Sharing Scientific Knowledge in the Aeronautical Domain

Authors:

José A. S. Neves, GMV, Portugal

Jose.neves@gmv.com

José R Parizi Negrão, Embraer, Brazil

parizi@embraer.com.br

Abstract (EN)

In aeronautics, the costs of research and technology developments, the scale of the risks associated with massive investments and the long term ROI makes it extremely difficult for a single company, or even a country, to be able to make efficient investments with significant impact. This situation favored the emergence of international cooperation and the sharing of technological knowledge in the aeronautical sector.

The globalization process brought, in a very short time window, new competitors, as well as access to new markets, requiring from governments and, in particular, from the aviation industry more innovation and greater competitiveness of its products. Contrary of the cooperation, that encourages knowledge sharing, innovation produces competitiveness and can even acts as a disaggregating factor, as will be seen at the end of this article.

In this scenario, the authors discuss the critical issue of sharing of intellectual property rights in consortia for technology development projects.

Abstract (PT)

No setor aeronáutico, os custos inerentes a atividades de investigação e desenvolvimento tecnológico, bem como os riscos derivados dos elevados investimentos associados, fazem com que seja extremamente difícil para uma única empresa, ou mesmo país, ser capaz de fazer investimentos eficientes com impacto significativo. Esta situação favoreceu o surgimento da cooperação internacional e do compartilhamento do conhecimento tecnologico no setor aeronáutico.

O início do século XXI alavancou novos desafios a todas as indústrias. Atuando como um fator desagregador, o processo de globalização trouxe na última década, em uma janela temporal muito curta, novos concorrentes, bem como o acesso a novos mercados, exigindo dos governos, e da indústria aeronáutica em particular, mais inovação e maior competitividade de seus produtos.

Neste cenário, o presente artigo discute o problema crítico da partilha dos direitos intelectuais em consórcios de projetos de desenvolvimento tecnológicos.

Introduction

In the present days, transport is essential for the functioning of modern societies, as it enables freedom of movement of people, goods, and services. On the other hand, the aeronautical industry is today a highly strategic sector for Europe, bringing citizens closer together and generating knowledge, skills, wealth and jobs.

Growth in the aeronautics sector is dynamic, with an annual increase in passenger numbers over recent years of around 8.5%. Outside Europe, according to the International Monetary Fund (IMF), certain regions are even seeing a more rapid growth, namely in Latin America, Russia, China, India, all being regions of growth and all already (or in the process of) addressing for international cooperation across the air transport sector.

In Europe, ACARE Beyond 2020 Vision [1] clearly states the relevance of the European Air Transport sector to the European society, generating a turnover in excess of Euro 94 billion and representing a pinnacle of manufacturing which employs almost half a million highly skilled people directly and spinning-out technology to other sectors...

To leverage the European position worldwide, several relevant decisions, as well as investment, have been promoted in the last 4 decades. The crucial element is that, today, the aviation is marked by the high complexity of its components, products, vehicles, systems and systems-of-systems, all of which are both technology and capital intensive. Air vehicles are subject to very long R&D cycles (up to 20 years). As such, major research efforts need to be based on a long-term programming approach that provides continuity across Research &Technology efforts over many years [1]. In the aeronautical sector, the costs of research and technology developments, the scale of the risks associated with massive investments and the long term Return on Investment (ROI) makes it extremely difficult for a single company, or country, to be able to make efficient investments with significant impact. On top, the globalization process brought, in a very short time window, new competitors, as well as new markets, and improved the need for stronger and faster innovation processes.

Seen for many decades as traditional market, the aeronautical industry is today exposed to the new requirements and needs. A few set of examples included the strong environmental limitations due to CO emissions, or the new Air Traffic Management infrastructure requirements proposed under the European Single Sky (SES) program which is deeply involving the industry under its SESAR technological arm. Indeed the environmental thematic is so relevant today that European aeronautical industry is not preparing the a continuation to the successful Clean Sky Joint Technology Initiative, under the European Union's Horizon 2020 Framework Programme for Research and Innovation.

