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на тему : The Moonshot Lab: deep-tech research and development organization

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CONTENT

1 EXECUTIVE SUMMARY

R&D in a technology space is often seen as a risky and costly endeavor that requires careful organization and management to achieve successful outcomes. On the other hand technology innovations that are developed during this process can provide significant competitive advantage to sustain and project business into the future.

A rapid growth in R&D investments of a Fortune 500 companies, growing number of deep-tech start-ups, availability of a capital and corresponding necessity of speeding-up go-to-market time, increases the interest in not only growing own technology R&D labs within the organizations but also for the contract research service labs that can provide innovation consulting and scarce technology development expertise. As the technology complexity grows, it gets overly expensive and operationally hard for companies to stay at the bleeding edge of technologies even if they own an R&D department. Hence, there is a growing demand for high-profile technology design consultants who can help companies not only design but also build new tech products in an ad-hoc manner.

The goal of this work is to research the typical organizational model of R&D departments and how these models fit into the case of service R&D. What and how to research? Where to find the right people and how to build the right network? How to commercialize the results of research?

The developed **findings are validated in the transformation of R&D unit of a global technology development** service company and provided as a case-study in a Chapter 4.

Here under the Research and Development we consider the deep-tech/science-intense activity aimed on creation of the new technology and corresponding solutions and services based on it. This spans the entire lifecycle from basic and applied research to its commercialization and product development. Domain-wise the focus is on Machine Perception, Life Science and Human-Computer Interaction. Here we do not consider commodity and routine engineering or marketing activities that sometimes are also referred to as R&D. This distinction is also common in the R&D tax incentive governmental programs.

Scope of this project consists of: detailed literature analysis and comparison of various R&D organizations, interviews with industry experts, organizational and ecosystem development strategy, global R&D services market research, market-driven research framework development, technology commercialization strategy, managerial conclusions and R&D performance metrics.

The business component is in the commercialization scheme for a deep-tech research lab that may be scalable and transferable either to other service/product firms or to technology-commercialization offices (TCO) of established research institutions (i.e. University research lab or Scientific Institute research). Such a scheme involves technology and market research steps, competitor’s analysis, product leadership planning and sales pipeline development.

The case-study work outlined in this project was influenced by most of the courses of MSTM program. From establishing the right culture, operations and team structure (Daniel Lewis, Tom Dybsky) to defining the right technology and product strategy (Steven Russo, Scott Sehlhorst, Alejandro Danylyshyn), marketing and sales approach (Joe Pons, Mychailo Wynnyckyj). The stakeholders are lab researchers of the unit who received a methodology to identify research focus, SVP of Technology and CTO who received a systematic set of metrics and a roadmap to assess the performance of R&D unit.

What was not in scope of this project, but was a part of R&D unit transformation: researcher competency map development, development of specific service offerings or customer proposals, go to market service strategy with corresponding market segment research and competitors analysis.

The resulting document is organized as follows. In **Chapter 2** the Introduction to the problem of R&D complexity, deep tech ecosystem and types R&D activities is given. We also provide here an overview of typical service R&D organizations with IBM being one of the distinct examples of service R&D within a large enterprise. **Chapter 3** is focused on aspects of managing R&D organization based on literature research and interviews with industry experts. Here particular focus is on identifying the right research agenda that answers "What to research?" question, methodologies of further technology commercialization and how correct management of the ecosystem can provide a boost to R&D organization. Finally, **Chapter 4** provides a case study where these approaches are tested in practice within the Transformation of an R&D department in a Global Technology Development and Consulting company. In this respect, some of the above approaches and methodologies were adapted to reflect the service component of the R&D. **Chapter 5** offers a number of managerial conclusions by the author.

The latter transformation of the R&D unit contained a number of challenges which also formed a bulk of the conclusions section. **First**, the culture component is of great importance for the research department and selection of the right individuals for R&D job is as important as the research strategy itself. Transforming a typical engineering unit into R&D or forming ad-hoc research teams from available unutilized talent will likely result in a failed attempt. **Second,** interactions of researchers with the ecosystem players may become a huge boost for the R&D, however building ecosystems and necessary links from scratch can be challenging and not always possible. **Third**, being a part of larger organization, it is important to constantly prove the value of R&D unit for various stakeholders. To this end, careful planning of short and long-term results is needed. **Fourth**, to succeed in research commercialization it is essential to align with sales and marketing teams to dedicate resources and focus to such projects. Eventually early steps in marketing the new technology can be orthogonal to the main strategy of a firm and success metrics of such organization. In this sense some sales and marketing activity can be owned by the R&D team until the process is mature enough to be scaled by the main organization.

