The European Commission's science and knowledge service

Joint Research Centre

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Technology readiness levels. Technology transfer basics

JRC training workshop

Strengthening University-Industry-Government cooperation

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European Commission

Outline

1. Technology development
2. Technology readiness levels
3. Key steps in technology commercialization (technology transfer)

Technology development

LASER TECHNOLOGY

1917 Einstein predicts "Stimulated Emission" laser technology foundation

1950 Quantum theory of stimulated emission (Nobel Prize in Physics)

1959 Columbia Uni. student Gordon Gould proposes stimulated emission to amplify light - LASER ("Light Amplification by Stimulated Emission of Radiation")

1960 First working prototype of a laser at Hughes Research Laboratories in Malibu, California (ruby laser for military)

1963 CO_2 laser developed at AT&T Bell Labs - lower cost and higher efficiency than the ruby laser

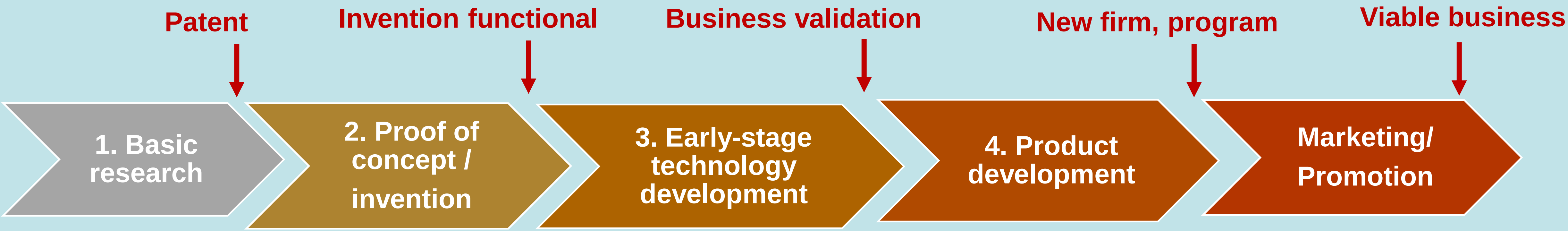
- **Technology: *techne*** + ***logos***

  techne: art, skill, craft, way by which a thing is gained

  logos: word, expression of a thought, saying, expression

- **Technology**:
  - ❑ Application of scientific knowledge to the practical aims of human life or to the change and manipulation of the human environment (Enc. Britannica)
  - ❑ Understanding how knowledge is creatively applied to tasks involving people and machines that meet sustainable goals (Open University)
- **Technology development:**
  - ❑ The process of developing and demonstrating new or unproven technology
  - ❑ The application of existing technology to new or different uses
  - ❑ Combination of existing and proven technology for a specific goal

Technology development stages



1. Basic research

- Provides the scientific understanding of a phenomenon
- Typically carried out in in universities or in large companies (e.g. pharma, energy, IT) with strong R&D departments

2. Proof-of-concept / invention

- Seeks a solution to a specific market need that may develop a competitive advantage for the business
- Can integrate existing technologies innovatively or develop something totally new, for a technical solution, a lab model
- University *proof of concept centres* to attract seed funding to early-stage research, accelerate commercialization.

3. Early-stage technology development

- Develop the product/process/service that is a solution to the market need → **prototype** developed and tested

Technology development stages (cont.)

4. Product development (engineering and manufacture)

- Turn prototype into a scalable product/ service that is mass-produced
- Search for materials, suppliers, appropriate storage and transportation, hire and train professionals
- Manufacture the product to deliver the solution to the final customer

5. Marketing

- Concept tests, market research and market testing, to check acceptance and distribution in test markets.

6. Promotion

- The product/service is launched nationally or globally, agile marketing for rapid results

