# Airbus Defence and Space

**Company Type:** LSI **GSTP Funding:** €5.3m **Compendia, Element 1:** Develop (De-risk & Building Block) **& Element 2:** Make **Competence Domains:** 2, 4, 5, 6 & 8 **Location:** Stevenage

## Company

Airbus is Europe's largest aeronautics and space company providing solutions, services and products. Airbus Defence and Space designs and manufactures around 25% of the world's GEO telecommunication satellites and leads international missions through ESA. Airbus UK are responsible for large in-orbit structures, propulsion systems and communications. They notably led the development of Europe's first interplanetary rover vehicle. Airbus UK has worked on 15 GSTP projects since CMIN19.

## Highlight of Activities

1. The first activity is a compendia completing the heterogeneous modelling, design and analysis of complex space systems. Space is a harsh environment where thermal management of a satellite is key and which way the satellite is facing can affect this. This is a multi-disciplinary tool that combines thermal and aerodynamic models to analyse space missions using high-performance computing to optimise missions at the design stage.

2. The second compendia activity is developing robotic interfaces and tooling for space-based solar power engineering (RISE). Space-based solar power is based on a concept to send very large solar arrays into space, convert the Sun's energy and transmit the power to a receiver on Earth. These arrays require assembly in space as they will be packed away during launch into orbit. The activity focuses on understanding the assembly process, how the robotic arms will work in space, and the qualification of the robotic arms to ensure they are reliable and work for the required duration.

## What has the GSTP funding enabled?

GSTP funding supports Airbus to develop lower TRL technologies that would not be funded through their internal programmes, as their programmes require direct results for commercialisation. GSTP activity outputs do feed into critical future missions.

The funding has enabled Airbus UK to build up a sovereign space capability stemming from GSTP activities. This has encouraged cluster development with small-medium enterprises and vital collaboration with academia.

## GSTP Funding Impacts

**3** FTEs supported per activity

**+2-3** TRL improvement per activity

**€0.5m** follow-on contracts

**Developing Space Capability**

Developing robotic arms for space-based solar power and large space infrastructure.

Strengthened links with South Central, South West and South East space and robotics cluster.

**Unlocking Growth**

Upskilling UK workforce by getting subject experts from other Airbus offices to support and train UK teams in GSTP activities.

Airbus run a two year early-career graduate programme with five rotations between departments.

**Growing Science Powerhouse**

Spin-off applications from development of intelligent coating for satellites within other parts of Airbus.

University outreach with Cranfield University, the University of Oxford and University of Leicester.

**Global Presence**

Strengthened strategic partnerships with Oxford Space Systems, TWI Ltd and Space Solar.

GSTP projects enable Airbus UK to become capability leaders across the Airbus group.

# Atout Process

**Company Type:** Micro SME **GSTP Funding:** €1.75m **Element 1:** Develop **Framework:** De-risk **CD7:** Propulsion, Space Transportation and Re-entry Vehicles **Location:** New Milton

## Company

Atout Process was founded in 2010 to use non-intrusive electromagnetic imaging and measurement techniques to develop innovative products initially in the aviation sector. A decade ago they discovered that their electrical capacitance tomography technology could solve a long-standing problem in space flight, gauging propellant in zero gravity. An initial UKSA grant through the National Space Technology Programme enabled the proof of concept for the Smart Tank.

## Activities

1. The first de-risk project focused on introducing the Smart Tank into space. A Smart Tank enables the accurate measurement of propellant and other liquids in space which is key to monitoring the spacecraft. The Smart Tank also measures the centre of gravity of propellant in real time which allows any torque generated by the propellant moving during travel to be calculated and mitigated to improve the stability and performance of the spacecraft. The project developed a set of tools including a generic test rig to facilitate the design of a measurement system for any tank geometry. These tools will enable Smart Tank applications on launchers, LEO and GEO spacecraft.
2. The next set of activities used the tools created in Activity 1 to design, build and ground test the key elements required for an in-orbit demonstration flight. The demonstrator is scheduled to launch in early 2026 and will fly to the ISS, conduct experiments and then return to Earth.

## What has the GSTP funding enabled?

GSTP has supported Atout to develop the Smart Tank technology and the tools around it, enabling them to bring the technology to market for commercial purposes. There are many use cases for the technology and Atout plan to licence the designs to companies who manufacture propellant tanks. GSTP has been instrumental in enabling Atout to undertake an in-orbit demonstration which is an essential requirement to demonstrate the technology's viability for future customers.

The modelling tools developed through GSTP and internal activities allow Atout to scan tanks and determine the propellant mass more effectively and with greater speed. This capability can be applied to future commercial and ESA missions.

## GSTP Funding Impacts

**3** FTEs supported

**+1** TRL improvement per activity

**£0.4m** revenue generated

**Developing Space Capability**

Critical capability required for transferring propellant from one entity to another during refuelling in space.

