlgoSolis R&D Facility, will tackle the essential issue of harvesting spirulina at the outlet of the production unit. The harvesting system has to deliver fresh, non-contaminated microalgae suitable as food, and be compatible with microgravity conditions. QinetiQ and CAPACITÉS SAS are therefore joining their respective expertise in space projects and microalgae cultivation and harvesting to bring this project to a successful completion.

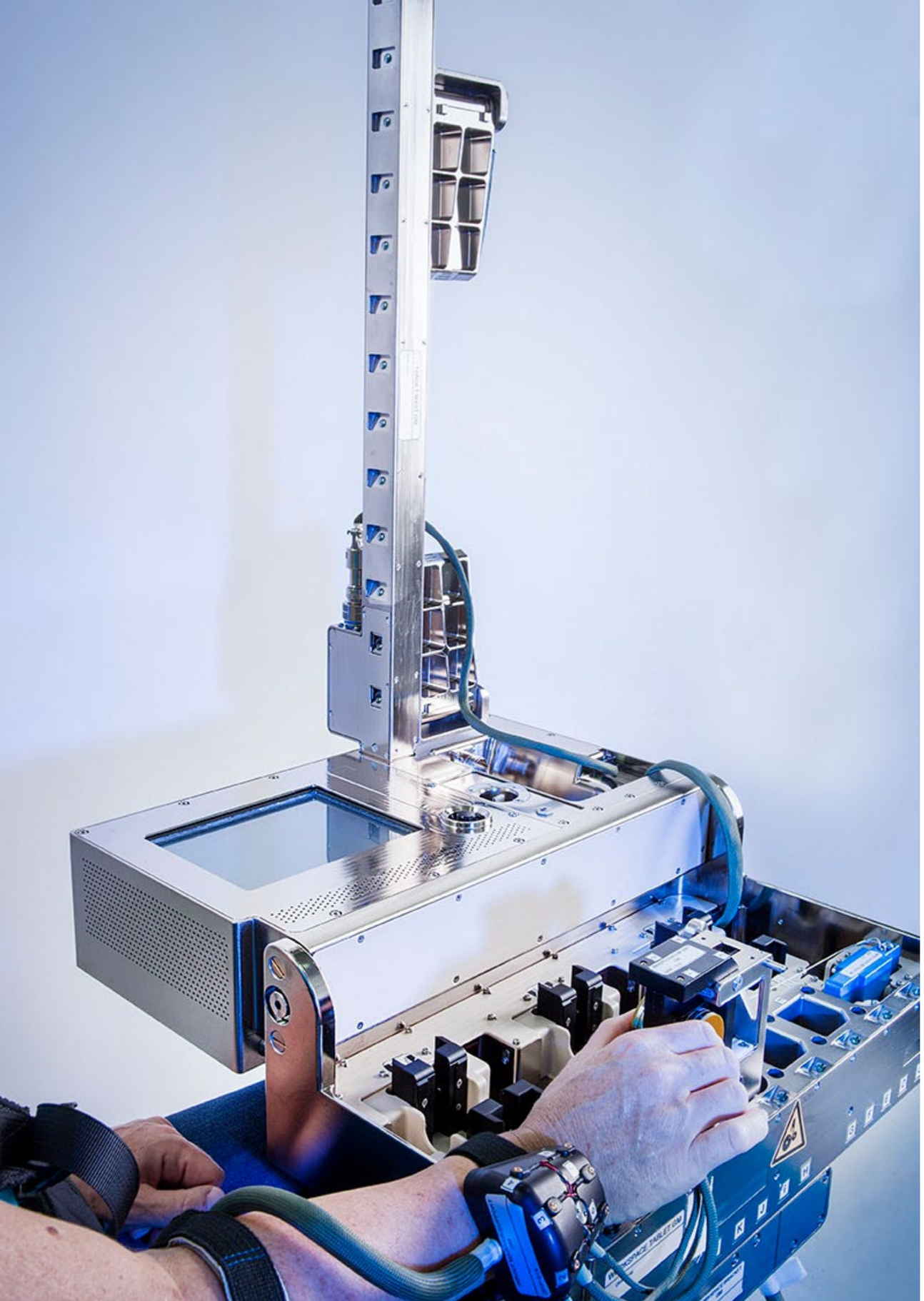
Biorat 1 is another project using spirulina. Currently in phase B1,it is collaborative project involving RUAG in Switzerland as prime contractor, Sherpa in France, and QinetiQ here in Belgium. The system is using the spirulina to convert carbon dioxide from air exhaled by humans back to oxygen. The Biorat 1 breadboard comprises three subsystems - the Gas Loop, the Liquid Loop, and the Solid Loop. We have responsibility for the development and testing of the Solid Loop subsystem and the global Control System and Electronics (CSE) to control the Gas, Liquid and Solid Loops.