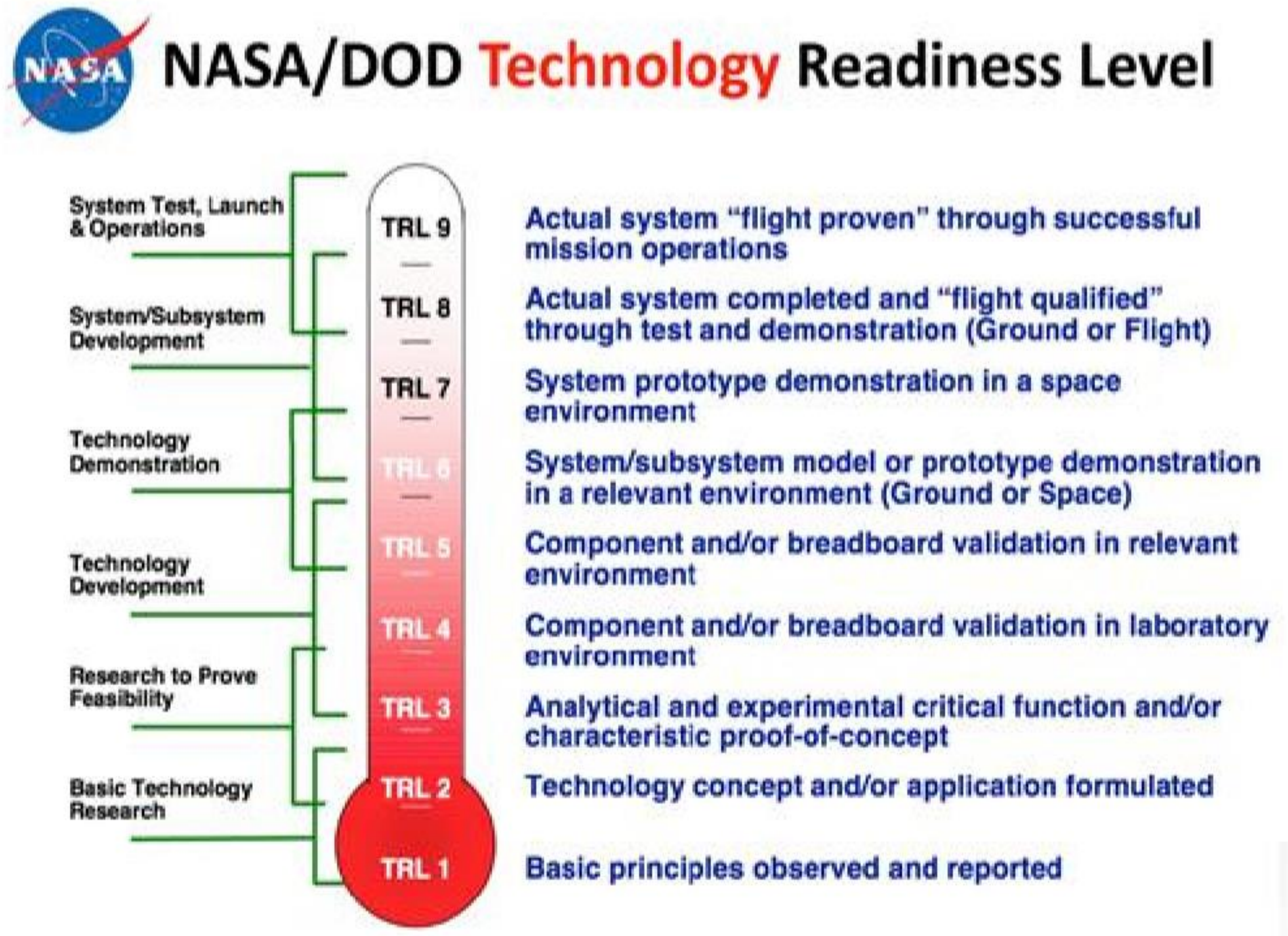
7. Continuous improvement

- Constant measurement and analysis of both the product/service and the process flows to improve them further

8. Diffusion to other areas, social and economic impact

- The innovation becomes adopted for other purposes than those originally intended.
- The innovation changed the society behaviour or involved a large part of the economy

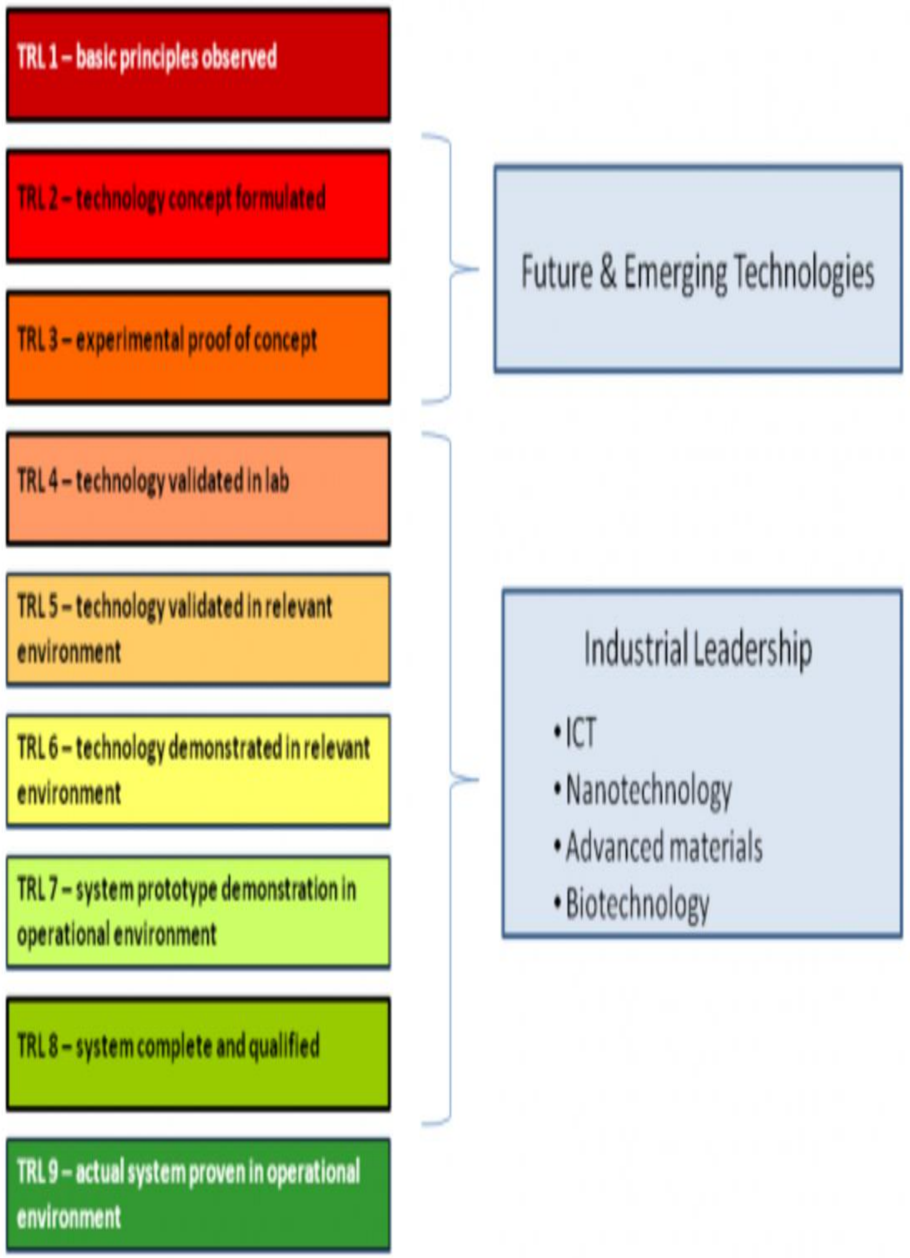
Technology readiness levels (TRLs)