Strengthened partnership with Surrey Space Centre and Kingston University.

**Unlocking Growth**

£0.4m commercial revenue from designing and building prototypes of the technology.

Supported 3 senior engineers full-time and UK-based subcontractors for sensors, composite manufacturing and design engineers.

**Growing Science Powerhouse**

Spin-in technology from oil and gas sector, used to measure complex pipe flows correctly.

Co-authored six conference papers and most recent was presented at the Space Propulsion Conference 2024.

**Global Presence**

Global leader in this technology, only one other known competitor.

Worked with DLR and ArianeGroup in Germany, and NASA in the USA.

# Frazer-Nash

**Company Type:** Large **GSTP Funding:** €2m **Route:** Competitive ITT **CD7:** Propulsion, Space Transportation & Re-entry Vehicles **Location:** Bristol, Burton, Harwell, Manchester, Glasgow & Belfast

## Company

Frazer-Nash Consultancy is a systems engineering and technology company specialising in the defence, nuclear and transport sectors. Frazer-Nash has 14 offices around the UK and has worked on space projects from the technical and economic feasibility of space-based solar power to client-side support to the Ministry of Defence's next generation satellite communications, SKYNET 6.

## Activity

1 This activity will develop part of the preliminary design for a flying hypersonic engine test bed, INVICTUS. INVICTUS will progress towards an experimental ("X") plane to demonstrate and de-risk advanced hypersonic air-breathing propulsion for space access applications. Frazer-Nash is being supported by Cranfield University and Spirit Aerospace for the guidance system and the airframe, respectively.

All rockets that currently reach orbit do not use air-breathing engines, meaning they must carry oxygen to reach orbit. This added weight increases the launch vehicle's mass and the thrust required to reach space, which in turn reduces the payload and raises the cost of accessing space. INVICTUS will test an air-breathing propulsion system designed to use atmospheric oxygen, like an aircraft jet engine, lowering the launch mass and be reusable, reducing the cost of space access. The technology represents a leapfrog in capability compared to current and planned European vertical launch systems, and would be competitive with SpaceX's Starship.

## What has the GSTP funding enabled?

For INVICTUS, the €2m GSTP funding has been combined with €4m Technology Development Element funding, an ESA programme for novel technologies. Together, they have enabled Frazer-Nash to build the case for participation with industry creating a credible delivery team. As the prime and systems integration Frazer-Nash is responsible for systems requirements, certification, safety, and programme definition and costs. This knowledge and experience is helping to develop a credible horizontally integrated systems integrator for novel space technologies, providing new capability, diversity and resilience to the UK industry.

Funding from the GSTP has facilitated the ongoing development of precooled air-breathing propulsion technology, initially developed by Reaction Engines Ltd (REL) with over £50 million from UKSA. This crucial support has preserved and further exploited valuable knowledge and technology that would have been lost when REL entered administration in 2024.

## GSTP Funding Impacts

**5** jobs created

**+2** TRL improvement per novel subsystem*

**Hypersonic vehicle and propulsion** European capability

| | | |
|---|---|---|
| **Developing Space Capability** | Developing a flying engine test bed, and precooled air-breathing hypersonic engine. | Working with Cranfield University to develop the guidance, control and navigation systems. |
| **Unlocking Growth** | Gaining experience of operating as a space systems integrator. | 3 senior and 2 junior engineers hired from REL to retain capability from leaving the industry. |
| **Growing Science Powerhouse** | Spin-off of precooled air-breathing hypersonic propulsion for national security applications. | Staff upskilled in the development of hypersonics required for the future of the UK's defence capability. |
| **Global Presence** | Strengthened strategic partnerships with Spirit Aerospace, Cranfield University and engaged with future international partners. | INVICTUS is key to enabling a European launch capability competitive to the US' Starship and achieving strategic autonomy. |

*INVICTUS is developing the X-plane for the lowest minimum cost, identifying which subsystems require new designs and which can be used as-is. This means that subsystems such as avionics will experience small TRL improvement whereas the hypersonic aircraft structure will see a high TRL improvement.

# GMV NSL

**Company Type:** Large | **GSTP Funding:** €0.2m | **Element 1:** Develop | **Framework:** De-risk | **CD6:** Physical Science Payloads & Robotics and Automation | **Location:** Harwell

## Company

GMV NSL produces technology and services related to position, navigation and timing (PNT) including guidance, navigation and control (GNC), autonomy, orbit determination and prediction. GMV NSL is the UK subsidiary of the global aerospace company GMV, located in Spain. They have around 120 employees across two sites in the UK - Nottingham and Harwell.