The Gas Loop takes carbon dioxide from ambient air and releases oxygen, and the Liquid Loop is responsible for biomass cultivation where the conversion of carbon dioxide to oxygen occurs. The Solid Loop has a double function. Not only does it filter harvest supernumerary biomass from the Liquid Loop to help maintain a steady biomass concentration, its storage volume also gradually releases nutrients to the Liquid Loop to keep the biomass healthy and nourished.

Anyone visiting QinetiQ's offices over the past few months may have witnessed some of our development work in connection with the Solid Loop - notably an illuminated bottle filled with a bubbling green mixture (our precious biomass!), loud noises, full PPE during the steam sterilisation cycles and the release of the bright blue filtrate from the Solid Loop. It has certainly been an exciting project to work on and the final functional test of the system is now running. On completion of the Post-Test Review, the Solid Loop and associated CSE will be shipped to Switzerland for integration with the Gas and Liquid Loops.

Negotiations for the future of Biorat 1 (phase B2 and 3, C, D) are ongoing, but the programme has already paved the way for a number of other significant projects. These include Green Lung. This is the proof-of-concept project that started at end of summer following its selection by ESA in the frame of their annual ITT for technology demonstration. This is a terrestrial application of the technology developed for Biorat 1 and features a column bioreactor being placed in the corner of one of QinetiQ's meeting rooms to purify ambient air (including the conversion of carbon dioxide to oxygen).

Due to lower meeting room occupancy during the global pandemic, most of the carbon dioxide in the ambient air will be generated by artificial injections. However, all QinetiQ colleagues are welcome to pop by and provide feedback on this technology demonstrator, as design aesthetics and end-user experience are important elements of the GreenLung project. Stay tuned for the "open house" dates!



Marc Dielissen
Engineering Manager

December 2020

Turning ‘the Final Frontier’ into a Perpetually New Scientific Frontier

For many years, QinetiQ’s commitment to effective collaboration in an increasingly diverse range of space programmes has not only helped to open new doors and possibilities in space exploration. It has also delivered new scientific insight and knowledge to inspire countless innovations and advances in medical science and practically every area of technology. One such example is the GRIP/GRASP experiments that have been used on board the International Space Station (ISS) to investigate the impact of different gravitational environments on haptic feedback and dexterity.

Launched to the International Space Station (ISS) in 2017, the experiments have been designed and built by QinetiQ for the European Space Agency. The objective is to improve understanding of how the human body’s nervous system controls movement and adapts to an environment where there is no up and down and where every object has no weight. Such insight will also show how long-duration space travel affects a human’s ability to regulate grip force and manipulation of an object. Significantly, the success of the GRIP/GRASP experiments will support increasingly ambitious crewed space programmes as well as advances in neurological sciences and the treatment of neurological diseases.

The GRIP experiment comprises a special chair and worktable fitted with an array of sensors to obtain precise measurements of the subject’s position, grip-force and finger humidity as they perform a test trial of a pre-defined series of tasks and movements. After three full pre-flight sessions to collect baseline data, the assigned astronaut then completes three scheduled in-flight sessions and two post flight sessions to provide a full data set for detailed analysis.