US-DoE 6 "relative levels of technological development"

NASA/DoD 9 levels

- Measurement system used to **assess maturity of a particular technology** and **compare maturity between different types of technologies** in assessing risk
- Originally conceived at NASA in 1974 for space exploration technologies, formally defined in 1989 with **7 levels,** then expanded in the 1990s to the current **9 levels** scale (1 lowest - 9 highest, the most mature technology)
- TRL recommended by the General Accounting Office in 1999 to be used for major **DoD acquisition projects**.
- US Dept of Energy (DoE): **6 "relative levels of technological development"**, based on R&D types taking place during the TRLs



TRLs in Horizon 2020

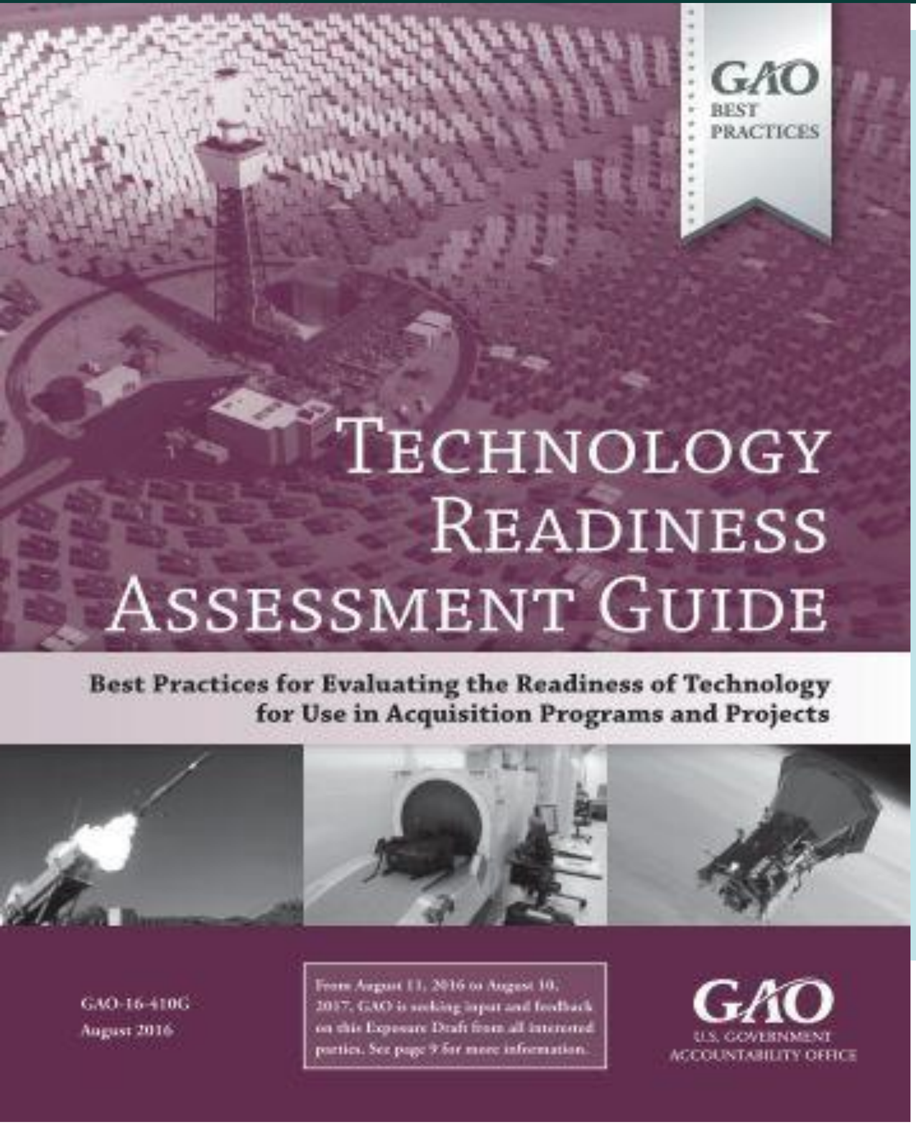
- European Space Agency (mid-2000s)
- **EC adopted TRLs in 2010 and used them in 2014 for the KETS in H2020**
- Easier translation to multiple industry sectors, not just space exploration

