SESAME

T-minus digital
Data automation in the European space launch industry

SESAME, or 'Smart European Space Access through Modern Exploitation of data science', was a three-year research project, funded by the EU and conducted by 8 partner organisations. It aimed to demonstrate European space companies **working together** and reducing costs by using **data science** for **predictive quality, predictive maintenance,** and **operational planning optimisation.** As the project draws to a close, we unwrap each partner's discoveries, the project's impacts - and identify future opportunities.

When most people think of space rockets, high-tech futurism and big brains come to mind. What they don't appreciate is the attention to detail and extraordinarily high production and operational standards involved. These exacting requirements do their job, but are slow, labour intensive and expensive. Set against this, cost and time savings are becoming critical, with launch customers wanting deployment on time and at minimum cost, or they'll look elsewhere.

Most modern industries have driven efficiency by adopting digital ways of working, underpinned by agile test-and-learn methodologies and data automation. This has not been feasible in this low-volume, high-standards environment. With space launches there's no sandbox – it either flies or explodes. Despite such forbidding challenges, the European space industry was determined to find a way.

Enter SESAME, created to prove the concept of using data automation in the space industry. Overseen by coordinating partner ArianeGroup, eight partners worked together for three years, amid the unfolding global pandemic, to propel the space age into the digital era.

What SESAME discovered: the results

Overall, SESAME proved that automated data systems can indeed reduce costs in a rocket manufacturing facility – using both predictive maintenance and predictive quality AIs (artificial intelligences). It also confirmed these data systems can increase the efficiency of space launch operations at Europe's space port by using planning optimisation algorithms.

Additionally, both ArianeGroup and France's space agency, Centre National d'Etudes Spatiales (CNES), learned they can share data and collaborate with multiple partners by using a cloud-based, open-data platform – while, critically, complying with the immensely high cyber security standards they are both subject to. Developed by Capgemini, this

solution was a huge insight for them, with major implications for how future multi-partner projects can be conducted.

Mission accomplished. But let's dive in deeper.

It unfolded at two sites. In Les Mureaux, France, Eurecat worked closely with ArianeGroup to develop machine learning algorithms (AIs). These analysed data from 1,200 newly installed sensors and learned to successfully anticipate the quality of welding on Ariane 6 rocket tanks. With this friction stir welding (FSW) process usually requiring up to 30 days of manual inspection, this predictive-quality approach marked a major breakthrough.

Working alongside Eurecat were Predict, who handled development of an AI that successfully anticipated failure of the FSW machine itself. Machine downtime is so expensive that this predictive maintenance is another big result. ***"Deploying machine learning and AI algorithms really helped us to understand and manage both welding stations, while also improving the weld quality"***, explained William Lacheny of ArianeGroup.

It's too early to accurately quantify the time and cost savings from these AIs – both the predictive quality one developed by Eurecat and the predictive maintenance one from Predict – as they need feeding more data before real world use. But they look set to drive both cost and time savings, together with quality improvements, in the future.

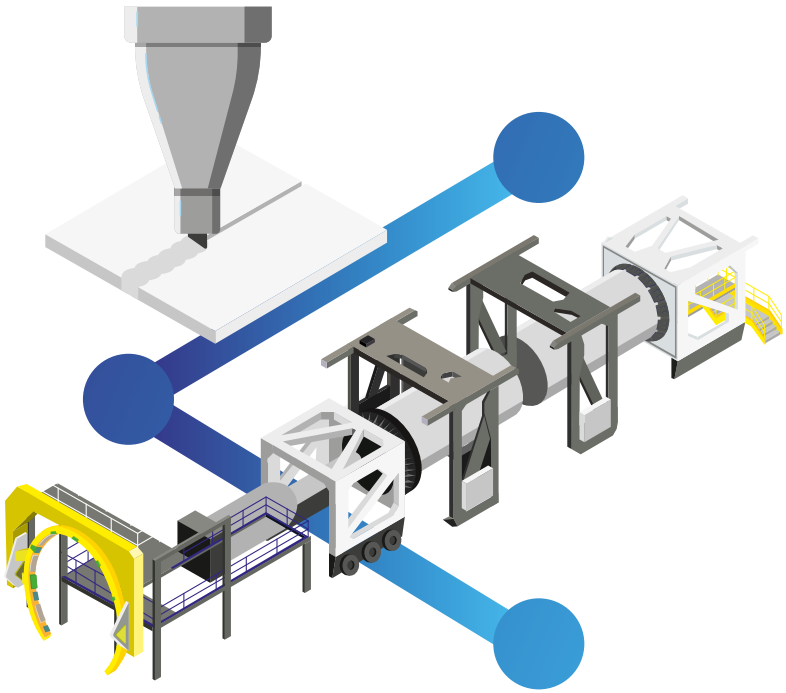
Meanwhile, close to the equator at the Guiana Space Centre (GSC), partners Telespazio (formerly Vitrociset) and the Consortium for the Research in Automation and Telecommunication (CRAT) were transforming launch planning. First, Vitrociset solved how to convert operational GANTT charts into mathematical form. This was then analysed by CRAT as they developed a model predictive control (MPC) algorithm to optimise the timing of various tasks across the spaceport.