In the GRASP experiment, the astronaut wears virtual reality glasses to map the link between what they feel and what they detect from observation, muscular movement and vestibular signals. The astronaut is suspended in a harness, fixing his/her position in the center of the ISS cabin so as to not fly away while wearing the VR goggles. Safety precautions were made to allow the astronaut to get free from the harness and electronic sensors in case of an on-board emergency.

The first experiment sessions were completed at the end of 2017. The hardware was unpacked again the following year by ISS Commander Alexander Gerst for a second series of experiment sessions and, just last week, two of the current astronauts on the ISS were once again using the equipment.

GRIP/GRASP has proved to be a very effective programme and the first sets of results from the experiments have now been released with very positive outcomes. There is little doubt the experiments are making a significant contribution to our understanding of dexterous manipulation and sensory adaptation to long-term microgravity. They are also shedding more light on motor learning processes that will hopefully help clinicians here on ground to improve the support for patients suffering from motor control pathologies.

This is just one example of how we are using Captain Kirk’s ‘Final Frontier’ as a laboratory to help challenge and push scientific frontiers further forward into completely new and uncharted territories.

Manipulative robots? Not necessarily a bad thing

Space and robots go back a long way.

The robotic Sputnik 1 launched back in October of 1957, making history as earth's first artificial satellite. Two decades later, the Voyager missions began a process that has seen robots being sent to the outer reaches of our solar system… and beyond. More recently, a machine named CIMON (Crew Interactive Mobile Companion) became the first AI-enabled robot in space.

Indeed, robots come in many forms and have many uses - but in this piece, we're going to discuss a lower-profile use of space robotics - 'orbital manipulation'.

What is orbital manipulation? What can we do with it?

Orbital manipulation (or 'in-orbit manipulation') refers to the use of robotic means to carry out tasks in orbit. Although sophisticated, it's not particularly new.

The now famous 'robotic arm' of the space shuttle, the Canadarm (also known as the Shuttle Remote Manipulator System or 'SRMS') - was first tested in orbit back in 1981. It has been used, amongst other things, to build the International Space Station (ISS) and to release the Hubble Space Telescope. Though Canadarm1 was retired in July 2011, Canadarm2 lives on today in the ISS.

And, as orbital manipulation increases in capability, it will find new uses in space. Here are four examples.

Clearing 'space junk'
One of the major (and growing) challenges is 'space junk (also known as 'space pollution' and 'space debris'). Space junk describes a range of debris left by humans in orbit, hurtling around the earth at roughly 18,000 mph. On the small scale, this includes paint flecks that have broken off of craft, and, on the larger scale, failed satellites and discarded rocket boosters.

This space junk increasingly falls into conversations on the impact we have on the environment - with space being part of that environment. As the amount of this junk grows, and as our need to use the space environment increases, it will become an increasing problem.

As such, technologies that are able to catch rapidly moving debris in order to safely deorbit it will be essential for the safety of near-earth operations. Ideas that have been envisioned include net-like devices and electro-adhesive boom arms.

Moving craft
NASA describes the process of seizing a craft or module via robotic means as a 'cosmic catch'. Moving craft has already proved to be important, and will be even more so, as we continue to make greater use of space.

A major consideration is moving things that lack their own propulsion systems - particularly those that are delicate, or that carry sensitive-payloads. It's far easier to dock with a craft that has its own means of movement (ie. its own engine).

This will be particularly important with satellites. Traditionally, the approach to satellite coverage was to build a small number of larger, more expensive satellites. But this is changing. Newer satellite 'constellations' consist of more numerous, smaller, and more cheaply built 'microsatellites'. One such high-profile example is SpaceX, which plans to launch roughly 12,000 satellites as part of its Starlink constellation.

The result of such constellations is a greater volume of craft, that have a greater probability of failing. Having a way to safely manage them will be essential.