## Activity

1 The de-risk activity concentrates on developing a multi-range GNC for fast lunar rovers. The aim is for the rover to travel at speeds over one metre per second, faster than previous rovers who typically travel at 10 centimetres per second. The increased speed enables the rover to out run the lunar night, staying in constant sunshine which provides both power and warmth. This makes missions far less complex, enabling reduced costs and a greater focus on science and exploration.

The de-risk improved GNC software created for a breadboard rover by GMV to become multi-mode, multi-range navigation system which operates in a continuous drive paradigm. The rover will continuously assess the terrain and conditions to determine which mode is best to deal with any obstacles.

## What has the GSTP funding enabled?

This activity is helping to build a lunar GNC space capability at GMV NSL, taking navigation which was typically produced at GMV Spain. The successful development of the technology has resulted in lunar GNC becoming a core offering from GMV NSL allowing the expertise to remain in the UK. Any future opportunities across the GMV group that requires lunar GNC will be centred around UK team.

GSTP funding is enabling a follow-on activity to mature the algorithms behind the navigation system, adding in navigation components to complete the GNC system developed in other projects and exploring machine learning and AI elements to better suit the lunar surface.

## GSTP Funding Impacts

**1** job created

**+2** TRL improvement per activity

**€0.6m** revenue generated

**Developing Space Capability**

Enabled GMV group to locate GNC leadership to the UK.

Outreach with university robotics teams including lecturing at the University of Sheffield.

**Unlocking Growth**

Participates in the annual UKSA Space Placements in Industry (SPIN) scheme.

Activity supported 3 junior to senior engineers full time.

**Growing Science Powerhouse**

Spin-off applications into mining and agricultural sectors.

Presented at: International Conference on Space Robotics 2024

**Global Presence**

Strengthened relationship with ESA Automation and Robotics group.

Outputs from the activity are being combined with other ESA lunar applications: LUPIN and GALEON.

# iCOMAT

**Company Type:** SME | **GSTP Funding:** €0.94m | **Element 1:** Develop | **Framework:** De-risk | **CD2:** Structures, Mechanisms, Materials, Thermal | **Location:** Bristol

## Company

iCOMAT are an advanced composite manufacturing company focused on commercialising their patented automation technology to produce lightweight carbon fibre components. They are a spin-out from the University of Bristol and provide beyond 'state-of-the-art' manufacturing solutions with their Rapid Tow Shearing (RTS) process. iCOMAT are producing structures for the space, aerospace and automotive sectors.

## Activities

**1** The de-risk activity designed and manufactured a cylindrical structure produced by the RTS technology. RTS produces carbon fibres that can be curved without defects which enables the tailoring of the strength of the composite depending on where the load is. For space applications, the ability to steer fibres in the optimal direction results in improved performance.

This structure was tested and compared to an equivalent structure manufactured using ESA's nominated 'state-of-the-art' process. iCOMAT's structure was 25% lighter, 30% stronger and had fewer defects making it more suitable for spacecraft primary structures for launch.

**2** The second activity was a joint follow-on activity with MT Aerospace who are a leading supplier of structures for space, part funded by the German space agency (DLR). This phase developed a manufacturing process which could build the cylindrical structure directly on to the mandrel rather than as a lay flat and roll wrap process.

## What has the GSTP funding enabled?

After successful research at the University of Bristol, iCOMAT identified that space would be the key market for RTS enhanced composite structures. GSTP provided the perfect route to prove the application, with for launch structures as the ideal case study. The results from activity one were posted to ESA's website which resulted in interest from potential clients.

Space is a conservative industry for technologies because satellites cannot be repaired once on orbit. The successful completion of the GSTP activities were a critical factor in building a strong reputation for iCOMAT's beyond 'state-of the art' composites. This demonstrated success has helped iCOMAT to raise private investment and, alongside a UKSA SCIF grant, build their first factory facility - ready to deliver commercial parts to the space industry.

## GSTP Funding Impacts

**8** jobs created

**+2** TRL improvement per activity

**£18.7m** private investment

**Developing Space Capability**

Showcasing RTS as the new 'state-of-the-art' composite manufacturing method for space structures.

Spin-off company from the University of Bristol. Sponsors Engineering Doctorates.

**Unlocking Growth**

£18.7m private investment led by 8VC and NATO Innovation Fund. iCOMAT is the first UK investment for 8VC.

8 specialist technician, designer and manufacturing jobs.

**Growing Science Powerhouse**

Spin-off applications in aerospace and automotive sectors with interest from Formula One.

2022 Finalist at the JEC Composites Innovations Awards.

**Global Presence**

Strengthened strategic partnerships with MT Aerospace, Airbus, TAS, SSTL, Space Forge and Orbex.

American aerospace companies are patenting structures enabled by RTS composite technology.

