# Our view of the Swedish innovation system

A framework for the national research and innovation agenda for aerospace — and for Swedish innovation as a whole

SUPPORTING DOCUMENT TO NRIA FLYG 2013

## DEFINITIONS

**Innovation** Taking forward new ideas that result in a product or service being brought to market.

**Innovation system** A system of functions that together ensure that innovation can be realised in accordance with the above.

**Research** Scientific study, an active, systematic and methodical process that is conducted by researchers to gain new skills and increase knowledge.

**Technology area** An area within business, industry or a profession where the development of joint technology is a key activity.

**Technology path** Specific technology developed within a technology area.

**Aerospace technology** Technology area for the development and manufacture of aircraft and their associated subsystems as well as of systems and methods for air traffic management.

**Market** The collective global demand for aerospace products and services, which Swedish research and innovation should be directed towards meeting.

## EDITORIAL INFORMATION

***Text:*** *Our view of the Swedish innovation system is a supporting document to NRIA Flyg 2013, the agenda for Swedish aerospace research and innovation for the period up to 2050. The objective is to clarify the function of the Swedish innovation system and its importance for the innovation power of the technology areas, and also to increase understanding of how the system can be used and developed for best results. The document has been compiled by the same stakeholders as the NRIA Flyg 2013, which all jointly own all rights to this document. The content may be quoted provided the source is clearly stated.*

***Photo/rendering: Cover*** *© iStockphoto.com/RichVintage* ***2–3*** *© iStockphoto.com/pixhook* ***4–5*** *© iStockphoto.com/tumpikuja* ***6*** *© iStockphoto.com/Photomorphic* ***8*** *© iStockphoto.com/deliormanli* ***10*** *© iStockphoto.com/nickp37* ***11*** *© iStockphoto.com/Photomorphic*

***Editorial, design, layout, illustration:*** *Gunnar Linn, LinnSideOut* ***www.linnsideout.se***

***Printing:*** *Åtta.45 Tryckeri AB, Solna, Sweden, 2013*

***Contact: info@nriaflyg.se***



# Our view of the Swedish innovation system

» Efficient innovation requires an understanding of how things fit together.

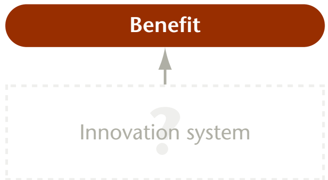
### A broader view

How do things really look with regard to aerospace in Sweden? What mechanisms and phenomena are important for research and innovation, in addition to the things we're discussing at NRIA Flyg 2013?

Let us look at it from the basis of accepted terms.

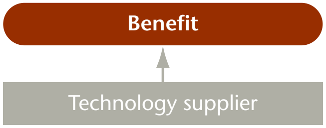
### Production structure

There is some form of *innovation system* which delivers the benefits we need. But what is this innovation system exactly? Let us try to describe it.




*To put it simply, an innovation system can be seen as a phenomenon that delivers some kind of benefit.*

Let us imagine that we have some kind of supplier for the benefit we desire. Since we're talking of technological innovation, let us delimit ourselves to talking about a techno-



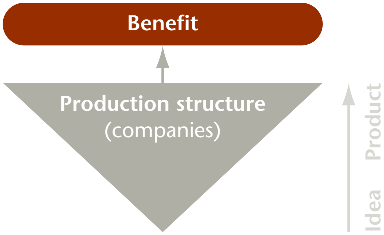

*When we look more closely at the benefit supply (within technological innovation) we realise that it must ultimately be undertaken by some kind of technology supplier.*

logy supplier of some kind.

This supplier is one that offers ready-to-use technical solutions, often in the form of products with an ever growing service content in order to satisfy an application area where a benefit is supplied to a market. We can call this a production structure. This structure includes companies of various sizes, from micro-enterprises through small and medium-size enterprises (SMEs) to giants.

In the aerospace sector, the production structure is dominated by the two major companies, Saab, and GKN Aerospace, as well as a number of smaller companies of which some are spin-offs from the two large companies. There are also several smaller companies which are already, or are about to become, suppliers to larger companies. Then there is the Swedish Civil Aviation Administration which operates air traffic services for both civil and military clients.