2 INTRODUCTION

2.1 The rise of R&D complexity and the deep-tech ecosystem

Innovations are at the heart of the modern technology ecosystem. They lead to novel business models and products that were previously unimaginable. In this scope innovations based on deep technologies are of particular focus. Being highly risky and uncertain this type of development can lead to exponential returns and high impact on a society and business ecosystem.

Commercializing deep technology takes significant time associated with moving scientifically intense research artifacts to a number of viable and marketable use-cases. Hence, moving up the value chain in this process may involve different players leading at different stages. To this end, an incorporation of the startup is usually not the initial step of the story, but one of the commercialization roadmap milestones when the science had been already proven and the work is focused on developing and targeting the particular market segment. [**Portincaso2019**]

Technology development is no longer concentrated only within high-budget corporate or academic labs, but spread over the number of ecosystem players. In addition, the speed of deep technology development is also advancing and is often linked to the growth of a software component part. It takes about 4 years to bring technology to the market for biotech, but only about 2.4 years for a blockchain solution that is predominantly of a software nature. [**Portincaso2019**] Investment-wise bringing the first prototype to live in biotech and blockchain differs as $1.4M and $200K which makes the latter technology readily affordable to mature in R&D departments of small to medium technology development firms and startups.

In this respect, the latter recently managed to attract significantly higher private investment funding than their non-deep-tech counterpart (see Fig. 1). Governmental support still remains crucial for the early technology developments. Here the US, China and EU are spending 2.7%, 2.1% and 2.0% of their GDP on R&D. Here we don't take into account the recent COVID-19 crisis.

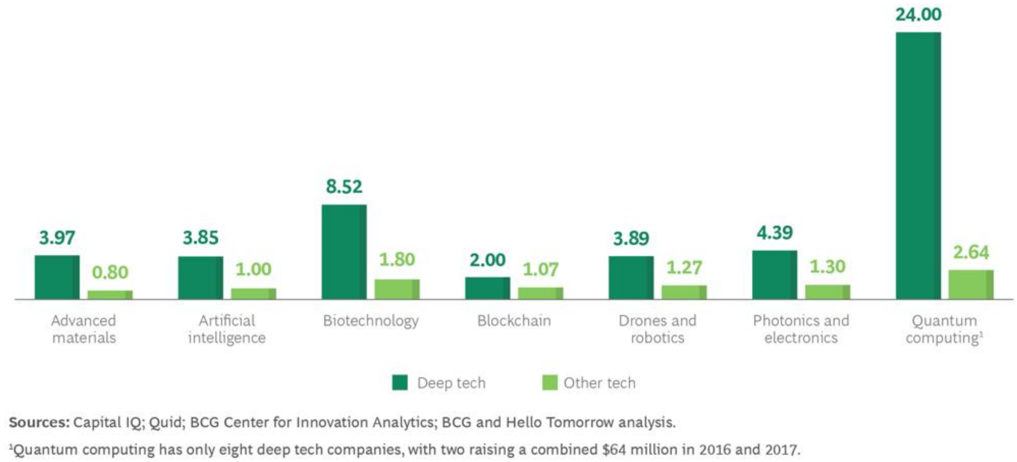


*Figure 1 Median private investments (2015-2018 in $ millions.) into deep-tech startups across various verticals [**Portincaso2019**].*

Along with the accessibility of deep tech for smaller players it is worth noticing that scientifically intense development complexity and corresponding costs to develop the final products have a tendency to rise. On one hand, this is linked to increase of corresponding scientific disciplines depth (biotechnology, artificial intelligence, material design, etc.) on the other due to the fragmentation of knowledge and skills as they reside in more disparate places geographically it became harder to harness all the necessary skills, industrially and functionally [**Portincaso2019**]. As a result, in some fields despite technology improvements, cost for incremental advancements is increasingly rising as the number of "low-hanging fruits" decreases. Here the particularly good example is a rise of the drug discovery costs over time, reflected in so-called Eroom's law – the cost of developing a new drug doubles every nine years (See Figure 2).