Scenario

1. The European Position

Since 1984, the European Union (EU) has been running its research and technological development strategic works on the basis of multiannual framework program. The 7th Framework Program (FP7) for Research, covering the period 2007 to 2013, has been an excellent catalyst for the EU to match its research policy to its ambitions in terms of economic and social policy. In the aeronautical sector, clear results have been measured and publish by Advisory Council for Aeronautics Research in Europe (ACARE) to develop and maintain a Strategic Research Agenda. The ACARE Beyond 2020 Vision reports the relevance of the European Air Transport sector to the European society, by generating a turnover of 94 billion Euro and employing almost half a million highly skilled people directly and spinning-out technology to other sectors. With a strong innovation driver, leveraged by consolidated technological challenges and novel research objectives, the FPs Program have bring benefits of paramount importance to the European society, raising the European competitiveness through innovation.

A relevant factor in aeronautics is that, in Europe, on average, 12% of aeronautic revenues, representing almost €7 billion per year for civil aeronautics alone, are *reinvested in R&D...* Aeronautical technologies are catalysts for innovation and spill-over into other economic and technological sectors, thus contributing to the growth of the European economy as a whole [1].The establishment of European financing instruments, with means to support long-term goals, was therefore essential and fruitful to the economy, being an enabler for European companies to associate themselves at European level, while achieving relevant scale factors. Performing projects at European level also contributed to the strengthening of European cohesion: between richer and poorer states, between bigger and smaller states, and between small and medium organizations and bigger industrial clusters. Additionally, and its clearly measured,from an SME perspective, performing projects, at European level, also opened several access doors, vital to their business.

2. Going beyond horizon

With the achieved results at European level, it is a fact that the approach to reach a secure, competitive and sustainable transport in a globalized world should take into account the following aspects:

− Cooperation, and

− Dissemination of best practices and technologies,

which, at a global scale, should go across the planet. At the end, the goal is to consolidate global results and benefits that require more than ever, today, global efforts.

Based on several Trans-Atlantic experiences, such the DIANA Project, from the European Commission Framework Program 6, or the preset on-going Karyon Project, it is truly recognized by the authors that, bringing together leading edge European engineering teams, throughout Europe, together with recognized worldwide industrial players, as an example Embraer from Brazil, is an additional promoter for a competitive and sustainable future of the European and Brazilian industry at a global level.

As already stated, aeronautics is a sector where the European public and private stakeholder provide world leadership. By compromising research and technology development with a close global market perspective, the FP7 Program has become a catalyst to the establishment of European leadership in the aviation sector, while leveraging the European position in the harmonization of standardization and certification processes globally. However, in a fast changing world, the aeronautics industry is not protected from the XXI century challenges and threats. The community is perfectly aware and the first steps to have a wider approach have already been taken.

3. The European – Latin American Cooperative Experience

Although the European Union recognizes research excellence and industrial capacities in Latin America, there are still relevant gaps in the aeronautics research cooperation, even, at communication level. Following international cooperation projects infields like health and food, the CoopAIR (from 2009 to 2010) has promoted the cooperation in the field of Aeronautics through collaborative research and development initiatives under the European Framework Program. The project was a major step to integrate the current scientific research, technological innovation and execution activities within the aeronautic research field, establishing a footprint to build a multinational and multi-stakeholder community involving relevant R&D European and Latin American actors (researchers, policy makers, users).

Oriented to Brazil, Argentina, Mexico and Chile, the impact of CoopAir can be measurable by the increased participation of Latin American countries in FP7 calls, related to aeronautics technologies, and by identifying technologies and stakeholders in areas for future cooperation that could be used as an input to design future R&D Programs. Indeed, CoopAir can potentially have a longer term impact through the execution HORIZON 2020, that will run from 2014 to 2020 with an €80 billion budget, to foster new growth and jobs in Europe.