# LENA Space

**Company Type:** SME **GSTP Funding:** €0.73m **Element 1:** Develop **Framework:** De-risk & Building Block **CD7:** Propulsion, Space Transportation & Re-entry Vehicles **Location:** Salisbury

## Company

LENA Space are a small business in the UK with the ability to design and manufacture very high performance liquid oxygen and liquid methane pumps for rocket engines. A turbopump is a key part of a launch vehicle's propulsion system and LENA's aim is to supply the high performance pumps to the emerging commercial space launch market.

## Activities

1. The development of a 25kN electric pump for liquid oxygen and for liquid methane to enable satellite launch vehicles. The fuel and oxidiser electric pumps are extremely high performance and only the second company to produce electric launch vehicle propulsion pumps globally.

2. The design and development of the turbine to create a turbo pump derivative of the electric pump to increase market opportunities. The turbine also enables a turbo-alternator for generating power on the lunar surface.

### What has the GSTP funding enabled?

Without GSTP funding, LENA Space as the only UK based company with the capability of designing high performance pumps for launch vehicles would have lacked the internal funding to develop new state of the art pump technology which attracted contracted with national international space and aerospace customers. Successive GSTP projects have increased the pump's reputation and sparked interest from Rolls-Royce which led to LENA Space being added to Rolls-Royce's supplier list.

Activity 2 is a follow-on to a GSTP activity before 2019. The initial activity proved the capability of the 25kN pump and this garnered the interest a Portuguese client, Omnidea. Activity 2 has led to an agreement between the UK and Portugal to combine efforts and develop propulsion together.

## GSTP Funding Impacts

**6** FTE jobs created

**+2** TRL improvement per activity

**£2.3m** revenue generated

**Developing Space Capability**

Potential launch cadence of 33 vehicles per year at year 10 (2035) of the Portuguese launcher programme.

Project partners with the University of Southampton's centre of advanced tribology (nCATS).

**Unlocking Growth**

80% of LENA's supply chain is in the UK.

12 highly specialised part-time roles for senior engineers.

**Growing Science Powerhouse**

Hydrogen pump spin-off opportunities under active development in automotive, aerospace and defence sectors.

Presented at: Taiwan Space Industry Expo 2024

**Global Presence**

New strategic partnerships with Rolls Royce PLC, Omnidea and the Taiwan Space Agency (TASA).

International projects with the Portuguese launcher programme (through ESA) and directly for TASA.

# Lift Me Off

**Company Type:** SME **GSTP Funding:** €1.07m **Element 1:** Develop **Framework:** De-risk & Building Block **CD7:** Propulsion, Space Transportation and Re-entry Vehicles **Location:** Reading

## Company

Lift Me Off (LMO) provide autonomous satellite services to inspect, track and safeguard critical space infrastructure. LMO design, validate and build propulsion systems and supply modified propulsion sub-system components for established space companies. Originally based in the Westcott Incubator, LMO moved to the Harwell Space Campus before scaling to a larger facility in Reading to accommodate their growing team.

## Activities

1. The de-risk activity scaled down a green chemical propulsion system to fit small satellites. Each component from the gimbal to the tanks and reaction control system (RCS), were designed to create a small-scale subsystem prototype to validate the concept for space.
2. This activity continued the development of the green chemical propulsion system for a specific application of fitting in Open Cosmos' smallsats. The system was qualified for an expected lifetime of five years and included thermal tests and replicated a low gravity operation of the propulsion system. LMO identified areas of improvement and implemented a quality and implementation approach for future activities.
3. The final activity designed an RCS and chemical propulsion system for ESA's LUMIO mission to the Moon. This activity built on the components developed in the previous activities and qualified critical hardware for mission use. The LUMIO satellite will use two propulsion systems from LMO.

## What has the GSTP funding enabled?

GSTP has accelerated the commercialisation of LMO products by generating contracts from incumbent space propulsion firms who were interested to adopt GSTP funded technology. Without the funding provided by the GSTP, the development of the propulsion system would not have progressed as rapidly and LMO would have attracted less private investment.

GSTP funding has facilitated collaboration between European satellite and propulsion companies with LMO addressing a gap in the market for green chemical propulsion. This builds a national capability that can be tested in the LUMIO mission and future ESA missions.

## GSTP Funding Impacts

**8** jobs created

**+2** TRL improvement per activity

**£1.5 m** revenue generated

**Developing Space Capability**

Green chemical propulsion subsystem planned to fly on LUMIO ESA lunar mission in 2027.

Strengthened relationships with the UK Propulsion Working Group.

**Unlocking Growth**

£1.5m revenue generated by supplying propulsion system components developed under GSTP.

8 specialist design and qualification jobs.
3 Space Placement in Industry students worked on GSTP activities.

**Growing Science Powerhouse**

Precision valves were spun-in from the medical sector which have high qualification standards.

Presented at:
2024 ESA Space Propulsion Conference

**Global Presence**

Enabled strategic partnerships with Nammo, Open Cosmos and ECAPS AB.