Within the production structure, it is possible — to varying degrees — to manage technological development from an idea to a finished product, with a natural primary focus close to the area of use: it is only when the developed technology reaches the market that it becomes a product.

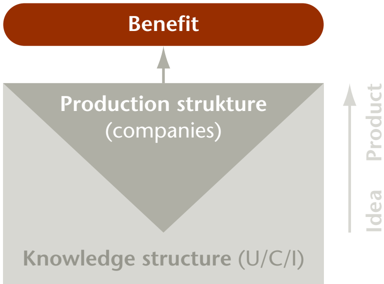



*The production structure consists of companies. Naturally, these are good at developing products, and the primary focus of the structure is at the product-end of the innovation spectrum.*

In the earliest stage of the process, the idea can be equated with thinking in a new way, which by definition (see page 2) turns the image into a rudimentary description of innovation. However, this image needs to be supplemented to become a functional description.

**Knowledge structure**

The companies in the production structure cannot meet the need for benefits by themselves. They are best for product development, but at the same time the development of knowledge and skills is also required — this is where research is needed. Even if the production structure is engaged in a certain amount of its own research, surrounding organisations are needed which develop and supply the knowledge which companies are unable or unwilling to develop — a *knowledge structure*.




*The production structure is complemented by a knowledge structure whose primary focus is closer to the idea.*

This knowledge structure has its primary focus closer to the idea, and

is indeed present before the idea is even a reality. Within this structure we find universities and colleges (U/C) and institutes (I) which operate at the borders of the research of universities and colleges, and the developments of the business world by further developing knowledge and skills. Institutes play a special role in strengthening the innovation capabilities, competitiveness, and regeneration of the business world.

The knowledge structure primarily consists of Chalmers, KTH, LiTH, LTU, LTH, HV, HiS, and BTH as the relevant universities and colleges. Among the institutes, it is primarily FOI, SWEREA, SP, and Acreo which are relevant to aerospace.

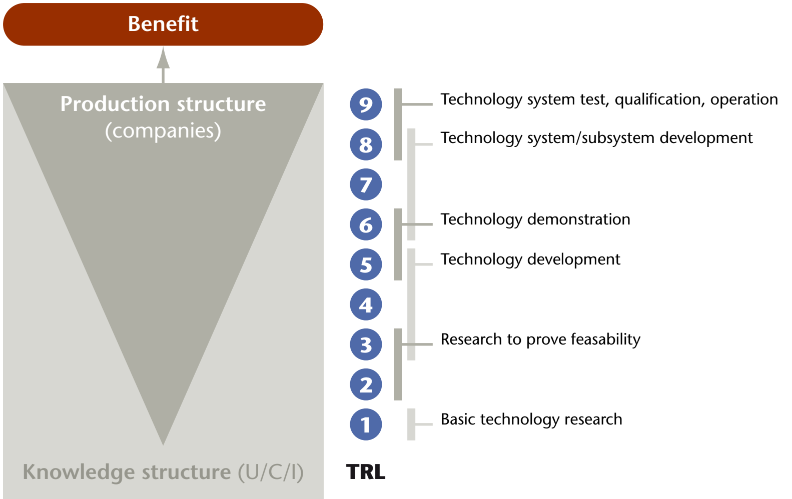
How far the innovation has come on its journey towards maturity from an idea to a product can be shown through the ”technology readiness concept”. The concept can contribute to a major understanding for how the research and development of different organisations contribute to the entirety of the innovation system.

Technology maturity can be specified in various ways — one of the more recognised is the TRL scale in which TRL stands for *technology readiness level*.

