
# Socio-economic benefits from ESA's Science Core Technology Programme

A report for esa

## CASE STUDY: Rad-Hard High Accuracy Accelerometer

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## From dependence on an American critical technology …


*InnaLabs*

Accelerometers are inertial sensors, which are utilised in space to measure the non-gravitational acceleration and angular velocity of an object[1]. They can be used for launchers, landers and to conduct orbital manoeuvres (e.g. orbit corrections and adjustments). Accelerometers help flag potential issues and offer critical precision, essential to optimise propellent use and extend satellites' lifespan. These instruments can also be used for navigation in space, notably for lunar and Martian rovers.

Overall, accelerometers tend to only be required in missions where ground control is limited, notably due to communication delays and/or visibility. This makes them key to the success of science missions and the maximisation of scientific returns. ESA has traditionally used American technology developed by Honeywell, as it was the only supplier of radiation-hardened (rad-hard) accelerometers for space. However, this created **significant reliance on America** on two fronts. ESA was:

- dependent on Honeywell's ability to supply the instrument and its pricing; and
- impacted by restrictions from ITAR export control regulations.

Supplying accelerometers from Honeywell also entailed that ESA Member States' taxpayers' money was directed to the US, instead of building capabilities of ESA Member States.

**Ensuring Europe's free and unrestricted access to this critical space technology and capability-building in ESA Member States** were the main drivers behind ESA's investment in developing of a European alternative to Honeywell's rad-hard accelerometer.

## … to the development of a European alternative …

With initial collaboration in 2014/15, **ESA chose Ireland's InnaLabs to develop a rad-hard accelerometer in late 2018 through a Core Technology Programme (CTP) investment**. The company had originally been developing inertial sensors for terrestrial navigation applications in the marine, defence, and aviation sectors.

*InnaLabs*

InnaLabs was particularly attractive as it supplied gyroscopes and accelerometers to industries that presented similar requirements (e.g. strong, long-lasting and reliable instruments that perform in harsh environments), standards, and testing procedures to space.

InnaLab's CTP contract consists of building on its reliable terrestrial accelerometer to make it space-ready, i.e. rad-hard. This involves shielding and redesigning the internal components (e.g. triplicate circuits) of the instrument, while ensuring performance is not affected. Overall, **the outputs of this ESA contract include a rad-hard accelerometer (AQUILA) and a technological kit (3-axis accelerometer), which are not subject to export restrictions**. Qualification is anticipated for early 2023.

[1] Munoz Diaz, E, 2019. *Inertial Sensors and Magnetometers.* Available at: https://www.sciencedirect.com/topics/engineering/inertial-sensor#:~:text=An%20inertial%20sensor%20measures%20the,by%20indirectly%20measuring%20specific%20forces

## … with potential for significant socio-economic benefits

While the AQUILA accelerometer is still currently under development, with the aim to be qualified in early 2023, **some initial socio-economic benefits have begun to emerge, with the promise of many larger, benefits** to come through its successful qualification and commercialisation – for the company, their customers, and for the broader European industrial base.

# Developing the only European rad-hard accelerometer on the market

### *Strategic market positioning*

The market for radiation-hardened accelerometers for space applications is currently limited, since they are not used for all satellite missions, and thus there is no need to have a large number of competitors or suppliers of space-ready accelerometers within Europe.

Through developing an accelerometer that is suitable for the space environment, and thanks to CTP's support, InnaLabs has positioned itself strategically within the market, with the unique role of being able to provide the only European-developed product that fits the majority of user needs within the space community.

### *Job creation*

Thanks to funding from the CTP and additional co-funding for the projects, InnaLabs has been able to **support up to 10 full time employees (FTEs)**, or almost 20% of its employees as an SME

This represents over 11 FTE per €1 million invested through CTP for the accelerometer, although it is important to note that additional co-funding and CTP support through the gyroscopes also plays a role in employee financing.

Whilst the COVID-19 pandemic slowed the hiring process previously, the company is now seeking to expand as work and opportunities increase, with new jobs opening up. **InnaLabs is therefore acting as a source of employment for highly-qualified individuals within the Irish economy**.

### *Increased competitiveness*

The aim of developing an accelerometer for space through ESA CTP support is not to create performance competition, although of course AQUILA will match its competitor in performance and compatibility, so that companies can switch providers if they wish without issues. If in the end it does have better performance or higher reliability, it would be an ideal outcome but that is not the primary goal.

Rather the objective is to create a European alternative, that will already benefit from cost-savings through the lack of outside restrictions and export control. Furthermore, it has already seen increased interest by non-US actors in the global space sector, who wish to **access technology that is not subject to export restrictions**.