Sold modified components to customers in the UK, France, Italy, Japan and the Netherlands.

# MARS Space

**Company Type:** SME **GSTP Funding:** €4.45m **Compendia & Element 1:** Develop **Framework:** De-risk **CD7:** Propulsion, Space Transportation and Re-entry Vehicles **Location:** Southampton

## Company

Mars Space provide consultancy services for space and plasma engineering with expertise in space propulsion and the space environment. Since its establishment in 2007, Mars Space have focused on the development of components for gridded ion thrusters over a range of applications from cubesats to interplanetary missions. They have formed a group under GSTP funding to progress towards a full system for miniaturised electric propulsion (EP) in space.

## Activities Summary

1. The first activity was an early breadboard prototype of a discharge chamber configuration for high power gridded ion thrusters. The discharge chamber generates the plasma to ionise the propellant to produce ions which feed into the thrusters.

2. The second group of activities focuses on creating cathodes for different engine sizes. The cathodes which emit electrons to act as a neutraliser into the ion beam to ensure equal amounts of positive and negative charges are emitted from the thruster. Mars Space have developed a low power cathode, a cathode with a very long-life and several other discharge hollow cathodes.

3. The third activity is the development of a miniature ion thruster and neutraliser to be used on cubesats. This miniature thruster is being used to develop and qualify a full EP subsystem with TWI Ltd, AVS and Techline. The propulsion technology will be integrated into innovative smallsat and cubesat missions such as the HENON programme.

## What has the GSTP funding enabled?

GSTP funding has enabled the growth of Mars Space, particularly through investment in its own test facilities. This has enabled it to rapidly test its own prototypes and products in the UK as opposed to expenditure on international facilities.

GSTP allows direct access to expertise, resources and laboratories at ESA to support the activities and it has been invaluable for promoting development in critical areas where the high risk of low TRL technologies is a barrier for commercial investment.

## GSTP Funding Impacts

**7** jobs created

**+2-3** TRL improvement per activity

**Miniature EP subsystem** UK capability

**Developing Space Capability**

Components planned to fly on ESA-HENON and M-Argo.

Collaborations with the universities in Southampton and Pisa.

**Unlocking Growth**

Mars Space has sponsored and supervised one PhD student.

7 high-value engineer and specialised technician jobs. Expected to rise to 22 jobs by the end of 2025.

**Growing Science Powerhouse**

Spin-in additive manufacturing technology from material treatment.

Presented at: Space Propulsion Conference 2024 IEPC 2024.

**Global Presence**

Partnerships with the Swiss Centre for Electronics and Microtechnology, Nammo, AVS, TransMit, TWI, Wayland Additive and Techline Systems.

Mars Space is the only producer of barium-oxide electron emitters in Europe.

# Nammo UK

**Company Type:** SME **GSTP Funding:** €5.2m **Element 1:** Develop **Framework:** De-risk & Building Block **CD7:** Propulsion, Space Transportation & Re-entry Vehicles **Location:** Westcott

## Company

Nammo UK are providers of space propulsion engines and subsystems for Earth orbit, Moon and interplanetary missions. They are a respected propulsion subsystem design, manufacturing and test provider to key satellite companies for Telecoms, GPS and defence. The wider Nammo group specialise in the production of ammunition, rocket engines and space applications with headquarters in Norway.

## Activities

1. The design, testing and development of the ACE-25 engine to raise payloads to operational orbit once in space. This engine, with 110N bipropellent thrust, would be arranged in multiples of four or six and replaces the traditional combination of a larger single engine for orbital transfer and several smaller engines to keep the payload in orbit. This solution is cost neutral while providing efficiency, reliability and simplicity
2. This activity designed and developed a 6kN bipropellant engine (RELIANCE) concept for ESA's Argonaut Moon Lander vehicle as a competitor to ArianeGroup's SPE-T. RELIANCE will be throttle-able which means you can reduce thrust which is necessary for landing and easier than traditional methods. Argonaut will incorporate three engines with a dedicated propellant feed and pump system, maximising reliability.
3. The construction of a high altitude test facility which replaces the need to have large engines tested at US facilities. This reduces travel costs for testing and introduces a UK testing capability.

## What has the GSTP funding enabled?

GSTP has enabled the development and initial testing of two new engines for different space applications. The tests proved that the engine concepts work and have stimulated interest from potential buyers. Without the initial investment from GSTP, Nammo's investment in new engines would have been less, leading to a less mature product that was unlikely to have captured the same level of interest and future sales opportunities.

The RELIANCE engine was selected to be the main engine for the Argonaut Moon Lander which secured €100m for the development and delivery of these engines by 2030. A successful demonstration on Argonaut missions positions Nammo to be the leading engine supplier for moon landers.