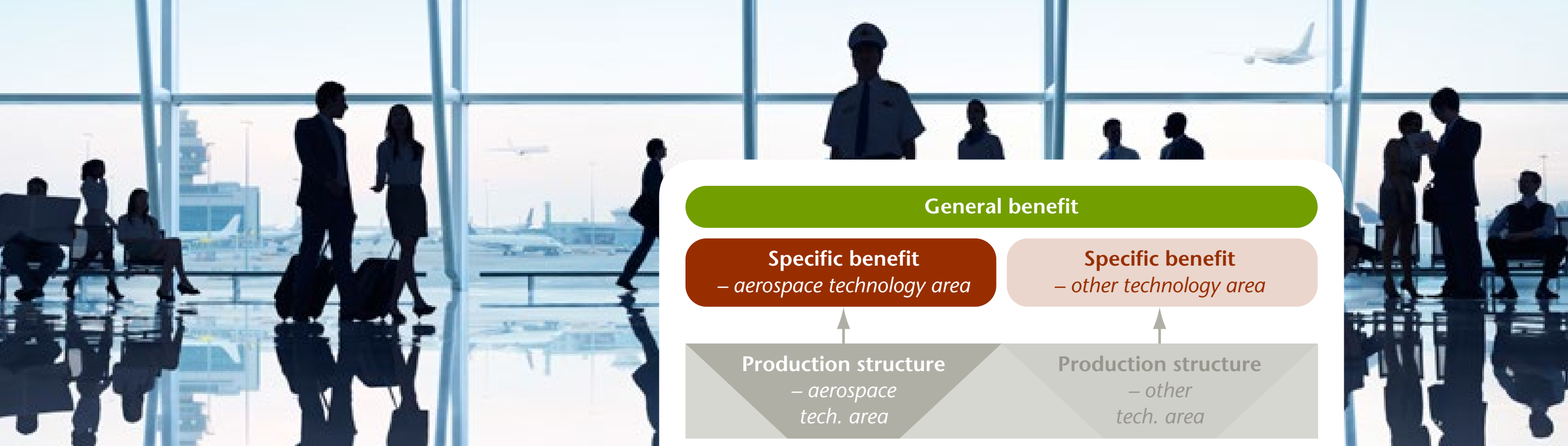
The knowledge structure which embraces the aerospace production structure in this regard is not specific

### INSTITUTES

Industrial research institutes are located both in the production structure as well as slightly within the knowledge structure to form a natural link between universities/colleges and companies. The institutes typically develop scientific knowledge from academia into technologies at a level whereby companies can assess whether the conditions exist for future industrialisation. In this way, institutions are able to rapidly contribute to transforming research-based knowledge into solutions and business models.




*The TRL scale uses nine stages to indicate how far a certain technology has come on its journey from an idea to a tried and tested product in the market.*




*The specific benefits of the aerospace sector help to realise the general benefits fed by a number of different technological areas.*

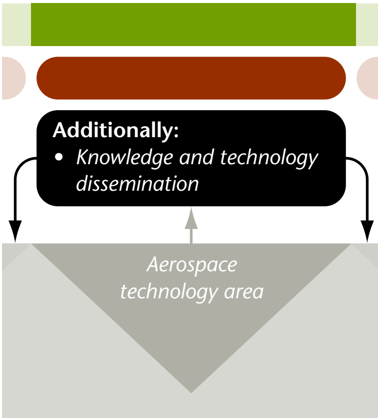

*In the case of aerospace, we see the specific benefits as being green, safe, and efficient transport in addition to support for military capability and public security. In turn, these contribute to the general benefits which Sweden seeks to realise: public services with improved quality and efficiency, a competitive environment and employment, and the ability to address global societal challenges.*

to the field of aerospace technology, even if in Sweden there are specific organisations within it which are highly relevant to aerospace. The knowledge structure is shared by many different technological fields. At low TRL levels, knowledge is generic and many companies are able to cooperate. At high TRL levels, knowledge is product and process specific, which makes it more difficult for companies to cooperate.

The fact that we include different technological areas into the reasoning also enables us to discuss different levels of benefit. Each area of technology/innovation can be expected to deliver its “own” *specific* benefits linked to an application area.

These specific benefits then function as a stepping stone to realising overall social benefits — we shall call them *general* benefits, which is what innovation in Sweden is ultimately aiming for.

The dissemination of knowledge and technology can also be seen as a specific benefit of the aerospace sector since its high standards and subsequently challenging technological solutions involve the generation of a lot of knowledge early on in the field of aerospace.