- **H2020 three main research areas ("pillars“):**
  Pillar 1:"Excellent Science“ -basic science (ERC, Marie Curie Actions) 13 bn
  Pillar 2: "Industrial Leadership“ (LEIT, Risk finance, Innovation in SMEs) 17 bn
  Pillar 3: *"Societal challenges"* (solutions for societal challenges, no technology)

- **TRL used to position the projects in the programme**
  - Higher TRL - EC looks for a more ***applicative*** solution in the project
  - lower TRL– EC looks for a more ***basic research project***

- **TRL as an indication of the ‘entry point’,** i.e. the maturity level of the given technology/product/process at the ***beginning*** of the project. A given TRL serves a a **‘lower boundary’ (**e.g. in the SME Instrument and in the Fast Track to Innovatio (FTI), the entry point must be TRL 6, no funding for lower TRL

TRL assessment



Technology Readiness Assessment (TRA)

- Examines concepts, technology requirements, and demonstrated technology capabilities (see the US GAO Guide)

- TRA of a complex system requires the assessment of all of its systems, sub-systems and components, including those elements that are thought to be mature because of past operational use.

- TRA is comprised of two parts:
  - 1. determine the current maturity with TRL Calculator
  - 2. determine what is required to advance that maturity in terms of cost, schedule and risk, with the **Advancement Degree of Difficulty (AD2) Calculator.** This calculator deals with TRLs.

Who is funding it?

TRLs 7-9: Private sector funding

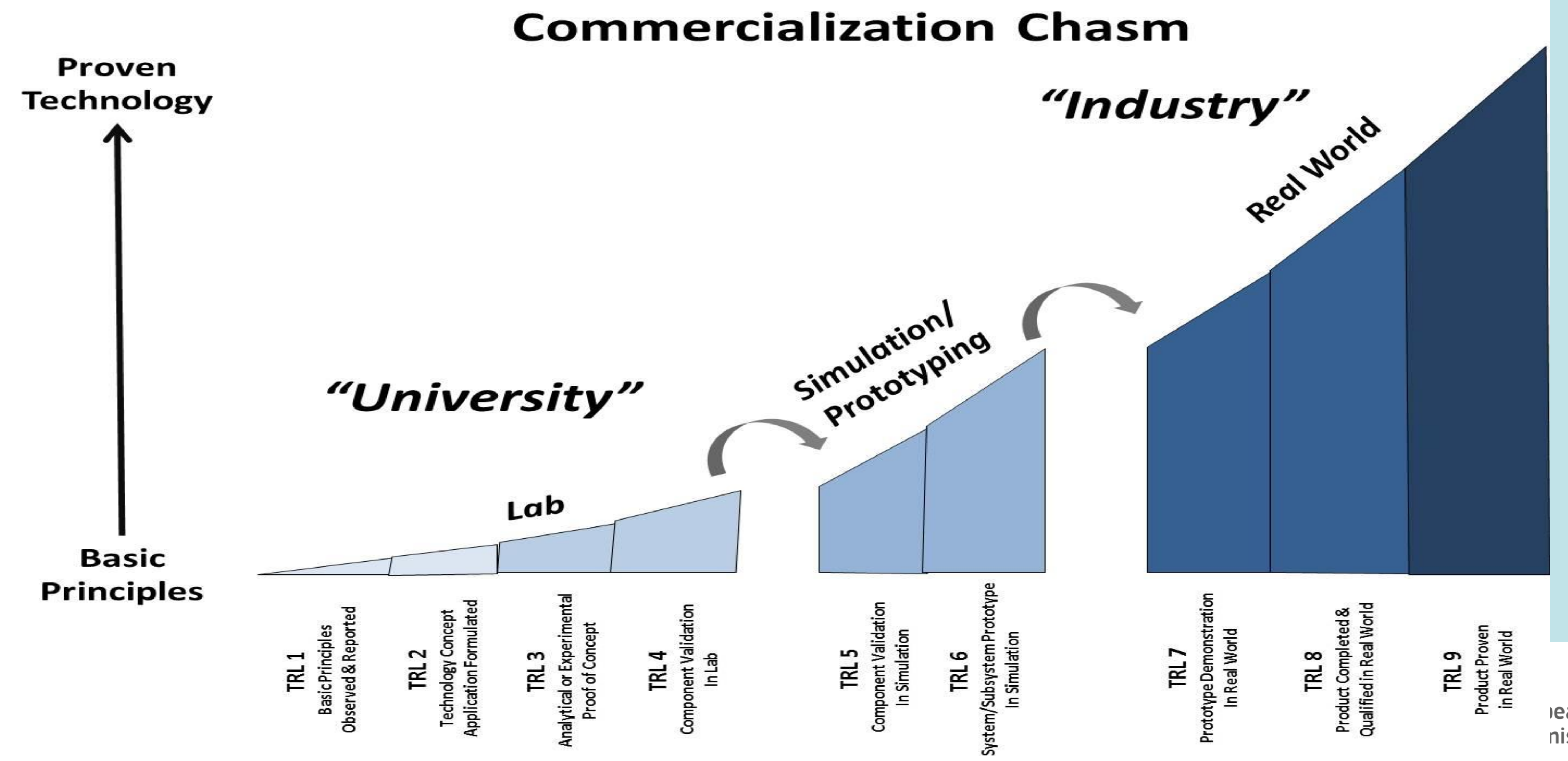
- Technology is beyond the reliance of S&T investment and is dependent on standard systems engineering development practices to achieve a fully mature status expected for eventual production