The Future

Transport is a high-technology industry, making research and innovation crucial to its further development. Research and innovation have been a key element to maintain European capacities and competitiveness and it is now time to align efforts towards a new-long term vision for the aeronautical sector. Being fully aligned with this effort, this paper intends to provide a clear reinforcement of international cooperation in the promotion of competitiveness for the European and Latin American industry and academia. In a global market, fostering innovation on aeronautical systems and promoting a sustainable cooperation, while establish efficient link between cross-Atlantic industries and universities, shall catalyse the placement of added value innovative products to the market.

As presented, from their professional experience, the author's objective is to promote fruitful International Cooperation that can create value by proving a global connectivity for

European and Latin American organizations. The establishment of strong and productive partnerships with Trans-Atlantic suppliers can be true catalytic, not only to maintain the European leadership in aeronautic systems development, but also an excellent economic leverage for European exports, beyond the European air framers. On another perspective this can be reflected in relevant assets to both sides of the Atlantic, and a unique example to other regions as well as to other industrial sectors, namely :

- To build up the possibility for European-Latin American countries to jointly perform technological research initiatives while opening the door for future bilateral business activities at the industrial and scientific level.

- To provide the industrial and academicals sectors with new resources to face the challenges of the aeronautics arena in a more competitive way, in Europe and Latin American (namely in Brazil where the sector is fully structured with a supply chain successfully established).

- To promote the exchange of knowledge and information among the different members of the supply chain, at the different levels of the technology readiness, and to facilitate the dissemination and exploitation of the project results.

Intellectual Proprietary Rights discussion

The early days of the XXI century promoted new challenges in all industrial sectors. These challenges have raised the level of competiveness, promoting a stronger need for innovation, supporting, at certain extend, the growth of modern countries. Worldwide, a common way to promote the development of new technologies is performed by applying investment of public and private resources on research and technology institutions and academic centers.

In Brazil and Latin America countries, the model of consortium formation in order to align interests and resources available in the states and industry, with the developments made by the research centers and universities, came to be used more intensively in the late 90s.

At first, in this process, several non-profits entities have emerged with the aim of organizing consortium and manage the activities of technological cooperation. Those entities facilitated mechanisms of inflow of financial resources made available by the government and industry on research centers and universities, and also, they have contributed to the introduction of modern project management techniques.

In the beginning, many of the agreements between industry, government, universities and research centers had mainly focused on obtaining the success of projects in terms of cost, time and quality of products. However, with the maturing of the processes of the institutions involved, the universities and research centers began to demand better conditions of Intellectual Property Rights (IPR) on the products of the projects, when establishing cooperation agreements.

A typical and surprising example of this situation occurred, for example, between an aeronautical industry and a government research center in Brazil. The project was aimed at exploring possibilities of application of control techniques for special situations of failures of aircraft systems, with time limit of two years of development. Despite having the project plan approved and resources were available for its execution, discussions about IPR between the industry and the research center dragged on for a period exceeding two years, making it impractical to carry out the project. In the dispute between the parties, the research center demanded rights on percentage of profits from sales of aircraft that could use the technology developed in that project.

Situations like that become common, making it difficult to carry out technology cooperation agreements between academia, industries and government. The discussions about IPR have included fair reasons and viewpoints consistent with the participation and involvement of each participant in the project. The agreements came to be analyzed case by case and solutions were defined for each project proposal in particular.

As previously referred, the authors discuss now the critical issue of sharing of intellectual property rights in consortia for technology development projects, addressing six particular elements as presented hereafter. It is proposed the use of the concept of technological maturity as a potential facilitating factor to foster cooperation agreements. It is also addressed future challenges posed by the requirements of innovation and competitiveness of products.