Changing payloads and undertaking repairs
For decades, space missions have helped to bring payloads up into orbit. For example, in 2018, astronauts replaced Canadarm2's ageing 'hands'. And, as the number and variety of platforms in space increases, interchangeable payloads could offer cost savings and provide greater task flexibility on existing platforms. For example, it's cheaper to repurpose an existing unused platform, than to deorbit it and launch another in its place. But this is still some way off yet.

In-orbit manufacturing
Made in Space's Additive Manufacturing Facility (AMF), which lives on ISS, provides the first example of in-orbit manufacturing. Made In Space claim to have manufactured over 200 tools, assets and parts to date. This, however, is just the first step in a long road.

It will be quite some time before we see large-scale orbital manufacturing. Currently, the majority of objects are manufactured on the surface, and then launched into orbit. In some cases, various components travel up on different payloads, before being assembled in space (by a robot).

The problem, of course, is that getting material into space is expensive; with the price is proportionate to the size and mass of the payload in question. And, for delicate components, the sheer force of launch is another consideration.

In future, the hope is for the robotic construction whilst in orbit. This could include individual components, all the way up to entire platforms, like crewed stations or satellites.

It's a realistic prospect. Back on earth, industrial robots (with some supervision) are already being used to build everything from cars to sophisticated electronic components. The ISS was built, in large part, in space. As such, we can expect to see further space applications as AI and automation develops.

Not only would this save significantly on costs, but it would also help to meet environmental targets - for example, the UK's target for Net Zero greenhouse gas emissions by 2050.

A long history and a bright future

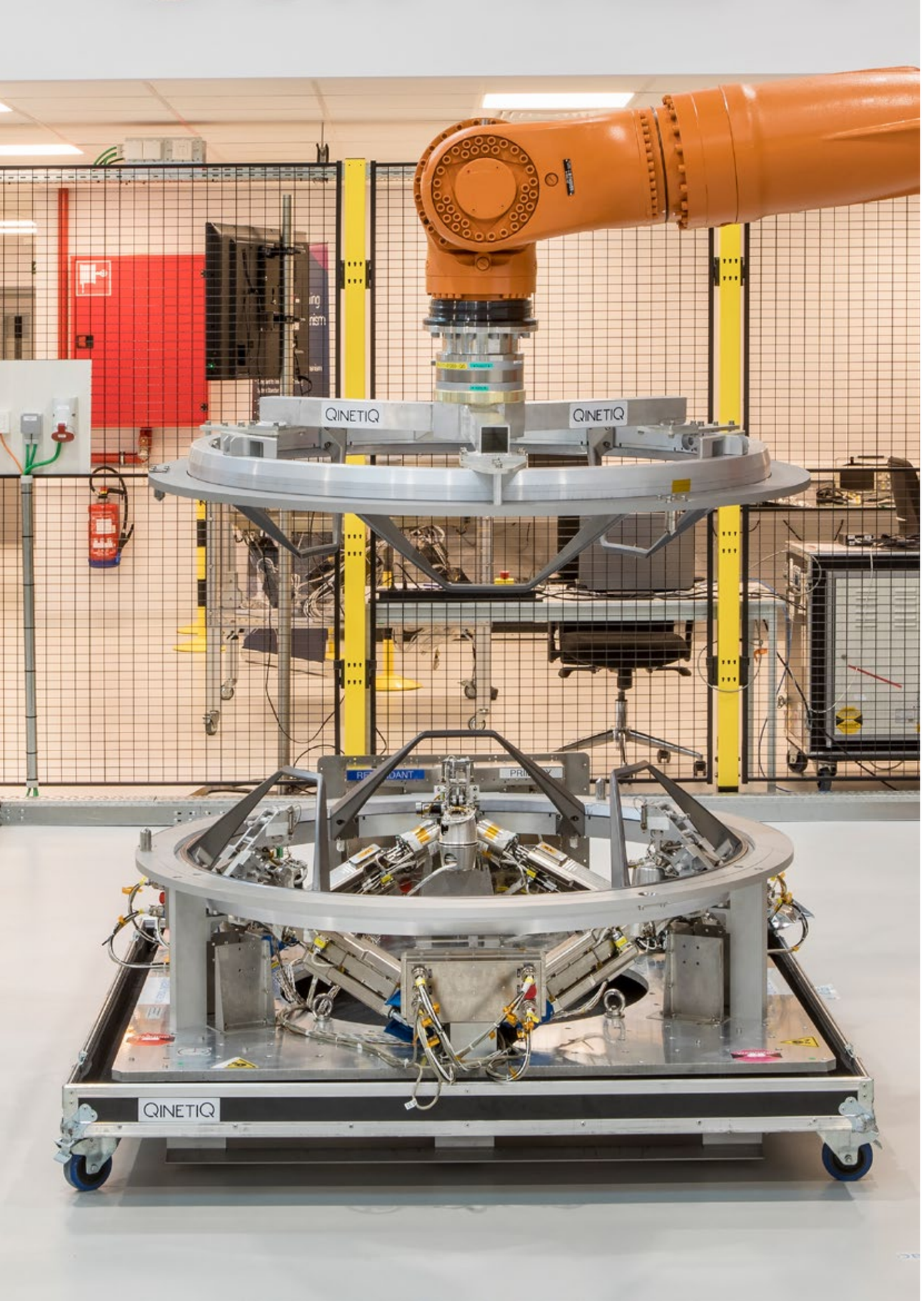
As robotic uses go, it doesn't grab headlines like Voyager or Sputnik, but orbital manipulation will be an integral part in our transition to a space-faring species.