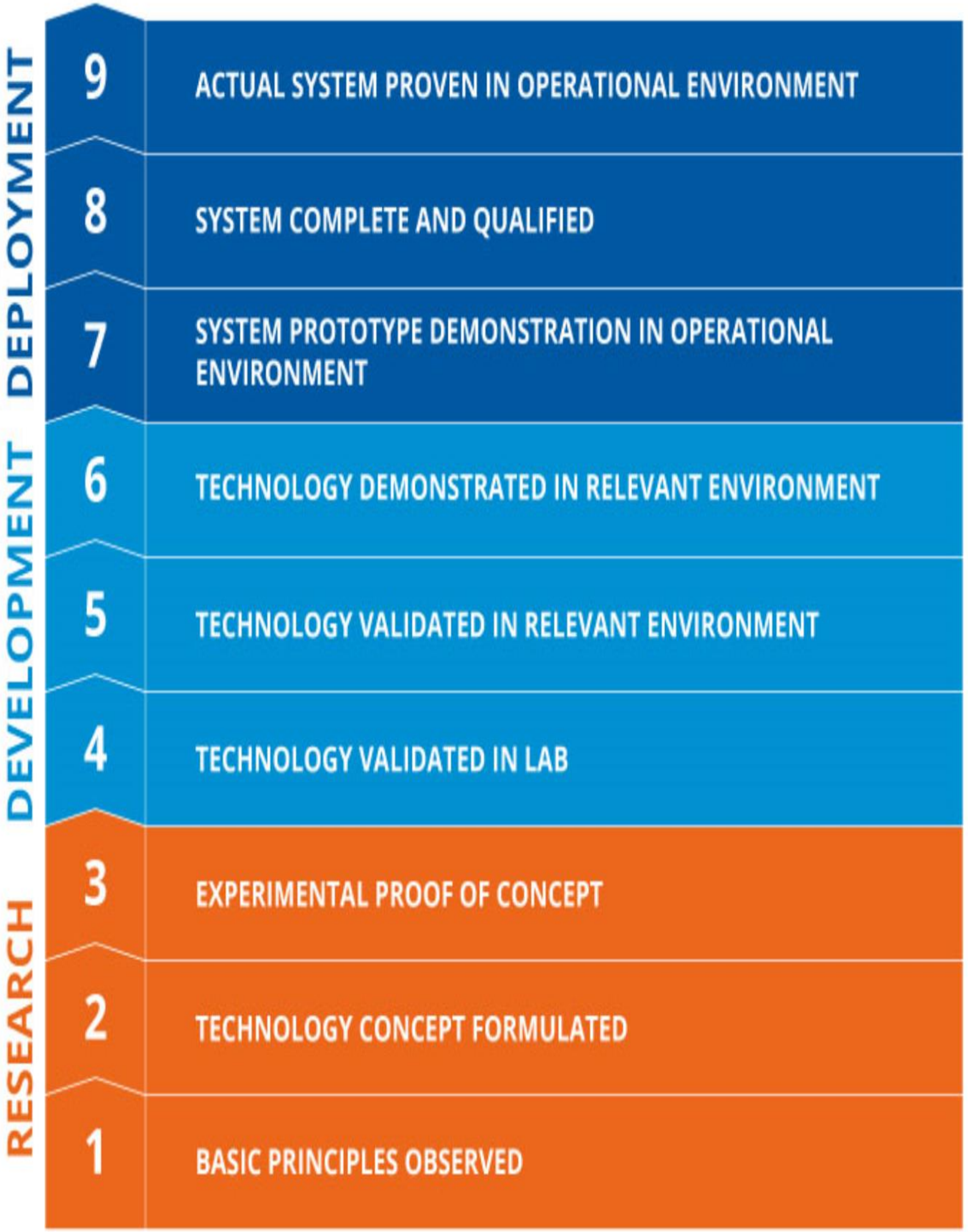
TRLs 5-6: ‘Valley of Death’