1) Problem definition: the current discussion aims to highlight elements or aspects that can impact and facilitate the evaluation of shared IPR on technology development projects.

The idea is to use the concept of level of technological maturity as a basis of understanding, upon which important aspects of the IPR can be analyzed, allowing that a consensus agreement is more easily obtained among the consortium members. Thus, it is presented below the concept of a level of technological maturity and, after, some important aspects related to IPR are discussed.

2) Turning ideas into products: the diagram below shows a schematic view of a process of transforming an idea into a product. The diagram suggests that the transformation of ideas into products can be obtained by performing one or more projects of technological development.

Despite being quite simple, the diagram allows the introduction of basic concepts, such as ideas, projects, technological maturity and products, as well as suggesting a possible relationship between these elements.

Figure 1: Technological Development Project

2.1) A project can be defined as a temporary endeavor undertaken to create a product, service or an unique result. Technological development projects aim to develop a technology that can turn into a product, or be incorporated into a product.

The development of a technology, somehow, means developing real artifacts with desired characteristics or processes with required behavior, starting from ideas created and imagined on a conceptual level.

The development of a technology typically is achieved through the gradual accumulation of knowledge about the production of artifacts and control of desired processes, giving rise to the term technological maturity.

2.2) Technology Readiness Level (TRL) is a concept proposed by John C. Mankins [7] of NASA. This concept proposes a systematic classification to describe the maturity of new technologies, as presented in the following image. Please refer to the end of the article for detailed description of each TRL Level.

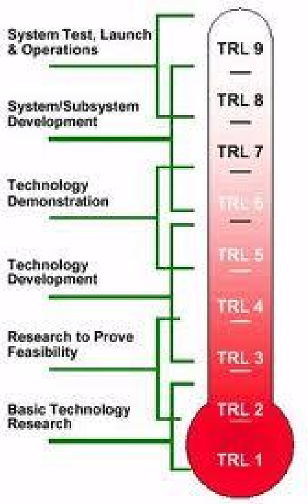

Figure 2: TRL Scale, [7]

In summary, this concept defines a range of a technology maturity, indicating, on one hand, the level of development and domain on it and, on the other hand, the availability and the possibility for the technology to be implemented on a product.

Thus, the lower extreme of the TRL scale indicates the idea or concept which led to a technology, while the upper scale extreme points to a product where the technology is implemented.

Typically, the maturity of a technology advances from a low readiness level to another higher level through the implementation of a technological development project. In these projects, efforts are combined to allow the technology to be improved and controlled to a desired TRL. The successful evolution of technology can be measured by time, cost and quality resulting from the project. In general, a succession of projects is carried out in order to elevate a low TRL technology to a level sufficient for incorporation into a product. Nevertheless, the actors involved in the process are, quite often, diverse from Level to Level.

2.3) From the point of view of marketing, Kotler and Armstrong [6] define product as “anything” that can be offered to a market for attention, acquisition, use or consumption and that might satisfy a desire or need.

Technologies are incorporated into modern products as a way to increase their intrinsic value. Some products are designed and developed based on a single technology. Others incorporate various technologies, each technology aggregates a portion of the final product value. The value of a technology in a product is an important factor in the discussion of IPR and its determination is not a simple task.

However, some parameters such as, development cost, production cost or market value of the product may assist in estimating the value of a technology. Production costs and market value are not discussed in this article.

3) - Uncertainties and projects products: the evolution of an idea for a technology and its possible implementation in a product may represent a long way. This path can be analyzed from different perspectives and each perspective may reveal important aspects of discussion regarding intellectual property. The following perspectives will be discussed herein: the uncertainties of the way, the required investments and the risks and opportunities to achieve a final product.

The first aspect refers to the uncertainties of the paths. Typically, different routes or paths may lead to a final product, or several final products. Even in the case of a single viable route, derivations of this route can lead to the appearance of different by-products and multiple business opportunities.