In the shorter term, we can expect to see developments in docking and berthing. 'Docking' refers to the joining of two free-flying space vehicles. 'Berthing' refers to operations in which robotic means (usually an arm) is used to connect a vehicle or module that lacks thrust with another craft.

QinetiQ is currently developing the International Berthing and Docking Mechanism (IBDM) for just this purpose. Previously, docking mechanisms have struggled with the issue of inertia, particularly with craft or modules that are unable to decelerate under their own power as they move in to dock.

IBDM overcomes this by absorbing relative movement - which minimises the impact forces and resultant structural loads between two objects while docking or berthing. Not only is this safer, it's also more efficient, increasingly the likelihood of successful docking.

IBDM is also extremely adaptable, allowing it to work with a range of object sizes and configurations. This facilitates a range of tasks: everything from resupply, to using a station for a starting point for a long-range mission.



Felix De Wispelaere
Programme Manager

January 2021

Revolutionary low impact docking solution ticks all of the right boxes

Developing a reliable and resilient berthing and docking solution that offers improved control, faultless capture, and optimum safety was just part of the challenge facing QinetiQ as the European Space Agency's prime contractor. A critical requirement was to deliver low impact docking capabilities to maximise flexibility on both cargo and crewed spacecraft as well as heavy and very lightweight vehicles. It was also essential for the new system to be compatible with the new docking ports as defined by the International Docking System Standard (IDSS) as well as the docking ports for the Lunar Gateway Station.

Put simply, it was quite an undertaking! Our work began with a detailed evaluation of current berthing and docking technologies to establish the limitations and operational parameters of existing equipment. This was followed by an exhaustive assessment of new technologies that offered the potential to increase system versatility, control capabilities, and performance. Working in close collaboration with our partners, the design and development programme then began in earnest. This has now culminated with the introduction of the International Berthing and Docking Mechanism (IBDM) – a system that overcomes the limitations of conventional docking systems and sets a new standard for versatility, safety and performance.

A fully computer-controlled solution

The new IBDM uses advanced electronics and a Stewart platform with six coordinated and servo-actuated legs to optimise alignment of the active platform during capture. It provides an autonomous solution with full computer control at both leg level and at platform level and has full fault detection and isolation (FDIR) capabilities. Significantly, the advanced safety features of the system negates any need to interact with vehicle avionics, and the fully configurable active control also enables the IBDM to be used on a large range of different mass vehicles covering both exploratory and resupply missions.