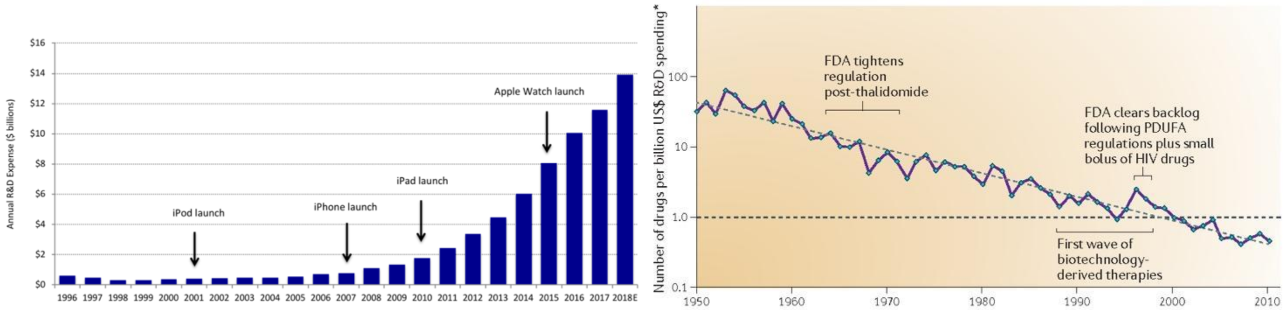


Figure 2 Rise of the annual R&D spending with the launch of new Apple products. Eroom's Law in pharmaceutical R&D. (Scannell, Alex Blanckley and Helen Boldon. "Diagnosing the decline in pharmaceuticals." (2012).)

To embrace access to new technologies and fight complexity trends the typical strategy of larger corporations is to introduce innovation programs, Corporate VC, incubators and various instruments to stay connected to multiple smaller players in the ecosystem at various stages of technology commercialization.

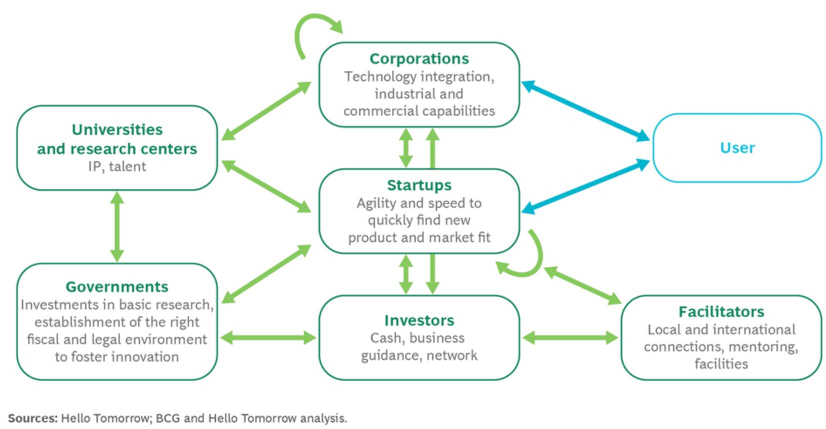


*Figure 3 Example of a deep-tech ecosystem taken from [**Portincaso2019**]*

In this respect the most important links that enterprises should keep in focus are:

- Academic connections with **Universities and research centers** to have early access and visibility of technological advances and early access to the top talent in the field
- **Startups** – via investments, co-development and technology partnerships.

- **Users** of a technology

In this sense, the corporation is not keeping all the benefits of its own innovations, but has to share it with customers, public or even competitors. It is important that own R&D department is mature enough both technologically and organizationally to identify, establish, facilitate and sustain such connections.

2.2 What is Research & Development?

Research and Development activities tend to differ much from organization to organization, but the similarity is that it has to focus on future product or service development, rather than yielding immediate profit. It is usually characterized by a greater risk and higher uncertainty in the resulting return of investment.