### *Potential revenue increase*

Development of the AQUILA rad-hard accelerometer supports further expansion and new products for InnaLabs into the space sector, which now represents up to 30-40% of its revenues.

InnaLabs was previously well-established in the accelerometer market, but for terrestrial applications only. The space sector has become an increasingly important source of revenue for InnaLabs, which has evolved from a company only focused on developing gyroscopes and

accelerometers for terrestrial navigation applications, such as marine, land and aviation, to one which has begun providing more and more space application solutions. With growing interest in space and engagement with ESA, InnaLabs became a new entrant to the space industry, with a space business line now representing up to 30-40% of the company's revenues. The ESA CTP contract for the AQUILA accelerometer prompted them to shift into the space domain for this technology, opening doors to new customers, missions and market segments and therefore potential new revenue streams.

### *New space market segments*

Through the development of AQUILA, **InnaLabs has added a product to its portfolio that will allow them access to new market segments within the space domain**.

Firstly, they are positioning themselves as a lead provider of accelerometers for space science missions, thanks to AQUILA being competitive versus the existing Honeywell product whilst also being European-based, and therefore a priority choice for ESA missions.

Their work with ESA has also instigated conversations with European primes such as Airbus, where AQUILA has the potential to be used as the replacement accelerator in Inertial Measurement Units (IMUs). IMUs are an electronic device to measure and report the spacecraft's specific force, angular rate and sometimes orientation of its body, made up of a combination of gyroscopes, accelerometers and sometimes magnetometers. The gyroscopes provide a measure of angular rate, while the accelerometers provide a measure of the specific force/acceleration. Both technologies are vital components of an IMU, with a typical configuration having one accelerometer and gyroscope per axis (of pitch, roll and yaw).

Previously, InnaLabs have won ESA CTP contracts to develop gyroscopes suitable for space missions, and they are currently offering an IMU useful for certain space activities already – POLARIS, which is suitable for short to medium-term space missions, such as launchers, micro-launchers, landers and re-entry vehicles. However, the accelerometer within POLARIS is based on an aerospace-grade design rather than a rad-hard accelerometer; therefore, with the introduction of the AQUILA into their portfolio, they have the potential to offer a more robust IMU product with both rad-hard gyroscopes and accelerometers. Furthermore, by selling AQUILA to other companies producing IMUs, they provide a solution for building a completely European IMU that is not subject to export restrictions, which to date has not been possible.

### *Improved terrestrial applications*

By undergoing the robust and high-quality development process expected by ESA and by the demands of making a technology suitable for the harsh environment of space, **InnaLabs has built up expertise that is transferable towards improving their terrestrial applications** also.

Whilst accelerometers for these markets do not need to be radiation-hardened, much of the standards and procedures required by high-performance sectors for land, marine and aerospace are very similar. Therefore, InnaLabs can use their growing expertise to enhance their product offers to these markets.

This brings increased revenue opportunities and market position strengthening, which is an important factor considering their targeted global high-end accelerometer market is expected to grow to €250 million by 2026 (4.0% CAGR between 2021 and 2026)[2].

[2] Mordor Intelligence LLP, 2021. *High-end Accelerometer Market - Growth, Trends, COVID-19 Impact, and Forecasts (2021 - 2026).* Available at: https://www.reportlinker.com/p06030481/High-end-Accelerometer-Market-Growth-Trends-COVID-19-Impact-and-Forecasts.html?

# Bringing niche expertise for a critical mission component to the Irish industry ecosystem

## *Expanded industrial capability and expertise*

InnaLabs' position as the only European provider of accelerometers for future ESA science missions provides a solution for Ireland's historical under-representation in ESA CTP projects

Ireland's membership of ESA is a key element of their *National Space Strategy for Enterprise*, to enable Irish companies and research institutes to bid on ESA tenders for the development of technologies, services and business applications.

However, historically Ireland has been under-represented within the Science Programme at ESA compared to its investment in the programme. InnaLabs' success through CTP funding opportunities, first with its gyroscope and now with its high-performance accelerometer, has produced an excellent solution in addressing some of these issues, as these are structuring activities for Ireland. Since this rad-hard accelerometer is the only accelerometer developed in Europe suitable for deep space exploration, it **positions the company very strategically for providing regular usage of an Irish technology on board ESA missions** in the long term, since many future science (and some EO and exploration) missions will require accelerometer technology.

Producing a rad-hard accelerometer builds expertise within the country that is niche but also regarding a critical component of any spacecraft that requires orbital transitions.