The active control of the Soft Capture System (SCS) enables the platform to minimise the impact loads and to capture even the lightest vehicles, with mechanical latches used to complete soft capture. Structural hooks are used to close and seal the mated interface to confirm hard capture, with a dedicated umbilical feature allowing power and data connectors to be mated between the docked vehicles. The IBDM also employs an integral separation system to provide initial impulse at the time of separation and departure.

We completed extensive testing and evaluation of the IBDM at our dedicated space facilities here in Belgium as well as at the NASA Johnson Space Centre Six-Degree-of-Freedom Dynamic Test System. The revolutionary solution has achieved Technology Readiness Level 6 and demonstrated full compliance with the complete range of IDSS defined masses and inertias and could therefore be demonstrated over the complete flight envelope, with the agile force-sensing controlled capture mode delivering a very high capture success rate.

The induced contact loads during docking with the IBDM are typically one third of the IDSS allowed limit. Such versatility and performance capabilities are, therefore, ideal for docking vehicles with a high equivalent mass like the Dream Chaser Cargo to the International Space Station, as well as more difficult dockings between vehicles with a low equivalent mass such as the Orion to a lunar lander.

QinetiQ just signed a new contract for the supply of four IBDMs to the International Habitat (IHAB), which is the European Space Agency's contribution to NASA's Artemis Program. This contract builds upon the IBDM development contract currently in its qualification phase with some specifics for the Lunar Gateway environment. This is just the start of what promises to be a long and enduring story for the IBDM. By putting convention to one side, exploring new ideas and capitalising on new technologies, we have delivered an androgynous low impact solution for docking and berthing large and small spacecraft that offers unprecedented control, safety, reliability and flexibility.

Testing for space: embracing change

Testing technology is difficult and intricate at the best of times. Testing technologies for space is in a league of its own.

The space industry yields particular complexities for testing, for a couple of reasons. Firstly, testing requires replicating the environment in which the hardware will be used. In space, these environments are nothing short of extreme – such as huge temperature variations, and immense vibrations caused by a successful launch. Earth's space radiation environment is also challenging to recreate for tests. Secondly, in most other industries if something goes wrong, you can react and fix it. This isn't usually possible once something is up in space.

Waste of space?

Owing to these nuances, the space industry has somewhat lagged in pace, adopting traditional testing approaches. The product being tested, say an ion engine, often has to run for its lifetime duration to see it through all stages, possibly taking an entire decade. Couple this with space's risk-averse outlook, and there's a perfect recipe for this lag to persist.

Now that more – increasingly commercial - players in space are utilising Commercial Off The Shelf (COTS) technology, the 'NewSpace' era is sending shockwaves across the field. For instance, the launch market is growing. Previously when designing flight hardware, just one launcher would be considered. Now, due to sheer competition, the aim is to qualify for multiple launchers, requiring broad specification levels and forward-thinking approaches to design. This entails greater time spent in the concept phase, plus enhanced testing. But the latter hasn't materialised. Testing remains mostly unchanged, restricting innovation simply due to re-testing every time something changes. Decisions will be made as to whether to ride the wave or sink beneath.

The merit of digital twins

As mentioned, there is little appetite for risk, so transforming testing of spaceflight hardware demands a culture shift towards 'failing fast', incompatible with current methods. So proving the case for it is tricky. Not only does the business need to be on-side, but the customer needs to accept risk. Beyond this, the customer's insurers need to buy-in, and they can be hesitant to insure a mission that hasn't considered all risks and isn't guaranteed to work. Ironically, this justification process is a time-consuming burden in itself, thereby vindicating remaining as is.

The 'digital twin' approach has revolutionised some industries, being deemed the Holy Grail for test and evaluation. Digital twins are digital replicas of the physical entity, which can be used to perform accelerated testing or for failure prediction – massively reducing the cost and schedule risk burden on major test programmes.

Meeting in the middle

Of course, implementing digital twins will not happen overnight. But to continue as we are will only make the leap greater in the future.