In what follows we will consider R&D which is focused on creation of new or improved technology helping organizations gain competitive advantage and facilitate future product developments. Corporate researchers create new technologies and generate IP that can be licensed, used for the core product advancement or even for spinning up a new business line. As a result, a successful research group might be able to pay for itself also with income from patents and ip-licensing if it remains competitive and creative [**Williams2008**].

The role of R&D department is manifold and it has a central role for the success of the entire company. In the spirit of the book [**Williams2008**] largely based on IBM example we can define it to include:

- Contribution to company strategy
- Research on possible product/service directions
- Generation of competitive intellectual property
- Work on replacement and optimization of current products with high potential ones
- Assistance in future products development
- Search for the new directions and business opportunities

With this, it is important that such a team has necessary links with the rest of the organization and a certain level of freedom to explore new ideas which might be in opposition to the short-term tactical goals and authority to push forward the necessary changes. The latter items often imply that such a group needs to report directly to the C-level or strategic management rather than VP of product or marketing [**Williams2008**].

Here it is important to state **the difference between R&D, Product Development and Marketing Research**. The latter provides insights about trends and market needs which indeed are important to define corporate strategy. However, marketing does not invent new materials and technologies, work with patents and in-depth technical research or build functional prototypes to test them in the marketplace, nor does it develop deep insights into a new technological direction. As a result, it is unable to reduce technological uncertainty that is highly necessary if the future product strategy bets on commercializing technology which is in its early stage. To this end, Marketing research can complement R&D, but can't be a suitable substitute for the technology research in the long run [**Williams2008**]. A classical HBR article provides good examples on the importance of the right model of cooperation between technology and marketing teams for the innovation-driven organizations [**Shanklin1984**].

Product and advanced development may in some cases be considered as R&D activity. Here product people define necessary features and strategies based on market and client demands. The developers role is to take existing technology, design and prototypes and implement them into a next iteration of the product, i.e. upgrade existing design, fix problems, improve interfaces. However, just by focusing on incremental improvements of the existing product the company may limit itself from the long-run growth [**Williams2008**]. Unlike above activities, **Research** is focused on exploration of future opportunities beyond the next product.

To better understand how the futuristic view of R&D defines the company strategy is important to consider a typical Horizons framework coined by McKinsey. Within this framework innovation pipeline of projects and initiatives in the organization can be split into 3 strategic buckets which have different time-scale and level of uncertainty (See Fig. 4).

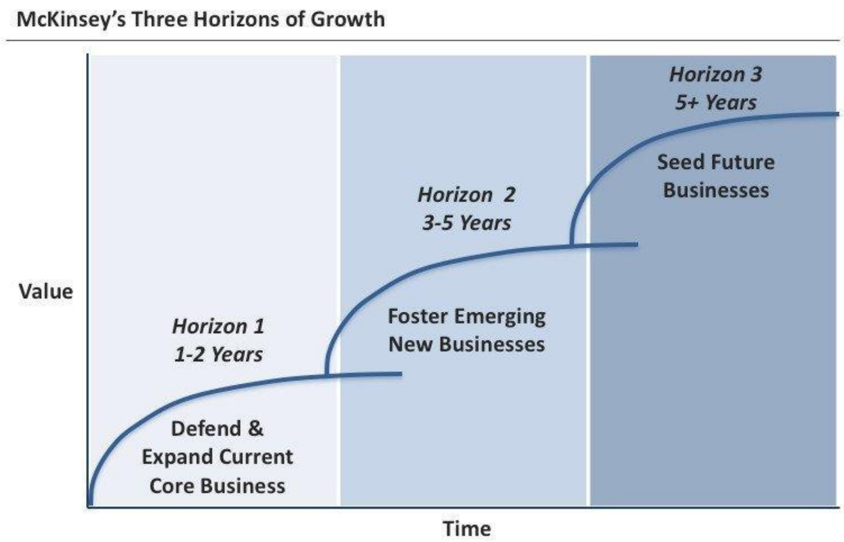


Figure 4 McKinsey's Three Horizons framework.