## *Supply chain expansion*

In order to develop a product that had the performance required for space application, InnaLabs had to form a supply chain – involving a mix of existing and new supply chain actors. This was a huge, energy-intensive activity for the company, since they did not have that particular area of expertise before.

Whilst much of this supply chain spans across Europe, establishing this area of expertise within the country offers up opportunities to sub-suppliers, and **having companies such as InnaLabs in Ireland helps to build up an ecosystem around it, strengthening the overall Irish industry**.

## *Training and expertise growth*

To address the needs of the challenging technological activities being undertaken, InnaLabs have very high standards in terms of the quality of engineers they are employing.

In order to continue with the demand of new skills and expertise, they are looking to institutions such as the University College Dublin (UCD) to provide them with graduates for ongoing training. Opportunities such as these provide an excellent career path for graduates who may otherwise have to seek employment or training outside of Ireland due to the limitation of highly skilled engineering jobs.

InnaLabs is focused on hiring local Irish experts and graduates, not only because they require presence on site for their employees, but also since they wish to support the growth of expertise within Ireland. In the future, they aim to have a scheme to hire graduates from early-stage career, and train them to become leading experts for accelerometers and gyroscopes.

## *National space strategy support*

InnaLabs' continuing expansion in the space sector supports the goals of Ireland's *National Space Strategy for Enterprise* through increasing space-related revenue and employment in the country, and engaging further with ESA

Ireland's *National Space Strategy for Enterprise 2019-2025* sets out its key vision and goals for space enterprise within the country, outlining its goal to have an: "Economically sustainable and expanding space-active industry, delivering quality jobs for the economy of tomorrow." Some of its strategic goals to achieve this vision include doubling the space-related revenue and employment in space-active Irish companies, supporting 100 companies to benefit from ESA engagement, and developing and attracting talent for space-active and related industries.[3]

By winning contracts with the ESA CTP, developing a new rad-hard accelerometer and expanding the business, **the activities of InnaLabs have directly contributed towards addressing these priorities within the national space strategy for Ireland**.

## Enabling European technological non-dependence and strengthening competitiveness

### *Enabling European non-dependence*

InnaLabs' development of a European-based rad-hard accelerometer has provided a solution for European non-dependence from ITAR-restricted American technology from Honeywell

One of the key objectives within European space policy is to ensure non-dependence on critical enabling technologies for space activities, ensuring strategic independence and security. This does not mean that all needed space technologies are developed in Europe ('independence'), but rather Europe has free, unrestricted access to any required space technology ('non-dependence').

ESA's *Agenda 2025* recognises the importance of this principle, especially off the back of the COVID-19 pandemic that exposed the dangers of relying on others for the provision of key societal needs. This has pushed strategic autonomy and technological non-dependence into a central position. Furthermore, it outlines the need for an industrial policy to empower a more resilient European space value chain and ecosystem, supporting Europe's industrial competitiveness.

The access to radiation-hardened accelerometers that are suitable for the harsh environments of space is severely limited, and there is one major provider for space missions: Honeywell, an American company that is covered by ITAR restrictions. Therefore, **thanks to ESA CTP support, InnaLabs is producing a European-developed solution that increases European non-dependence for a critical technology**.

### *Enabler of future missions*

The AQUILA accelerometer under development by InnaLabs has already been preselected for two important upcoming ESA missions: PLAnetary Transits and Oscillations of stars (PLATO) and the Atmospheric Remote-sensing Infrared Exoplanet Large-survey (ARIEL).

PLATO is a medium-class mission within ESA's Cosmic Vision programme, seeking to find and study a large number of extrasolar planetary systems, especially for the properties of terrestrial planets in the habitable zone around solar-like stars. It has a targeted launch date of 2026.

ARIEL also sits within the Cosmic Vision programme as a medium-class mission, aiming to answer key science questions around how exoplanets are formed and how they evolve over time. As the first mission dedicated to measuring chemical composition and thermal structures of hundreds of transiting exoplanets, it is contributing far-reaching planetary science towards addressing the

[3] Department of Business, Enterprise and Innovation, 2018. *National Space Strategy for Enterprise 2019-2025*. Available at: https://enterprise.gov.ie/en/Publications/Publication-files/National-Space-Strategy-for-Enterprise-2019-2025.pdf

question of 'what are the conditions for planet formation and the emergence of life?'. It has a foreseen launch date in 2029.

Beyond these two missions, AQUILA is well-placed to be the accelerator of choice not only for further future ESA space missions, but for space missions within other countries also, as it is offering a solution that is simpler and cost-effective, as it is not subject to outside restrictions.