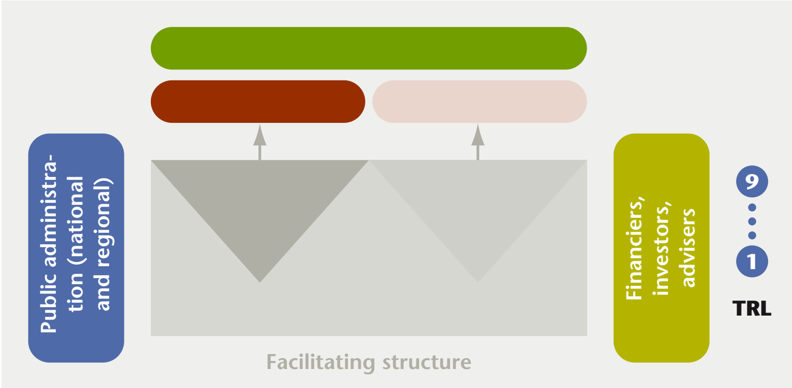



*The aerospace sector generates knowledge and technology at a level which is often higher than other fields of technology. Subsequently the conditions exist for this knowledge and technology to be disseminated and utilised outside of the field of aerospace technology.*

**Facilitating structure**

This combination of production and knowledge structure does not function without a further structure to supply the framework within which the transformation of knowledge to benefit can take place. We are talking about the *facilitating* structure.

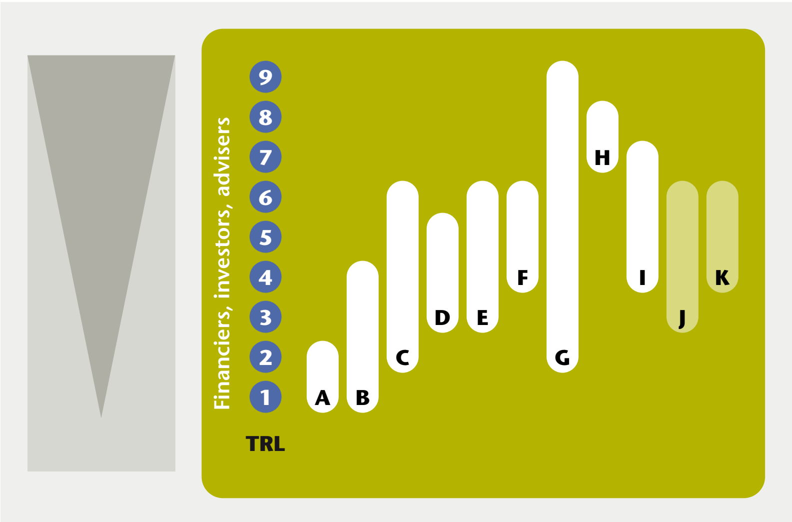
The facilitating structure consists of the financial system and public bodies (authorities and regions) which have the role of creating the conditions and guidelines for how the innovation system is to operate. An important aspect concerns the funding of research, development, and investment in which financial institutions as well as investors and advisers contribute, but also public administration which set societal targets and co-fund research and development areas. The public sector also plays an important role in creating collaboration areas — especially technology parks — in which knowledge, technologies, and financing can work together.




*There must be a facilitating structure around the production and knowledge structure which provides the conditions for different stakeholders being able to carry out their activities in a targeted and efficient manner.*

Public co-funding is important for the field of aerospace since challenging demands entail considerable technological risks, and the surrounding global conditions s often lead to different national conditions. The requirements and monitoring of the civil aviation system is carried out by the Swedish Transport Agency with collaboration with the equivalent international authorities. The Swedish Armed Forces set the requirements for and have responsibility over military aviation.