## GSTP Funding Impacts

**10** jobs created

**+4** TRL improvement per activity

**€100m** ESA funding

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|---|---|---|
| **Developing Space Capability** | Confirmed main engine supplier for the Argonaut Lunar missions and introduced national testing capability. | Regular engagements with the universities of Cranfield, Kingston, Southampton, Surrey and Imperial. |
| **Unlocking Growth** | €100m over the next 4 years to develop the Argonaut engine to be flight ready. | 10 permanent staff hired with 20 more to be hired over the next 4 years to scale up for Argonaut contract. |
| **Growing Science Powerhouse** | Spin-in techniques from additive manufacturing to build engine components around internal pipes. | Presented at: Space Propulsion Conference 2024 |
| **Global Presence** | Combination of 90 suppliers across the UK and Europe to provide the supply-chain of the Argonaut engine. | Interest from Lockheed Martin and Blue Origin for the ACE-25 engine. |

# National Physical Laboratory (NPL)

**Company Type:** R&D **GSTP Funding:** €1.25m **Element 1:** Develop **Framework:** De-risk & Building Block **CD1:** EEE, Components, Photonics and MEMS **Location:** Teddington

## Company

The National Physical Laboratory (NPL) is the UK's national metrology institute, a public sector research organisation focused on research and development in measurement science with applications in e.g. the communications, navigation & timing, energy, health, defence and other sectors. NPL's sustained expansion into space aims to provide essential components for missions with time-dependent infrastructure, reliant on the precision measurement capability and accuracy provided by NPL innovations.

## Activities

**1** Building on a previous GSTP funding cycle, this activity developed a commercial off-the-shelf metrological thermal imager for measuring sub-system temperatures during pre-flight vacuum testing. The project expanded the imager's capabilities to operate over a wider environmental range, including cryogenic temperatures as low as -175°C, and to measure objects with surface temperatures down to -80°C.

**2** NPL are developing a trapped ion optical clock for space applications, leveraging their expertise from creating robust, high-performance terrestrial clocks. The team have conducted structural and thermal analyses and test campaigns to assess clock sub-systems ability to withstand shock and vibration levels encountered during rocket launch and satellite deployment, as well as thermal and radiation perturbations in orbit. In comparison to static ground-based high performance optical atomic clocks, this system operates with low power lasers, offering resilient, robust portable clocks with much-reduced size, weight, power and cost (SWaP-C) in a variety of space missions and ground applications.

## What has the GSTP funding enabled?

NPL has utilised GSTP funding to mitigate risks in their planned space activities and to build the scientific and engineering expertise needed to become trusted industry partners. UKSA's funding has been crucial for NPL's continued progress in space component research and development. Without GSTP funding, NPL & UK would not have capability to develop advanced space clocks.

This funding has also increased brand awareness of NPL within industry and ESA, leading to new partnerships with space companies & opportunities to fly their instrumentation in missions.

## GSTP Funding Impacts

**5** Scientists / engineers supported

**+2.5** TRL improvement per activity

**£1.8m** ESA funding

**Developing Space Capability**

Prototypes developed also as part of a study for the LISA mission, a space-based observatory studying gravitational waves.

Space science and engineering teams were integrated which produced cross-discipline ideas to the research.

**Unlocking Growth**

€1.065 m from ESA's NAVISP and NGGM to develop optical cavity sub-systems.

Supported 5 junior to senior research and development jobs and upskilled graduates in the space industry.

**Growing Science Powerhouse**

Spin-off application for thermal imager in nuclear sector.

Presented papers at: ESA ICSO Conf. 2022 & IET Quantum Engineering and Technologies 2023

**Global Presence**

Enabled strategic partnerships with UK and German LSIs to integrate the new products.

Developing a next-generation optical atomic clock as a UK capability.

# Oxford Space Systems

**Company Type:** SME **GSTP Funding:** €1.6m **Elements 1 & 2:** Develop & Make **CD5:** End-to-end RF & Optical systems, Products for Nav., Comm. & Remote Sensing **Location:** Harwell

## Company

Oxford Space Systems (OSS) is one of a growing number of satellite hardware manufacturers, they leverage innovations from beyond the space sector to make deployable antennas smaller, lighter and cheaper than traditional designs. Established in 2013, OSS have key skills in the manufacturing of composites and reflective mesh to create the antennas.

## Activities Summary

**1** The development of a helical antenna across three GSTP activities. The initial activity developed a cubesat helical antenna (30cm) for Internet of Things (IoT) providers. The antenna has a low data rate which allows it to work in the unlicensed frequency bands for satellite communications, making it low cost to implement. The second activity developed an isoflux version which spreads power across the horizon rather than in a single beam to increase coverage. The third activity developed a four metre version of the helical antenna to transmit air and marine VHF (very high frequencies), servicing other sectors.