- No academia funding (focus on publications)
- No business funding (risky, expensive projects)
- Many technologies, albeit promising, may not reach maturity
- Public money, collaborative efforts are required to bridge the Valley of Death (e.g. H2020 goes to TRL7 - is a research <u>and innovation</u> funding instrument)

TRLs 1-4: Universities & government funding

The Death Valley (The commercialization chasm)





Who is doing it?

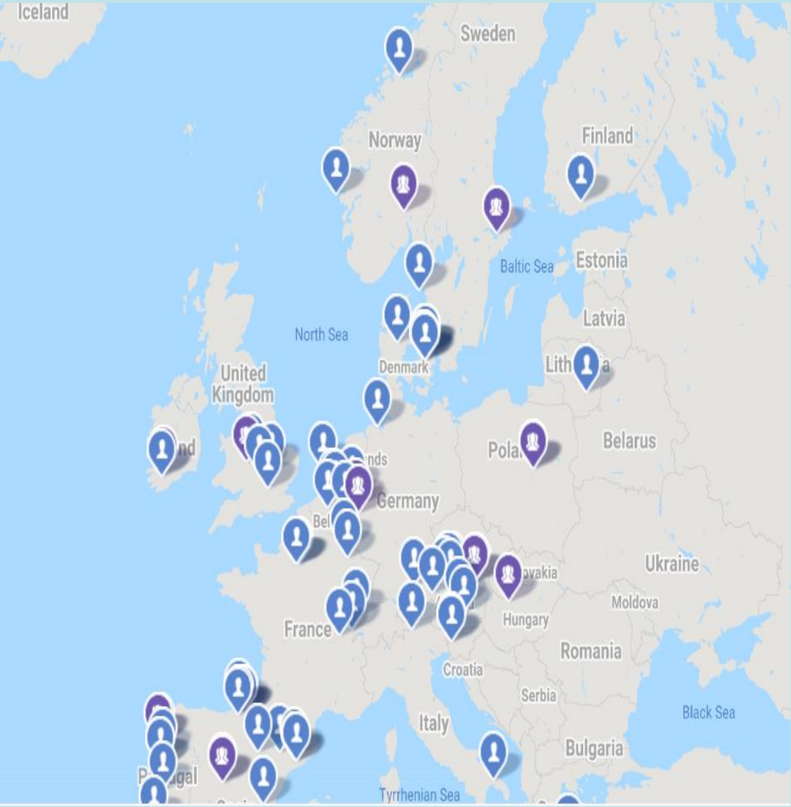
TRLs 6-9: High-tech firms

TRLs 5-9: Research firms

TRLs 3-6: Research and Technology Organizations (RTOs)

TRLs 1-4: Universities/PROs

What are the RTOs?



https://www.earto.eu/

- RTOs are non-profit organisations with public missions to support society.
- Closely cooperate with companies (large and small), public actors.
- RTOs work ranges from basic research to new products and services development, in all fields:
  1. **Support translating basic research** into applicable scales, solutions.
  2. **Host research infrastructures**: multi-use research (prototype) and low-rate manufacturing facilities supporting piloting and pilot-production (test & validation), for the use of large firms, SMEs, universities and governments.
  3. **Foresight and ideation actions** that feed industrial strategies and stimulate political decision-making
  4. **Develop existing products/processes** for industry and consumer needs.
  5. **Train and educate experts** to provide expertise and HR for other RTOs research organisations, industry, government
- RTOs not recognised in official OECD or EUROSTAT data, little systematic information about the sector is available
- The European Association of RTOs (EARTO) fact-finding studies on the impact of RTOs over the years

Limitations of the use of TRLs

- **1. TRL scale implies a linear character of the technology, which may not apply at higher TRLs**
- RDI processes are not linear, need feedback (e.g. the Chain Linked Model 1986)
- Higher maturity requires additional research → a technology in the stage of pilot production can be thrown back to the stage of technological feasibility (and require research), as flaws in the product design emerged because of problems in manufacturability.

2. Single technology maturity approach / focus on a single technology

- Lower TRL levels concern one single technology, but the higher TRL levels integrate different individual technologies, with different maturities, into complex products
- Application of the higher TRLs to ***complex systems*** is complicated→ require complex solutions rather than single component development.