As part of the efforts to increase value creation based in research-based knowledge and other knowledge-intensive business ideas, access to seed capital and other venture capital in the early phase is an important aspect. Almi, in collaboration with Sweden's Innovation Agency, The Swedish Agency for Economic and Regional Growth, The Swedish Energy Agency, regional bodies (such as




*With regard to funding there are currently several public bodies — from initial research to market — including **A** Vetenskapsrådet; **B** Stiftelsen för strategisk forskning; **C** VINNOVA; **D** KK-stiftelsen; **E** Energimyndigheten; **F** EU (via frame programmes); **G** Försvarsmakten/FMV; **H** Riksgälden (conditional loans); **I** banks. Additionally, **J** the regions – Västra Götaland, East Sweden (Östergötland), Trollhättan and Linköping – provide financial support in conjunction with **K** Tillväxtverket.*

Innovationskontor Väst), institutes, universities, and colleges in addition to their innovation-supporting functions form the basis for achieving this. Industrifonden and Fourier transform (TRL 4-6) are also important for SMEs.

With all of these structures in place, we start to get a picture of what we call an innovation system — a system which ensures that *thinking in a new way results in a product or service on the market.* The national innovation system works together with the global system to generate an international foothold and exports.

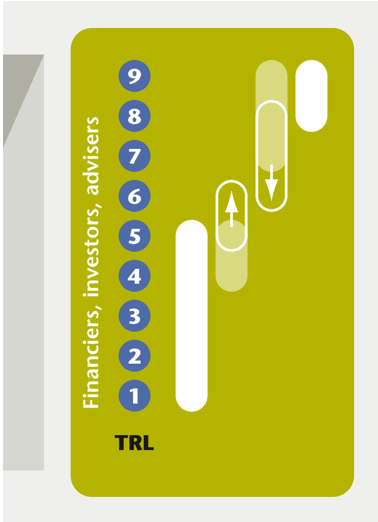
The approach of TRL provides the opportunity to analyse the function and critical elements of the innovation system. Let's take a closer look at a couple of these.

## The importance of an unbroken TRL chain

If ideas are to be realised in the form of products, the journey through the innovation system has to be unbroken. All TRL stages have to work with smooth cooperation between the various organisations for every TRL.

This doesn't just mean that a given TRL may not be lacking pure research practitioners, that is to say within the knowledge and production structures, rather it is equally important that there are no gaps in the facilitating structure and all its functions.

We will illustrate this with a typical example: difficulties with funding for certain TRLs. The variety of funding available for the field of technology must be such that no stage of readiness is left uncovered. Overlaps are, of course, only a good thing, but if there are gaps then it is desirable for duplicate financiers to transfer their