A key enabler element to obtain an agreement of IPR is to get a common understanding of the relationship between the uncertainties involved in the development of technology and the level of maturity of the technology.

The suggestion is to admit a simple relationship: the lower the TRL classification of a certain technology, the greater are the uncertainties of this technology to reach enough maturity to be incorporated into a product. Thus higher risk levels for researchers and, when applicable, investors.

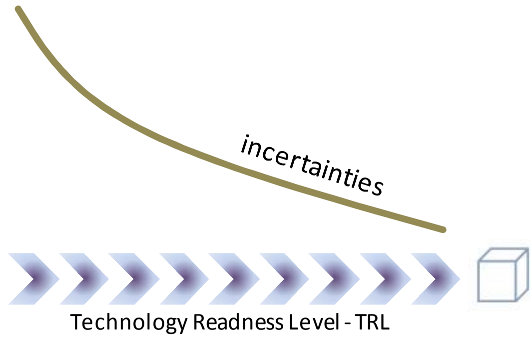

Figure 3: Uncertainties versus TRL

The uncertainties associated with the maturity of a technology are related to technical, financial, temporal and others types of difficulties that must be overcome to advance in the TRL scale. These difficulties are often called "technological barriers". Technological barriers arise unexpectedly, are amazing and occur in unexpected places and times of a technological development project. Typically, they generate significant delay in time and strong impact on the budgets planned.

Different routes or paths taken at the beginning of a project, can lead to different technological barriers, with huge losses to the success of a project.

The higher the maturity of a technology, or higher rating in the TRL range, the lower are the uncertainties to transform the technology in a product.

Note: the difficulty related to the scalability of some processes is not exactly a technological barrier, since often this problem is known a priori, not occurring the surprise element in such cases.

4) Investments required: main investments required for a technological project are financial, human resources and the infrastructure to support its activities.

From the author's perspective, there is not a typical relationship between the amount of resources needed and the maturity scale TRL. Apparently, each development technology project has its own characteristics.

However, some observations that affect the IPR should be highlighted.

The sum and the total investment required to mature a technology grows proportionally with the difference between the final TRL (product) and the initial TRL.

Proofs of concept and demonstration of basic physics concepts related to technologies of low maturity are often carried out in facilities and generic laboratories. In these situations, research centers and universities often contribute strongly with highly skilled human resources, physical facilities, laboratories, etc. It is admitted, in such cases, that most of the funds are originated originate from public resources.

On the other hand, the technology validation in actual application environments is required for higher mature technologies, and, in general, it requires demonstration means specifics for each technology. Typically, these facilities are built by private entities that protect its methods, tools and results through patents. Often, large specific investments are made by private and individual entities. Some of them idem for the general public, throughout its development phase.

As already presented, generally, industry and private entities are reluctant to invest in low maturity technologies that present large uncertainties associated to its development. The rationale for this behavior is, not only, related to the possibility of failure in the development of the technology, but also includes lack of specialized personnel, the time that may require for an idea to "come true", investment losses, damage to the product, i.e. the so-called technological risk, as discussed below.

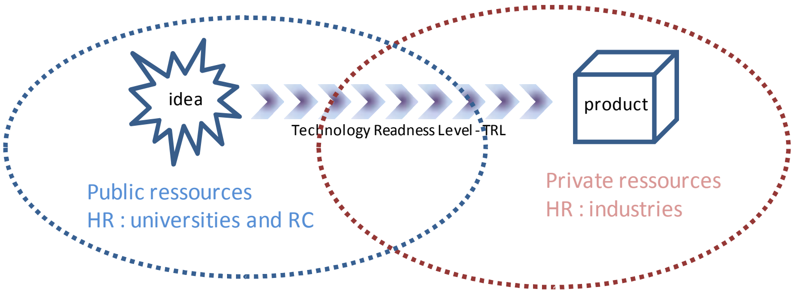

Figure 4: Public versus Private ressources

The same way as the implementation of a new technology can add value to a product, the development of a technology may also cause damages to a project and a product (and in a larger scale to even a company or research centre, as the experience as shown). This question is treated as technological risk.