Recommended reading

EARTO (2014), The TRL Scale as a Research & Innovation Policy Tool, EARTO Recommendations

Limitations of the use of TRLs (cont.)

3. Focus on product development, rather than manufacturability, commercialisation and organisational changes

- The original TRL scale was about product-oriented technologies, and **did not incorporate non-technological aspects**, like the readiness of an organisation to implement the innovation.
- Innovation is not about technology (product and process) alone. Financial and organisational activities that are also crucial to commercial success should be incorporated into the definitions, broadening the TRL scale.

4. Context specificity of TRL scales

- Purpose and use of different TRL scales differ → different purposes lead to different operational needs → definitions of levels must be adapted to specific purposes

The process of technology commercialization (technology transfer)

Research → Invention disclosure → Assessment → Patenting → Identifying potential licensees → Negotiation → Licensing → Revenue and commercialization

The steps can vary in sequence, may occur simultaneously

1. Research

- Research observations and experiments may lead to discoveries and inventions with commercial applicability → **intellectual property (IP)**
- The university owns the IP if:
  - it is created by a university employee (faculty, researcher, staff, or student) within the scope of employment.
  - it is created on university time, with the use of institutional facilities or state financial support.
  - if it resulted from research supported by public funds or 3rd-party sponsorship.
- If IP is created together with another academic institution or company → Inter-Institutional Agreement
- The inventor must pay attention to publication → for inventions that may have commercial potential, inventors submit an invention disclosure at least 60 days in advance of a publication

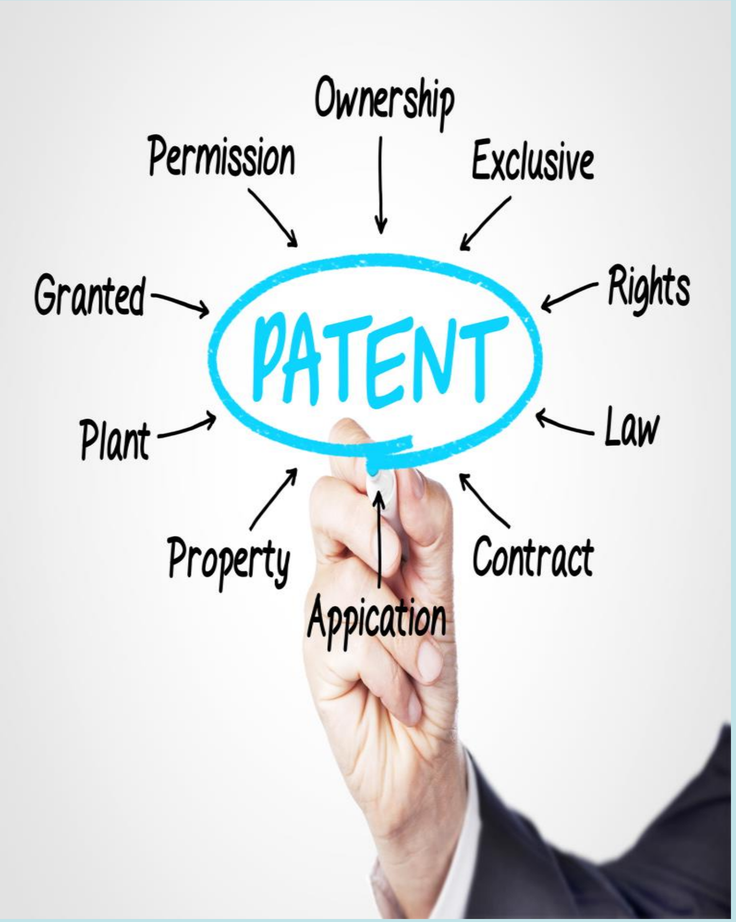
2. Invention disclosure

- The researcher reports the invention to the Technology Commercialization office (TCO, TTO, TLO) via a confidential **Disclosure Form**, to initiate the commercialization process.
- The invention disclosure describes technical aspects of the technology, e.g. scientific base of invention, advantages over prior art, potential drawbacks, scope of use, and legal matters (such as IP ownership).
- The researcher enables the office to assist and support throughout the commercialization process, if the university is interested in the technology
- The invention disclosure should be submitted as soon as the researcher determines that the invention is potentially patentable or may have commercial value (at least 60 days before publishing or presenting the invention)

3. Assessment

- The Office patent administrator receives the invention disclosure form, assigns an ID number and enters the technology into the database.
- Licensing specialist reviews invention with the PI/responsible manager/patent attorney for patentability
- The assessment focuses on:
  - ✓ Novelty of the invention
  - ✓ Marketability of potential products/services
  - ✓ Relationship to related IP
  - ✓ Size and growth potential of relevant market
  - ✓ Time and money for further development
  - ✓ Pre-existing rights associated with the invention
  - ✓ Potential competition from other products / technologies
- Licensing specialist may collect information from industry, venture capitalists, government contacts, etc. to establish a preliminary commercialization strategy.
- Assessment outcomes:
  - ✓ file a patent on the invention and begin marketing
  - ✓ delay patent prosecution and marketing to allow the technology and/or market to ripen
  - ✓ close the case