In the meantime, making current testing facilities more effective will go some way. Efficiencies can be offered to industry via national testing facilities, such as Oxford's Harwell services. UK companies can access this for their specific needs, rather than building their own facility, streamlining the entire testing process. But again this calls for collaboration and collective change; without this, we cannot build our own path towards the inevitable digital future.

Alan Whittle
Director of Strategy and Plans, Inzpire

December 2020

Breaking into Space

I'm old enough to remember fondly from my time in the military when there was a remote chance of being posted to some far-flung places around the globe where the sunshine was rather more convincing than in Germany or the UK, which is where most of us ended up. These postings were coveted to the point that a certain mystique surrounded the chosen few, and it was often said in the Squadron bars in the British Army of the Rhine that postings to Hong Kong were only available to those who had been there before. Clearly there must have been some special attributes vested in those lucky enough to be selected that drew the eyes of the manning office like moths to a flame.

However, due to a last minute sickness of 'one of the chosen' and the trust of a great boss, I was eventually lucky enough to be selected to go to Hong Kong for 6 months as part of Op CULEX. The veil of secrecy was finally lifted. There was nothing special about such a sought-after posting (apart from the size of the mosquitoes - they were pretty special!).

Thankfully, my earlier training ensured I had the knowledge, skills and information to be effective and the ability to take new responsibilities in my stride. We were operating helicopters over rugged terrain, out to sea and over remote jungle - sometimes working with the RAF (I was with the Army Air Corps) and sometimes working with the Royal Navy. I suppose it was an early example of Joint Operations.

We had to come up with new tactics and new ideas as not many people had experience of chasing speedboats in the South China Sea in order to arrest people. Even multiple viewings of contemporary James Bond movies didn't add much to the mix. We succeeded in part because it was a new experience where we weren't constrained by preconceptions or the operational bias of people who had been there for ages. We could think outside of the box, offer a new perspective and be innovative - and it worked.

The aim was to combine the Land, Air and Maritime domains (they weren't called domains at that time) in order to influence, compel or coerce the vast numbers of Chinese citizens to stop trying to escape from the Chinese Communist regime for a better life in Hong Kong. We had a high degree of success. Of course, by pure accident, I had now become one of the chosen few who could be considered for a longer tour in Hong Kong because I'd been there before. I was in the club!

Fast forward half a lifetime and Joint Operations are considered the norm. Indeed, we are progressively moving towards Multi-Domain Integration. But that's not all. Our fighting domains have also increased to include Cyber and Space. This allows for a neat Segway into Inzpire where we have long-recognised the requirement for targeted Multi-Domain Integration and have developed our training syllabi and services accordingly. We have also invested in the learning and development of new skills, including what I would call the 6th fighting domain - the electro-magnetic spectrum - but that is for another time.

Having the capability to deliver training and services in the Space domain is not enough, though. It was just as important to be accepted by the industry as having the capability, because we had never done it before. Or to put it another way we had never been to 'Hong Kong'!

Fortunately, farsighted and trusting planners in the Allied Rapid Reaction Corps (ARRC) presented us with the opportunity to form a bridgehead into the Space domain. They asked if our expert instructors could deliver a Military Utility of Space Capabilities course (MUSC) to HQ ARRC. We could and we did, and the course was attended by 42 NATO students from the UK, United States, the Netherlands, Turkey, Germany and France as well as the Commander and Deputy Commander of the ARRC. I'm pleased to say that feedback was absolutely outstanding.

This course is just one of many that our expert team have designed and developed. We were able to dig deep into our tacit understanding of all of the fighting domains to ensure relevancy to the training while also identifying the need for modern blended learning techniques that cater for a diverse student audience. Needless to say, we are now available for other short notice postings in Space …. or should that be 'in the sunshine'!

Paul Jones
Senior Campaign Leader (Space Ranging)

December 2020

Space Ranging – Extending our Space Capabilities

Effective innovation is all about capitalising on specialist expertise, proven capabilities and technical know-how to deliver mission-led benefits and real service gain for customers. Such a progressive mindset continues to underpin our success as a trusted partner and collaborator in so many areas of the space industry – from cutting-edge propulsion and satellite platforms to a huge range of research experiments and highly complex system integration and instrumentation projects.