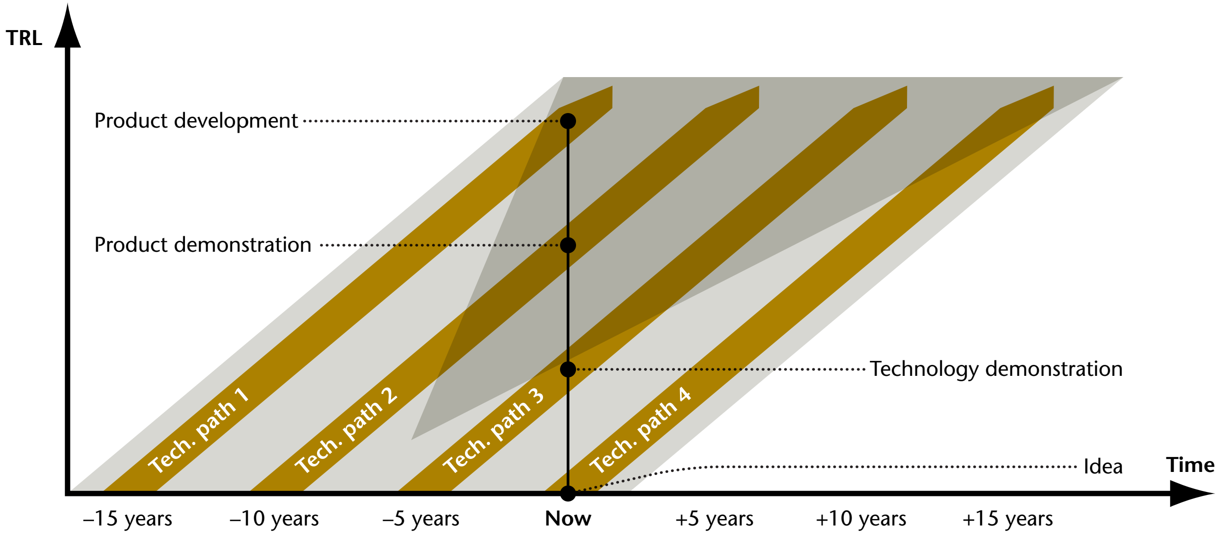

*For ideas to become a reality in accordance with the mechanisms for innovation, the readiness chain must be unbroken in that organisations and the right conditions for these activities must exist at every TRL stage (exemplified here by financiers). If the chain is broken at some point, this must be addressed.*

working area within the TRL stages to levels that are more in need.

## Skewed-wave principle

We get an interesting picture when taking into account the passage of time while climbing the steps of the TRL, something which we call the *skewed-wave principle*. It describes how a specific innovation — and its technology — are developed in a technology path and mature over time from idea to market.

The principle means that vision and the innovation process can be illustrated in a communicative man-




*If we describe the visions of an area of technology in, for example, five-year intervals with four successive technology paths — four skewed waves — we get a 20-year roadmap. It becomes clear that several parallel things are taking place at the same point in time:*

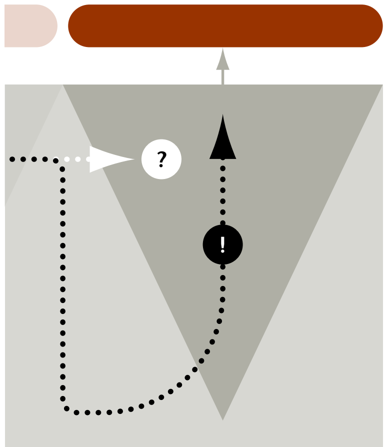
- *products are being developed with technology that started with an innovation idea 15 years ago (technology path 1);*
- *technology is demonstrated as a product which started its development 10 years ago (technology path 2);*
- *technology is demonstrated which started as an idea 5 years ago (technology path 3);*
- *a new innovation idea is hatched, starting a new skewed wave (technology path 4).*

ner. The link between different TRLs and the different technology paths becomes visible over time, which is a condition for us to be able to invest in the right research at a low TRL and in good time to be able to release products on the market when they are needed. It is clear to see that in a single sweep one has to think operationally (now), tactically (in the short-term), and strategically (in the long-term) for the innovation system to function optimally.

**Looking at ideas from the outside**

Thus far we have assumed that the idea which forms the starting point of innovation is born somewhere in the beginning of an area of technology. This has been supported by the accepted pairing of the term ”innovation” with *thinking in a new way*, but this is not the whole truth. The idea does not need to be entirely new. It is sufficient that it is *new for the area of technology in question* in order for innovation to be generated.

Let us envisage an idea which comes from a certain TRL in an area of technology other than its own. The idea will be unable to take its place in the new area of technology at the same TRL. Put simply, it is specialised in the wrong thing. In order for it to be used, the idea must be brought down to the TRL in which the idea’s generality is so large that it can be utilised in the new context. The idea



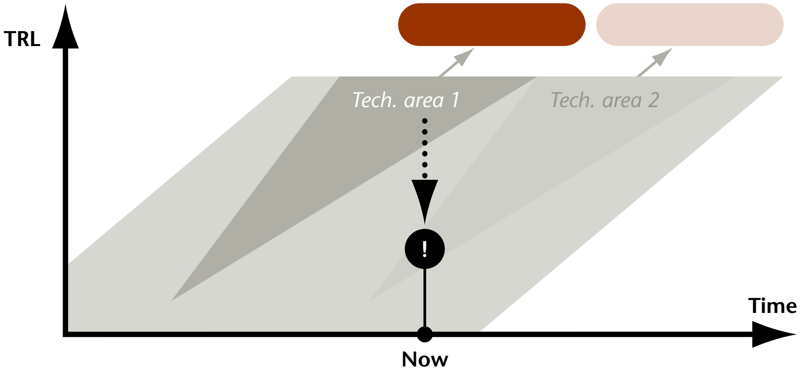

*A technology may seldom or never be moved from one area of technology to another while simultaneously retaining its TRL. A tie-back has to be made at lower levels in order to adapt the technology to the new area.*

can then be developed in the new area of technology and thus finally lead to a complete innovation.