**2** The next set of activities focused on wrapped rib antenna which enables the cheaper transfer of high resolution imaging from smallsats, irrespective of weather conditions or sunlight, compared with traditional methods. The first was the qualification of the antenna to ensure it meets the required space standards. The second was the upgrade in size of the antenna from three metres to four which OSS determined is the more attractive commercial product.

## What has the GSTP funding enabled?

The flexibility of GSTP funding has enabled OSS to scale rapidly, meet changing demands from customers and increase the TRL of its products. Without GSTP funding the helical antenna may not have been developed by OSS as the full commercial value was not well understood due to low level of design maturity. The initial €200k funding was essential to the key product development to get the antenna flight ready.

The wrapped rib antenna activities have been core to OSS building a relationship with major prime contractors who have enabled their understanding of the quality processes required for space products

## GSTP Funding Impacts

**33** jobs created

**+1** TRL improvement per activity

**£9m** revenue generated

**Developing Space Capability**

17 helical antenna units launched on LacunaSat, JoeySat, NuLIoN and others.

Supported the Harwell space campus open day and regularly provides tours for schools and scout groups.

**Unlocking Growth**

£3m revenue generated through helical antenna. £6m revenue generated through wrapped rib antenna.

33 early to mid-stage jobs for mechanical and process engineers, and assembly technicians.

**Growing Science Powerhouse**

Spin-off applications in aviation communications over oceans and portable terrestrial satellites for defence.

Exhibited at:
Space Tech Expo Europe 2024
Small Satellite Conference 2024
UK Space Conference 2023

**Global Presence**

Strategic partnerships with international key prime contractors, and research and development institutions.

Global customers across USA, France, Germany, Spain, the Netherlands, Norway, Turkey, Australia and South-East Asia.

# Space Forge

**Company Type:** SME | **GSTP Funding:** €1.2m | **Element 1:** Develop | **Framework:** De-risk | **CD7:** Propulsion, Space Transportation and Re-entry Vehicles | **Location:** Cardiff

## Company

Space Forge are pioneering a new platform to enable manufacturing in space and the safe return of materials to Earth. Manufacturing certain materials in the micro gravity environment in space allows perfect crystal formation and uniform alloy mixing with no contamination. These materials can be used in electronics to increase efficiency of heat transfer and in pharmaceuticals to change the state of the product.

## Activity

1 Project Pridwen, to design and develop a deployable re-entry heat shield for a flight test of a prototype 50kg re-entry vehicle. The heat shield uses a high-temperature alloy shield which is large enough to radiate the re-entry heat without burning the material as opposed to a transitional disposable ablative heat shield that melts and sheds material. This allows the shield and platform to be preserved on re-entry and reused across multiple missions. This approach is much smoother for the payload and helps preserve its integrity.

The activity will involve a ground-test with a prototype of the re-entry lift control system to further improve the landing accuracy of the vehicle so it can be collected.

## What has the GSTP funding enabled?

The GSTP funding has enabled a completely new capability for the UK with a deployable radiative heat shield. This will allow the return of space manufactured semiconductors, orbital debris and return samples from missions to Mars, the Moon and Venus. It could also be used during the landing of vehicles on the Mars when the cargo requires a softer entry.

GSTP enabled activities that the company and ESA are interested in developing further. The validation of the product through flight tests garners interest from potential users of the space manufacturing platform. Without GSTP, Space Forge would not have garnered the same level of interest and funding from private investors.

## GSTP Funding Impacts

**20** jobs created

**+2** TRL improvement per activity

**£12.3m** private investment secured

**Developing Space Capability**

Developed an entirely new supply chain to build the 300-500kg platforms.

Sponsors the UKSEDS - National Student Space Conference for the exploration and development of space.

**Unlocking Growth**

£1.6m revenue generated.

20 early career to high-value jobs for engineers and designers.

**Growing Science Powerhouse**

27 patents active relating to the re-entry vehicle or recovery technology.

Exhibited at:
Space Tech Expo Europe 2024
Ignite Space 2024
UK Space Conference 2023

**Global Presence**

Strategic partnerships with Voyager, Redwire and Northrop Grumman.

World leading capability for the UK. Only one firm in the US with a similar capability.

# Teledyne e2v

**Company Type:** MNC | **GSTP Funding:** €2.3m | **Element 1:** Develop | **Framework:** De-risk | **CD1:** EEE Components, Photonics, MEMS | **Location:** Chelmsford

## Company

Teledyne e2v manufactures and provides specialised components and subsystems for innovative solutions in the medical, aerospace, defence and space sectors. For the space sector, they provide high quality complementary metal oxide semiconductor (CMOS), charge-coupled device (CCD), and MCT image sensors which enable high performance imaging. Teledyne e2v is part of the Teledyne Technologies group with operations primarily in North America and Europe. They employ circa 1,000 people at their Chelmsford site, 240 directly working in Space Imaging.