Horizon 1 (1-2 years) represents Core Business activities and technology focus. Here the focus is mainly on maintaining current technologies (i.e. improving iPhone 6 to iPhone 6s) and targeting existing marketing. The R&D activities are reflected in tactical short-term engineering for the products or services to better fit the existing market. Hence, this stage is mainly marketing dominated as the technology uncertainty is minimal.

Horizon 2 (3-5 years) is focused on Emerging New Business, adapting and maturing technologies. It is characterized by identifying disruptive technologies and innovations that start gaining traction. Here the R&D activity is focused on technology development, adoption and benchmarking to gain better understanding of its capabilities and applications to various use-cases. At this stage the product leadership is in the hands of R&D group as prototyping and deep ideation about possible enabled use-cases allows to validate hypotheses with customers, identify the potential customer segments and viable business opportunities.

Horizon 3 (5+ years) is a long-term strategic bucket aimed for the projects that seed the future business potential. What technologies can destroy the existing market? Investing some time and efforts in it far in advance may allow us to embrace the change once these technologies will mature to Horizon 2.

2.3 Types of R&D activities and organizations

Research and Development activities usually falls into following categories that further reflect type of organizational structure for its support [**Jain2010**]:

Basic research – set of activities aimed to gain a complete knowledge of the subject under the study without particular application in mind. For the industrial needs this usually is focused on strategic advancements in a specific scientific domain that may be of a commercial interest. This type of research forms a background of understanding of how technology may open up new possibilities. Here the main artifacts are research publications circulated among the colleagues and scientific community. In terms of Horizons Framework such activities mainly fall into Horizon 3 bucket.

Applied research – is focused on activities that have particular commercial objectives – i.e. enables specific features for products or processes. Here researchers methodologically develop ideas into practical operational form which are often reflected in concepts, engineering research papers and patent applications. These are typical Horizon 2 activities.

Development – is focused on application of knowledge and understanding gained during the research phases. This leads to production of materials, devices and systems, including prototyping. Here the R&D unit makes an exercise of transitioning Horizon 2 technologies to Horizon 1.

As the result of such basic categorization we can define typical R&D organizations that work on different types of activities [**Jain2010**].

Mission-driven R&D – as is clear from the "mission" in the name, these are research organizations with clear long-term strategic goals typical for most of the industrial research labs. These typically are vertically organized with research being conducted on all three strategic buckets. Researchers in turn often contribute to support and commercialization of their findings. It is worth mentioning that mission-driven R&D may be well on the basic side, however it is directed by the objectives and mission of the organization rather than pure scientific curiosity.

Scientific Institutional Research – here the mission of the organization is primarily defined in scientific terms with the goal to advance the frontier of a particular field of studies.

Academic Research Organizations – these are relatively small-scale basic research teams located in university departments. The research activity is carried mainly by students and post-graduates under the direction of the university professors.

A successful research lab usually belongs to a particular type, but is acting on other fronts using a well functioning ecosystem of partners. An example can be an Academic Research Organization that receives State funding to advance a particular field of studies and has a network of industry partners to commercialize the research.

2.4 **R&D as a Service**

We observe steady growth of technology markets and rise of investments in R&D, along with diffusion of open innovation models that brings in multiple players at various stages of technology commercialization pipeline. This implies that multiple activities of

R&D cycle, that previously were concentrated in-house, tend to externalize and push demand for contract **technology development and research**. Such companies play a bridging role of connecting innovative ideas and science developed in different labs and helping to translate them into practical and commercializable knowledge that can be exploited by the product firms.

Here we outline a few examples of typical service firms: Technology Development Firms that operate as separate entities, Contract Research Organizations that provide research outsourcing services for the Life Science industry, IBM as an example of service-oriented research division within a large enterprise.

2.4.1 Technology Development Firms

R&D service firms (or Technology Development firms) are well defined players in the ecosystem of technology-intense businesses. While they make an important contribution to the economy, such development is usually in the shadow of conventional research organizations or companies that deliver the final product.

Services of such companies usually include R&D, design and technology services, management consulting, information and communication services, legal services (including those related to intellectual property rights) and various market-related activities [**Probert2013**].

Recent research by [**Probert2013**] showcases on the example of the UK that R&D service providers do provide an important impact and contribution in the **Cambridge Technology Cluster**.