There is also a desire for the ideas to be innovative to the extent that they almost revolutionise the creation of new products for other areas. This desire stems partly from the need for major changes; travel in the aviation sector is increasing quicker than the pace at which technology can make aviation more efficient and improve its environmental performance. This results in an increased environmental impact in absolute terms — if new ideas do not contribute to radically changing technologies, concepts, and products.

The desire stems also from companies' ambitions to be world leaders with a technological advantage that provides a greater value added and a better cost/benefit balance than what their competitors can offer — an ambition which is shared by society at large in the name of innovation. Ideas that migrate between areas of technology at an advanced level of readiness seldom offer significant technological advantages over competitors and thus often provide low margins and smaller product development stages. Consequently, it is at lower levels of readiness that revolutionary ideas migrate, but then arrive at the new area of technology with a higher risk and hence increased difficulties with regard to funding and implementation of the new technology.

Conditions are needed which allow the ideas to migrate both horizontally and vertically towards specific application areas and benefits. In order for this to work, there must be a general understanding among all parties involved, in all inherent structures, with regard to how far advanced the research concerning the idea is. Apart from the pure identification function, to see at which level the technology locates itself, a communication function is needed for the inherent parties to be able to reach consensus. Over and above this, together the parties need to be able to analyse the situation and the road ahead. The TRL tool allows these collective requirements to be fulfilled.



*At a certain point in time, technology and knowledge may flow from a high TRL within an area to a low TRL within another area.*

A high TRL consciousness creates the necessary conditions for the dissemination of technology; the tool provides an understanding of how the research outcomes can be transferred between different areas of technology provided that the level at which the outcomes can be utilised in the new area is taken into account. The term also shows that ideas can be generated at several TRLs, especially when knowledge is transferred between different areas of technology.

If we now apply the skewed-wave principle to this as well — that is, the fact that climbing up the TRL ladder takes time — we see that, at any given time, research is being conducted at different TRLs within different areas of technology.

Here we can see another strategic aspect, namely the opportunity to take advantage of the dissemination of technology between areas of technology in order to get competitive products to market exactly when they are needed.

The area of aerospace technology is technology-intensive and develops products for an extremely demanding market. This means that aerospace often disseminates technology to other areas of technology. In some cases, aerospace may lag behind other areas of technology, such as in terms of production technology, due to the extremely long lead times in aerospace. The skewed-wave principle applies in both cases, however.

**Consensus for innovation — everyone is needed**

This description of the Swedish innovation system has been developed to streamline consensus among stakeholders within different structures and areas of technology.

In order to meet the needs of society over time, everyone in the innovation system will be needed. From politicians, funders of research, government agencies, large and small companies, universities, colleges, institutes, regions, corporate financiers, advisers and many more. It is vital that all participants **understand their role and operations in the innovation system,** and how **cooperation should take place in the innovation process** so that ideas can be brought to market and create innovation. The national innovation system must then work together with the global system to generate an international foothold and export income for Sweden.

The TRL tool provides a good starting point. Through increased understanding at universities, colleges, and institutes regarding the reality of high TRLs, governance of their own research and innovation is created. Conversely, better understanding of lower TRLs generates knowledge within the industry regarding which areas are approaching industrialisation and what sort of advantages these may have compared to old technology.

Using the TRL tool, we create the conditions for collaboration with other areas of technology and their research and innovation agendas. Together, we can create new arenas with the potential for creating value growth for a number of areas of technology which increases the return on investments in research and innovation.

In the long-term, it should also be possible to communicate the innovation system we have described with external parties. This may apply to financiers of research just as much as the public administration which make decisions regarding the focus of the research financiers, but also to the general public which both contributes to the innovation system through taxes, and is the end-user of many services and solutions developed by it.

info@nriaflyg.se