We're now going one step further. Building on our unrivalled range management experience and expertise in the effective delivery of range launches and test and evaluation programmes, we're now finalising plans to provide a bespoke, highly flexible and affordable space ranging solution for customers.

This move is in direct response to the UK Government's drive to extend the country's capabilities in space exploration and research and to meet the needs of spaceport and launch vehicle operators for a reliable and commercially attractive space ranging capability. To date, only three space missions have been launched from the UK. All of these have been managed successfully by QinetiQ from sites operated by the company as part of its Long Term Partnering Agreement with the UK Ministry of Defence.

However, we're now adopting a layered and networked approach using local, regional and command capabilities in different locations to provide a concerted space ranging service covering all launch, tracking and telemetry, surveillance, communications and termination procedures for both orbital and sub-orbital missions. Our initial focus is here in the UK because of the assets and expertise we already have but, in time, we are optimistic this will grow to become a global capability.

Our objective is to work in collaboration with partners and customers to provide a safe, competitive and sustainable space ranging solution to meet the growing demand for small, micro and nano satellites and sub-orbital launches. Significantly, this will take full advantage of our decades of experience in managing complex and potentially hazardous range activities. This includes full compliance with the stringent operational requirements of the Ministry of Defence and the Civil Aviation Authority as well as all safety and environmental regulations and, of course, the Space Industry Act 2018. No other organisation is in a position to provide such robust assurances for customers and the myriad of SMEs working in support of the UK Space Agency.

Alison Fiddy
Flight Operations Controller, Rotary Wing Test & Evaluation Squadron

November 2020

An Out of this World Phone Call

Everything was just winding down for the Easter break. Everyone else appeared to have gone home and I was just about to sign-off for the weekend. As I completed the final paperwork in readiness for flight operations after the Bank Holiday, the phone rang – but this was unlike any other call I had received before. The familiar voice at the other end was clear and friendly enough, but there was a very long time delay that rather broke the flow of conversation.

After several minutes trying to guess who was on the phone, it suddenly became clear that the person I was speaking to was someone who had worked with me on Rotary Wing Test and Evaluation Squadron following his graduation from ETPS some ten years before. It was none other than Major Tim Peake, the first British astronaut from the European Space Agency (ESA) who was calling me from orbit during his 6 month stay on the International Space Station (ISS).

It was quite a shock to receive the call from Tim – very exciting and unforgettable, but not something I was prepared for as my mind was turning towards a long weekend break. Despite the time delay, we had a great chat. Coincidentally, I had just seen a TV programme on Heston Blumenthal's project to provide the former Army Major with some culinary delights for his spell in space. Thanks to the efforts of the acclaimed celebrity chef, the British astronaut was able to enjoy a selection of distinctive but familiar food - including the first ever bacon sarnie ever eaten in zero gravity!

Tim attended ETPS, the world's first Test Pilot School, in 2005 where he graduated with flying colours and even received a special trophy as the year's best rotary wing student. He then served on the Rotary Wing Test and Evaluation Squadron here at Boscombe Down where he completed many trials on Apache helicopters. Many of the skills he developed as a Test Pilot clearly held him in good stead as he then excelled against over 8,000 other applicants for just six places on ESA's new astronaut training programme.

Tim spent a total of nearly 186 days on the International Space Station and, just two months prior to our conversation, he was the first British astronaut to complete a spacewalk outside of the ISS. It was very reassuring to know that, despite all of the pressures and new experiences of his work in space, he still retained his sense of humour as he made a phone call to one of his former places of work. But after our conversation, of course, I still had to pinch myself and check the caller's number before telling other colleagues at QinetiQ. Once I knew the call had been routed through NASA in Houston, I knew it was for real …. and not just a prank pulled by a mischievous Easter bunny!