5) The technological risk is defined here in terms of the probability of failure in the development of a technology and the losses or damage caused by the project failure.

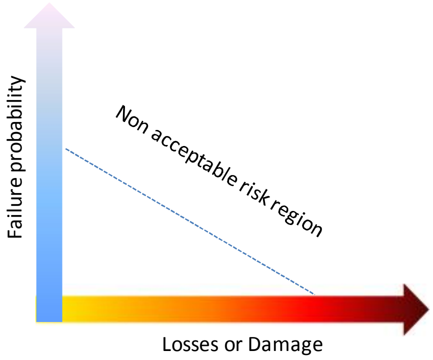

Figure 5: Technological Risk

Losses or damage considered here can appear in two ways: at the technological development project or on the product where technology should be implemented.

The failure in the technological development project can be considered under three perspectives: a rising of the development costs, delays in the development process or a reduction of the desired quality for the technology.

The quality of a technology may be assessed by the desirable characteristics that the technology must present and also by the unwanted side effects associated with it.

Several factors can affect the failure or success of a technological development project, such as project management, technological barriers, stakeholders and other factors.

Damage or loss caused to the product may occur in several ways. For products already on the market, losses may appear as a reduction of the competitiveness of the product. In the case of a product in development that depends on a particular technological solution, the failure in the development of this technology can generate cumulative losses as delay in product launch (delayed time-to-market), reduction in return on investment (ROI), market reduction (regarding market share, but not limited to it), increasing until the complete infeasibility of the product (meaning cancellation).

Common sense suggests that there should be an inverse relationship between the probability of failure of development of a technology and the damage caused to the product, see diagram. The region of acceptable technological risk is located below the line of 50% probability of failure and some acceptable loss in the return on investment.

The traditional way to mitigate the technology risk and reduce the potential for damage, especially financial, is to perform the maturation of the technology in stages, i.e., in the form of a sequence of two, three or more projects of technological development with smaller and further well controlled investments.

This procedure, in a certain way, favors that the majority of public funds investments to be available for projects of low maturity, while a higher concentration of private resources be placed in projects of high maturity, where the uniqueness of the results grows, and time to market, is greatly importance. In projects, with a high TRL level, discussions for a settlement of IPR become quite clear and objective in relation to the possible value added by a technology.

6) Conclusion on Intellectual Proprietary Rights: from the authors perspective, it is recommended that IPR agreements on projects of low TRL should seek to ensure the preservation and the shielding of the knowledge developed within the project consortium partners. This conclusion is based on the uncertainties, risks and technological resources required to develop the technology up to its implementation in a product.

At the other extreme, IPR agreements on projects of high TRL, in general, must take into account prior knowledge or experience brought to the project, typically referred as background knowledge, as well as the effective added value contribution of each project partner.

Innovation challenges

This final section raises some challenges and issues relating innovation for future analysis and further discussion within the community.

According to the Oslo Manual [8], the Organization for Economic Cooperation and Development (OECD), innovation is all newness deployed by the productive sector, through research or investment that increases the efficiency of the production process or which implies a new or improved product.

It is noted that by definition, innovation is characterized by the gain of competitiveness of products, made by the productive sector, through the use of high technology TRL.

On the other hand, the use of public resources in the development of technologies for high TRL is classified as government subsidy to industry. However, it is unclear to which TRL, the support of public resources is acceptable. This is the cause for frequently disputes between nations at the Word Trade Organization (WTO), namely in the Aeronautical sector between Boeing and Airbus. One new chapter of this dispute can be seen in [9].

Just as it is acceptable the industry having little participation in the development of low-TRL technologies, due to the risks involved, it is not morally acceptable for governments to support high-TRL technologies. As a matter of fact, more often the industry is willing to take the benefits, but not always the underlined risks.