Many companies in the Cambridge region adopted a model of R&D contract work for customers rather than developing products [**Probert2013**]. Along with high availability of venture capital, the R & D service sector is playing a crucial role in providing product companies with the bleeding edge technologies and expertise that allows to radically speed time to market for high-tech firms.

As can be seen from the Table 1 below, such companies are usually of the middle size of up to 300 employees and operate on the global marketplace. Most of these firms either work closely with the VC-backed firms or VCs or operate their own venture capital fund allowing them to invest in young entrepreneurial technology firms [**Probert2013**]. Work on multiple clients within the same technological space allows such firms to gain insights and expertise allowing the creation of their own intellectual property. Its careful management is crucial for developing a revenue stream from licensing or spinning-up companies based on such IP.

*Table 1 Revenue estimates of a number of TCO firms of Cambridge UK cluster. [**Probert2013**]*

Firm	Specialism	Founded	Employees	Revenues
Cambridge Consultants	Broadly based	1960	263	£31.0 m (2008)
PA Technology[a]	Broadly based	1970	200+ est.	£40.0 m+ est. (2008)
Sagentia Group	Broadly based	1986	224	£29.1 m (2008)
TTP Group	Broadly based	1987	292	£37.8 m (2009)
Team Consulting	Medical devices	1986	32	£3.6 m (2008)
Symbionics	Telecommunications	1987	140	£12.0 m (1997[b])
Plextek	Telecommunications	1988	102	£29.0 m (2008)
Cambridge Design Partnership	Consumer and medical	1996	43	£3.3 m (2008)
Sentec	Utility metering	1997	28	£2.8 m (2008)
42 Technology	Fluids handling	1998	17	~£2.0 m (2008)

[a] Estimates based on contribution of PA's technology services to overall PA Consulting Group.
[b] Final year before sale to US-based Cadence.

Cambridge Consultants is one of the founding players in the Cambridge cluster and a good example of the technology consulting firm. Founded in 1960 "*to put the brains of Cambridge University at the disposal of the problems of British industry*" it started its IP portfolio around inkjet technologies and to date its labs have a portfolio of design and applied science expertise to deliver innovations in consumer electronics, semiconductor, medical and telecom industries. Since 2002 the company became a part of the Altran group.

The core services of the company are:

- Technology and Product Development
- Human-centered design
- Technology and Management consulting

With the core scientific and engineering expertise that span across:

- Electronics & ASICs,
- Mechanical Systems and Industrial design,
- Signal processing and Algorithms,
- Physical Sciences,
- Sensing Technologies,
- Radio and RF systems

PARC (Xerox) is another example of a multi-disciplinary service R&D company. Founded in 1969 by a Chief Scientist of Xerox Corporation, it was originally a part of Xerox. The "*advanced scientific and systems laboratory*" aimed to develop future technologies of Horizon 2-3 and contributed for developments of laser printing, ethernet, modern PC, GUI and desktop paradigm, object-oriented programming, ubiquitous computing, electronic paper and other well-known technologies. It became an independent subsidiary in 2002 and now provides technology development and product design services for the number of commercial partners and clients.

PARC's current technology focus areas are:

- AI and Human-Machine Collaboration

- Novel Printing
- IoT and Machine Intelligence
- Semiconductor materials
- User-experience design
- Design and Manufacturing
- Microsystems and Smart Devices

The company services are mostly around technology development and commercialization.

- Cleanroom services (fabrication of novel prototype devices and technologies)
- Commercialization of technologies from PARC portfolio
- Technology and Product development

The estimated annual revenue of PARC is $70M with a size of a company being approximately 200 employees [https://www.owler.com/company/parc]. It is worth noticing that half of the revenue still comes from the work for the parent company Xerox.

The success of the PARC is linked to a few factors: careful work with talented people and their ideas, coordination of resources both internally and with the external partners and clients.

2.4.2 Contract Research Organizations

Contract research organizations (CROs) are outsourcing firms that undertake more precise and focused R&D functions for the pharmaceutical or biotech industry. Their main function is to close the “time-to-marketing” gap through effective application of innovation, engaging in a full spectrum service for the small biotech companies' clinical trial activities.