To support SESAME, ArianeGroup upgraded its GPS-based internet-of-things, *"ArianeTracks",* and moved it to the new cloud-based data platform – meanwhile expanding its antenna network to cover more of the vast space port. This brings the site a step closer to using real time data, from ArianeTracks, for planning and optimising operations. Estelle Aimar of ArianeGroup described how, *"Utilising our internet-of-things provided additional data for the SESAME algorithms, but it also improved operational agility, allowing better management of the spaceport's resources, and especially so for CNES."*

Instead of long end-of-day meetings deliberating over planning charts, the algorithm provided managers an on-demand schedule of optimised operations across the space port. Using simulated data, the algorithm was always better than the human approach, with potential time savings of around 10% – a big result considering the scale of the port and launch operations. And the solution can be updated in moments, as events unfold.

Another major result is within data science itself, as CRAT also overcame the hurdle of making MPCs scalable – and with that has made them suitable for many other large projects.

Alongside all the data, engineering and operations research, SNSPA looked at the effect of data automation on people. They confirmed their hypothesis: that space launch staff's readiness to accept and use new technologies is a strong predictor of their performance and engagement with it. Camelia Crisan explained, *"You could have the best machine in the world, but people may simply not trust or use it."* So keeping staff fully on board throughout digital transformation is critical – or it may be a failed venture.



What was achieved: the impacts

The prevailing mindset in the launch industry was that digital transformation is great – but just not for them. The exacting standards and low production volumes simply don't invite it. But SESAME has singlehandedly changed a lot of minds – and as SNSPA found, expectations of positive change are fundamental to making things work. In this way, the project has laid the ground for the digital transformation of European space rocket manufacture and launch.

It's a change that's already happening. CNES, the European Space Agency (ESA), ArianeGroup, and other partners are creating the next generation space port in Guiana. Jean Oswald explained, ***"This is a wide-ranging update to the GSC and will incorporate the sort of data methods demonstrated by SESAME, plus additional high-tech systems from the start – implemented across a much larger range of operations."***

The predictive welding AIs have been licensed to ArianeGroup – and Predict is in discussions with ArianeGroup to continue developing them. Florent Barbier was upbeat about the SESAME benefits for Predict: ***"Already another FSW-manufacturer has approached us to explore predictive AI opportunities."*** For Eurecat, this was their first experience in aerospace, and having now solved how to adapt machine learning algorithms for a low volume setting, Francesc Bonada encouragingly reported, ***"Many new opportunities appear open and ready for our expertise."***

More immediately, a potential major launch delay was avoided when the AIs anticipated two major weld errors during Ariane 6 production. This is exactly the sort of impact SESAME set out to demonstrate, and it did so within its short project window too.

Down at the space port in Guiana, SESAME's planning optimisation challenge was a well-known one in academia: the ***"assembly line balancing problem"***. CRAT's solution, using a scalable MPC algorithm, resolves the puzzle – and they are poised to create opportunities for many businesses and industries across the EU. Furthermore, an AI-based control framework has been proposed to address the considered scheduling problem. In this respect, Andrea Tortorelli of CRAT pointed out, ***"Data driven, deep learning methodologies are building blocks of the Industry 4.0 paradigm – the 4th industrial revolution – which SESAME has helped usher into the space launch industry."***

Telespazio already worked at the space port and were on the lookout for new opportunities. ***"Working on SESAME positioned us to now move into a collaborative operational planning role, with partners such as CNES and ArianeGroup,"*** revealed Fabrizio Rocci.

SNSPA's occupational psychologists and philosophers already knew how important people are to the success of digital transformations. But they hadn't appreciated just how critical staff communications are – not just their content, but their form and consistency too. For example, a manager promising digital innovation while still using pen and paper themself, undermines the messaging and potentially sabotages the initiative. SNSPA will be beating the drum much louder on this. In fact, one partner has already taken this on board and set up a storyteller initiative to explain, in plain language, what such changes involve for the average worker.

Finally there's the impact on carbon emissions. Rocket science may not be in the vanguard of low carbon industries, but the big reductions in inter-site travel within and between countries, made possible by Capgemini's data sharing platform, nudges things in the right direction.

Looking to the future

Already, the predictive maintenance and predictive quality AIs are being considered for other manufacturing processes. ArianeGroup is now eyeing their use in the welding of a rocket-fuel mixer tool, used on both Ariane 6 and VEGA rockets.

These predictive welding AIs will likely start appearing in both space industries and the broader manufacturing sector. Predict are poised to lead this innovation, expecting to boost *"right first time"* production while minimising machine breakdowns – and not only for FSW processes. Aeronautic and Automotive welding is a prime opportunity and extending a low-volume data technology into such a mass-production market will be remarkable.

As the space port gets its digital overhaul, CRAT have already started work with CNES on building a new optimisation algorithm that tackles energy use. Dr Francesco Liberati remarked, *"This should reduce energy consumption at the GSC and* (later) *across European industries in general."* Another breakthrough to look forward to.

Future opportunities have come early for Capgemini and CNES, with them seeking to develop a cloud-based open-source data platform together. Pascal Porcar, of Capgemini, remarked, *"Having seen how ArianeGroup and SESAME were able to meet all the security requirements, CNES realised it can satisfy those same exacting standards itself."*

Let's not lose sight of the people in all this – AI can worry many of us with thoughts of redundancy and it's a concern that SNSPA addressed. While machine learning technologies can make some human roles unnecessary, it simultaneously provides new ones. So, it's not a case of handing over the factory keys to algorithms. Instead, we can expect a host of new jobs in data measurement, interpretation and representation – together with roles for trainers and suppliers of these new competencies.

Stepping back to take in the big picture of space, it's… so big. But SESAME provides proof, within the most quality-exacting of conditions, that data driven solutions can reduce launch costs and timescales – which means better access to space for European businesses. Now even the sky is no longer the limit – and space, vast as it is, comes that bit closer.

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