Despite that, with a global completion taking place and the pressure to promote the deployment of added value jobs, most governments have promoted innovation programs aimed at increasing the productivity of their industries, where are used technologies of high TRL, very nearby to products.

In Europe, the 7º Framework Program of the European Commission greatly promoted cooperation between Europe and Latin America (as well as with other regions of the globe). However, the new HORIZON 2020 program includes a strong bias in their innovation objectives. Thus, some questions and obvious consequences are expected from this change of attitude of the European Commission. How will Europe's relationship with Latin America from now on? Perhaps the simplest is to consider that cooperation projects in Tier 1 should continue, even if there is substantial reduction in resources available for those activities in Europe.

Ultimately, concluding the abstract proposal, the cooperation encourages knowledge sharing, while innovation produces competitiveness acting as a disaggregating factor between nations.

References

[1] European Union, Innovation Union, http://ec.europa.eu/research/innovation-union/index_en.cfm

[2]CoopAIR - Cooperation between EU and LAin Aeronautics and Air Transport Research, http://www.transport-research.info/web/projects/project_details.cfm?ID=37914

[3] Advisory Council for Aeronautics Research in Europe (ACARE), Aeronautics and Air Transport: Beyond Vision 2020 (Towards 2050), June 2010

[4] DIANA Project, Distributed equipment Independent environment for advanced avioNic Applications, http://cordis.europa.eu/search/index.cfm?fuseaction=proj.document&PJ_RCN=9595624

[5] Karyon Project, Kernel-based Architecture for Safety-Critical Control, http://cordis.europa.eu/fp7/ict/embedded-systems-engineering/factsheets/karyon.pdf

[6] Kotler P., Gary A.; "Principles of Marketing", Prentice Hall, 2005 – ISBN 0131469185

[7] Mankins, J.C.; "Technology Readiness Levels: A White Paper". NASA, Office of Space Access and Technology, Advanced Concepts Office. (6 April 1995).

[8] Organization for Economic Cooperation and Development (OECD); "Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data, 3rd Edition", 2005, ISBN 978-92-64-01308-3

[9] Press Center of Airbus; http://www.airbus.com/presscentre/pressreleases/press-release-detail/detail/next-chapter-in-eight-year-old-wto-conflict-boeings-wto-default-prompts-12-bn-in-annual-sancti/

Technology Readiness Levels Summary

TRL 1 - Basic principles observed and reported
Basic scientific research that can be turned into an application or a concept when a research and development program is considered.

TRL 2 - Technology concept or application formulated
An idea is proposed for the practical application of current research, but there are no experimental proofs or studies to support the idea.

TRL 3 - Concept or application proven through analysis and experimentation
Active research and development begins, including analytical laboratory-based studies to validate the initial idea, providing an initial "proof of concept."

TRL 4 - Basic prototype validated in laboratory environment
Basic examples of the proposed technology are built and put together for testing to offer an initial vote of confidence for continued development.

TRL 5 - Basic prototype validated in relevant environment
More realistic versions of the proposed technology are tested in real-world or near real-world conditions, which includes initial integration at some level with other operational systems.

TRL 6 - System or subsystem model or prototype demonstrated in relevant environment
A near final version of the technology in which additional design changes are likely is tested in real-life conditions.

TRL 7 - System prototype demonstrated in a relevant environment
The final prototype of the technology that is as close to the operational version as possible at this stage is tested in real-life conditions

TRL 8 - Actual system completed and qualified for flight through test and demonstration
The technology is thoroughly tested and no further major development of the technology is required. Its operation as intended is demonstrated without significant design problems.

TRL 9 - Actual system through successful operations
The final operational version of the technology is thoroughly demonstrated through normal operations, with only minor problems needing to be fixed. Any further improvements to the technology at this point, whether planned or not, will be treated as a TRL 1.