Outsourcing such services offers a competitive advantage for a biotechnology company; it can be very cost-effective to pay a contractor compared with having in-house staff. This may be especially true for smaller companies that do not have the financial resources to build, equip and staff a research or analytical laboratory.

2.4.3 Service research at IBM

IBM Research stands somewhat aside from the above examples. The main difference is that here the Research division started as corporate funded R&D focused on benefiting future products, but over the time transformed into a service R&D component of the parent company.

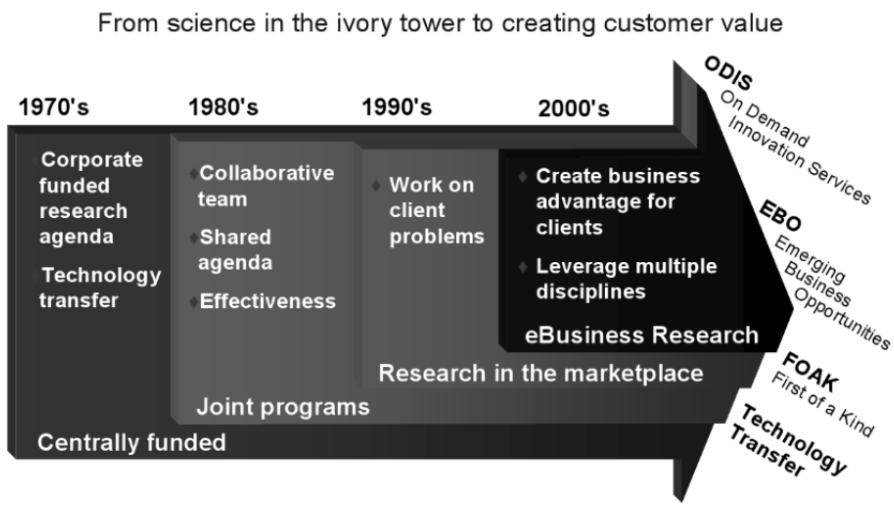


*Figure 5 Evolution of a service R&D model at IBM [**Williams2008**]*

Example of IBM showcases that it is important for researchers to acquire business skills to better understand customers in particular industries. In this respect, IBM introduced a number of Industry Solutions Labs that allow clients executives to discover innovative solutions that can solve their business problems. Along with demonstrations such labs involve customers in a few days workshops to elaborate how technology applies to their particular business. Here research is a differentiator for IBM instilling confidence that company invests for the long term in the critical areas. It also allows researchers to interact directly with the customers and gain necessary market insights.

Interesting approach concerns piloting the research results and co-development with the customer. Such projects often are treated as a First-of-a-kind project and provide numerous benefits to customers: access to emerging technologies and skills of world-renowned researchers as well as a financial model that minimizes the investment costs. On the other hand IBM researchers build a pilot and learn about particular market problems that allow commercialization of technology for the IBM products or service engagements.

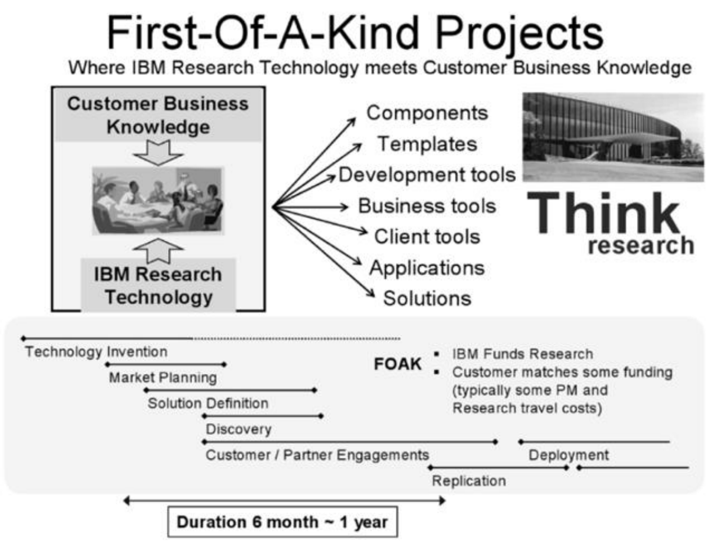


*Figure 6 A First-Of-A-Kind framework by IBM to pilot highly risky R&D projects with the customers. [**Williams2008**]*

Finally, On Demand Innovation Services are an umbrella of services similar to what other Technology Development Companies provide in R&D as a service space.