## Activities

1. Space validation of a manufacturing technique to enable CMOS sensors for use in space which led to the development of the CIS 115 sensor. This opened up a new sector for Teledyne's CMOS sensors.

2. This activity transferred highly sensitive capabilities for low-light traditionally found on a CCD sensor to a CMOS sensor. CIS120 sensor developed and was integrated onto a time delay and integration platform to enable the sensor to scan an environment to produce a high-resolution image.

## What has the GSTP funding enabled?

GSTP provided the seed funding for the development of two imaging sensors for space applications. This de-risked the business case for these technologies by progressing the technologies to reach threshold development for investment from the parent company as well as external validation that this technology is desired by the market.

The GSTP activities validated the manufacturing technique of the CMOS sensors which has enabled them to be selected for at least seven missions. CMOS sensors offer a higher resolution, faster readout speed and lower power consumption than traditional CCD sensors. These sensors have been developed further through internal investment and separate UKSA funding to become a suite of five CMOS sensors with different applications. These sensors have enabled ESA to participate in internal missions with NASA.

## GSTP Funding Impacts

**26** jobs created

**+3** TRL improvement per activity

**£11m** revenue generated

### Developing Space Capability

Missions:
JUICE, EnVision, CO2M, Sentinel 2NG*, Sentinel 3NG*, GeoXO*, LISA* and more.

Partnership with The Open University to advance imaging detector technology.

### Unlocking Growth

£8m revenue from EnVision.
£3m revenue from enabled activities.
£80m revenue for other sensors in the suite.

26 high-value, specialist engineering jobs created.

### Growing Science Powerhouse

Developed the CIS 125, CIS 220 and CIS 300 using the techniques and knowledge from the GSTP funded activities.

Research presented at:
RADOPT 2023
Space & Scientific CMOS Image Sensors Workshop 2024

### Global Presence

New partnerships with Thales Alenia Space in Switzerland and Satlantis in Spain.

Buyers:
United States of America, Canada, Europe, South Korea, and Japan.

*other sensors in the suite selected.

# TWI Ltd

**Company Type:** R&D **GSTP Funding:** €1.75m **Compendia & Element 1:** Develop **Framework:** Building Block **CD2:** Structures, Mechanisms, Materials, Thermal **Location:** Cambridge

## Company

TWI Ltd is a technology and research membership organisation, specialising in engineering, materials and joining. Their space applications focus on precision welding techniques and coating technologies to meet the exacting demands of the sector.
Precision welding is key for ensuring the structural integrity of critical spacecraft components during a mission. TWI Ltd are also the ESA technology broker in the UK, supporting companies who want to enter the space industry.

## Activities

1. The first building block activity is the design, build and testing of a hydrogen embrittlement testing rig. This hydrogen pressure vessel will test components dynamically at a high temperature (up to 425° C) and high pressure (up to 500 bar). This allows materials to be tested to fatigue as well as cyclic loading and unloading of materials. The results from testing different materials will be used by companies when designing propulsion components for space. This is key to understand if the components can be reused.
2. This compendia activity is the development of in-line, non-intrusive inspection techniques for advanced manufacturing. This allows components from laser power bed fusion and wire-arc additive manufacturing to be inspected for cracks and faults.
3. The second building block activity is a follow-on from a previous GSTP activity to develop linear friction welding (LFW) to lower the cost and environmental impact from manufacturing. This technique starts with near net shape, reducing the buy-to-fly ratio when compared to the alternative large forging. This reduces the amount of materials and long lead times required for large forging.

## What has the GSTP funding enabled?

GSTP funding has enabled the development of a UK capability with the hydrogen test rig, the applications of the test results will ensure companies understand the capability of the materials they use. This test rig would not have been built without GSTP funding.

GSTP encourages companies to work at the forefront of research and development, utilising techniques from other sectors such as LFW, which is used for blisk manufacturing. This activity is high risk due to the capital investment of the machinery and would not have been tested without GSTP. Now end users, such as Airbus, can work with TWI Ltd to see if it is more efficient for their components to manufactured in this manner.

## GSTP Funding Impacts

**2** jobs created

**+2** TRL improvement per activity

**€0.3m** internal investment

**Developing Space Capability**

Hydrogen embrittlement test rig is a unique capability for the UK.

Developing LFW techniques reduces the reliance on China for large forge welding.

**Unlocking Growth**

Advises non-space companies on how to enter the sector. Supports them through the ESA procurement process.

15 technical jobs supported through GSTP funding such as technicians and component testers.

**Growing Science Powerhouse**

Spin-off applications to LFW in nuclear, defence and automotive sectors.

Spin-off applications for test rig results for hydrogen fuel cells in automotives.

**Global Presence**

Strengthened strategic partnerships with Airbus, ArianeGroup and MTC.

Presented at: North America Worldwide Advanced Manufacturing Symposium 2024