4. Patenting. Protection of IP



- Inventions and/or other IP works may be protected under patent, trademark, trade secret, and/or copyright laws

5. Identifying potential licensees

- Market research, online marketing, conferences, industry events
- Examination of complementary technologies
- Existing relationships (with VCs and other investors, entrepreneurs, companies, government agencies, etc.)
- Information and marketing materials, info produced by inventors (publications, posters and presentations)
- Can take weeks/months to find a licensee, subject to technology development stage, competing technologies, availability of patent/other legal protection, market size
- The earlier the invention is in the product development cycle, the longer it takes to find licensee
- Licensee chosen based on its ability to commercialize the technology for the benefit of the general public: can be an established company with experience in similar technologies and markets, or a startup

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6. Negotiation and due diligence

- Meeting with the licensee, inventor and university office, for in-depth discussion of the invention.

- “**Due diligence”:** in-depth review of the science, development path, patents, or market opportunity

- Sign a **non-disclosure agreement (NDA)** to protect the invention confidentiality during evaluation by potential licensees.

- What is negotiated:
  - ✓ Scope of the license grant (exclusive vs. non-exclusive licensing, limited fields of use vs. all fields of use, sublicensing rights)
  - ✓ Licensee’s obligations regarding development and commercialization of technology, milestones
  - ✓ Compensation to the university and inventors for the license grant (fixed fees, royalties based on product sales, and/or equity in the licensee.
  - ✓ Licensee pays patent expenses.

7. Licensing

- **License**: permission to the licensee to use the IP, granted by the owner
- **License agreement**: defines the licensee's rights to use the technology and their responsibilities to bring the technology to market and to compensate the university and inventor(s)
- Licensing agreements widely used for commercialization of technologies invented by universities or government labs.
- The path to commercial markets depends on the invention nature, market, stage of development.
- Licensing agreement can include technical or regulatory milestones, development of pilot facilities or commercial prototypes, and first commercial sale.
- **Licensed IP is usually one or more patents**, trademarks, copyrighted materials, e.g. software.
- **Single or multiple licensees**, either non-exclusively or exclusively, each for a unique field of use (application) or geographic territory.

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Licensing

Licensee Benefits:

(i) the licensee can get a faster access to certain markets

(ii) licence agreements can be a route to get access to innovative technologies and expertise, an important competitive advantage in particular for SMEs without in-house R&D

Licensor Benefits:

(i) additional source of income

(ii) to solve situations of infringement

(iii) the organization is not well equipped to directly exploit the technology

(iv) to enter into new markets

Licensee Risks:

(i) the licensed IP may be challenged and the technology become obsolete

(ii) the royalties to be paid may be too burdensome

Licensor Risks:

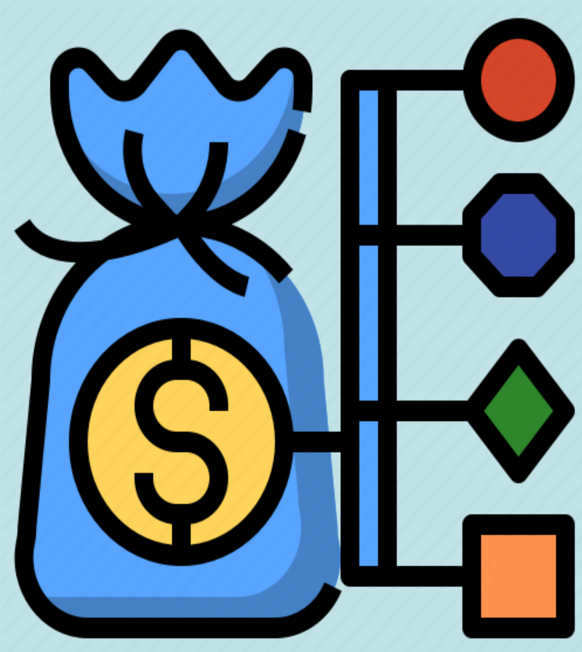
(i) losing control on information

(ii) the licensee becomes a competitor

(iii) an unskilled licensee affects the income the licensor receives, which is particularly dangerous in exclusive licences

https://www.meee-services.com/what-is-licensing-a-product-and-how-to-license-a-product/

8. Revenue & commercialization



- The licensee is obliged to develop the inventions into commercial products/services.
- If the licensee is unsuccessful in commercializing an invention, the license agreement can be terminated and the university can seek another licensee.
- The university shares 50% of licensing revenues, after recovery of expenses, with university inventors.
- The 50% share of two or more university inventors shall be allocated by mutual written agreement of all inventors →**Inventor Distribution Acknowledgement** form.
- The distribution agreement is ideally negotiated before a licensing agreement is finalised.

Thank you!

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