Outlined in the table below are future planned and proposed missions (launching after 2023), that could potentially require an accelerometer such as AQUILA (to note, this does not confirm AQUILA will be the selected solution). Launchers (e.g. Vega-C) for these missions could also require this technology.

| ESA-led missions and their launcher | Other missions and their launcher |
|---|---|
| • Large (L-) class missions<br>  ○ L2, ATHENA: Advanced Telescope for High Energy Astrophysics, planned launch in 2035<br>  ○ L3, LISA: Laser Interferometer Space Antenna, planned launch in 2035<br>• Medium (M-) class missions<br>  ○ M3, **PLATO**: search for exoplanets and stellar oscillations measurements, planned launch for 2026<br>  ○ M4, **ARIEL**: Atmospheric Remote-sensing Infrared Exoplanet Large-survey, planned launch in 2029<br>  ○ M5, EnVision: Venus orbiter for radar mapping, planned launch in 2031<br>• Small (S-) class missions<br>  ○ S2, SMILE: study of interactions between Earth's magnetosphere and the solar wind, planned launch in 2024 (joint ESA-Chinese Academy of Sciences mission)<br>• Fast (F-) class missions (launched alongside M-class missions as an 'add-on')<br>  ○ F1, Comet Interceptor: encounter and explore a pristine comet, planned launch in 2029<br>  ○ F2 (to be selected, to be launched with M5)<br>• Missions of Opportunity (M*): PROBA-3 (planned launch in 2023) | • MMX: Martian Moons eXploration (JAXA-led with ESA, NASA and CNES participation, planned launch in 2024)<br>• MOM2 (ISRO-led, planned launch in 2024)<br>• LUPEX (JAXA and ISRO-led, planned launch in 2024)<br>• DESTINY+ (JAXA-led, planned launch in 2024)<br>• DISH (ISRO-led, planned launch in 2024-25)<br>• Shukrayaan-1 (ISRO-led, planned launch in 2024 or 2026)<br>• LiteBIRD (JAXA-led, planned launched in 2028) |

*Increasing European competitiveness*

The AQUILA accelerometer is not bound by outside restrictions, making it a simpler, cost-savings solution that is competitive in the market

Export control restrictions (which the Honeywell technology would impose) add burdensome costs and regulatory compliance complexity for companies, and can limit where technology is sold and to whom, with a previous estimated cost to be around €100K-200K per payload.

InnaLab's AQUILA accelerometer is not bound by outside restrictions thanks to its European development, making it a simpler, cost-saving solution that is competitive not just for Europe, but for non-EU companies seeking to avoid the burden of heavy restrictions, such as in Japan and India. **This provides European industry with its own accelerometer than allows them to sell products much more easily across the globe, and this is impactful not just for InnaLabs, but for European primes who incorporate AQUILA into their IMUs**.

## Would these benefits have been realised without ESA?

**InnaLabs would not have developed a rad-hard accelerometer, or even entered the space sector, without ESA's CTP funding** alleviating the significant non-recurring costs (millions of euros) required, which would have made it difficult for InnaLabs to break-even.

*ESA*

Supplying instruments for ESA Science missions was also traditionally seen as developing one-off, specific technologies with little follow-on potential. However, InnaLabs saw that the market was valuable in and of itself, as rad-hard accelerometers can be used in various institutional science and EO missions and in the commercial space sector (telecoms, LEO and GEO markets, particularly relevant in the context of New Space).

*"We use ESA's CTP investment for the space market, but it also has spillovers in our non-space activities"*

- Alberto Torasso, InnaLabs

## … plus further development and benefits to come

The confirmed order of InnaLabs' rad-hard accelerometer in future ESA Science missions like PLATO and ARIEL means **that the company and Ireland will continue to reap the benefits of CTP investments**. The accelerometer could also be used in other ESA missions, on its own or as part of an IMU, notably for Vega rockets.

InnaLabs' CTP work enabled the development of a key technology block, which led to discussions with European primes (e.g. Airbus France, Thales Alenia Space) and with stakeholders around the world seeking to distance themselves from heavily-restricted technologies**. InnaLabs, now a niche national champion**, is in a position to be approached by Tier-1 suppliers when mission consortia are being established.

**CTP-funded activities on the rad-hard accelerometer also enhanced InnaLabs' skills, capabilities, and knowledge, which spill over to the company's terrestrial technologies.** This could improve the performance of InnaLabs' product portfolio, increasing its attractiveness. This can help the company secure more contracts, including with new customers (e.g. in very high-performance markets).