3 R&D ORGANIZATION

R&D work in the company brings up unusual challenges that do not fall in conventional management practices. On the one hand, the complexity is associated with the high market and technological uncertainty of R&D projects. On the other hand, this leads to demand in a specific type of people who are comfortable dealing with a high-uncertainty environment. The latter are often highly autonomous, diverse and creative individuals with high-profile technical training or scientific degrees. Manager of R&D organization has to provide vision and purpose for such a team of highly skilled and autonomous researchers, but also keep team activities in order by dealing intelligently with the necessary level of uncertainty in the portfolio of research projects.

Challenges of R&D organization leader usually are associated with:

- selecting the right type of R&D for the particular enterprise,
- finding the right people and motivating them to carry the R&D work,
- finding the research topics and value proposition for internal and external stakeholders,
- organizing the daily work of researchers to keep the high level of creativity and performance
- transferring technology and linking R&D to business strategy and marketing

Based on a number of industry interviews and overview of business and research literature, this chapter uncovers some of the typical patterns of R&D organization in terms of management, portfolio organization, technology commercialization and ecosystem management.

3.1 Managing R&D organization: people, ideas, funds, culture, productivity

According to [**Jain2010**] management of R&D organization is particularly focused on people, ideas, funds and culture.

People involved in R&D have rather unique characteristics that were nurtured via natural self-selection during the graduate time such as persistence, curiosity and ability to tackle complex analytical problems. To carry on innovative and highly technical activity such people have to come from the corresponding science or deep technology training that brings in specific communication channels and personal contacts networks to exchange and validate ideas. Such personalities are rather flexible and self-sufficient, task-oriented and tolerant to ambiguity **[Jain2010]**. On the other hand, this leads to the fact that R&D professionals better respond to "knowledge ladder" system rather than the typical managerial hierarchy and hence are hard to manage in the typical corporate environments **[Debackere1997].**

In the context of the above discussion on characteristics of researchers it is worth asking the question "**Who are the research managers?**". It is important that leaders of the organization can share some of these qualities and assist them in terms of project management, personal and strategic planning. A study by **[Farris1974]** have shown that research groups where supervisors had excellent technical skills were more innovative. This, however, is not undermining the necessity of administrative skills and business acumen of such a person. The latter is often missing in academic leadership, where promotion decisions are usually based on the individual contribution of the researcher.

Ideas are usually a result of a collaborative work and exchange that may be facilitated via the number of innovation methodologies. An important component of a person that graduated from a good science or engineering program is a unique communication network that she brings in and that allows to circulate novel technology ideas. Researchers need freedom to connect and interact with other thought leaders in the world and their success is often measured by how much they are recognized inside and outside the company. To this end, participation in professional conferences and publishing results is crucial for the career of the researcher. By allowing researchers to publish results of their work, the company buys a ticket to interact and learn from best minds in the field [**Jain2010**].

Funds are essential to maintain employees, equipment, laboratory space and multiple operational expenses. Balanced R&D activity can hardly be cheap and it operates on the long-term time scales such that true ROI may not be effectively estimated on the annual or even longer periods. This leads to a more complex process in attracting the necessary funds and providing corresponding success metrics. In this respect the well defined Research or Technology Strategy should be well balanced and include a combination of short-term and long-term results to keep interest and support of different stakeholders groups. In the long term a successful R&D organization could be able to cover basic operational costs from service R&D and IP licensing.

Culture is an important component of any creative work. Various studies suggested that an innovative environment has direct correlation with internal perception of the workplace by the research members. Hence, it is important that managers foster good working conditions **[Jones1994]**.

3.2 **What to research? A market-driven view**

While the organizational structure of a research team and attraction of funding sources is somewhat similar to other corporate processes, the important question for a successful research team is how to set up the right research direction. The typical complaint of operational and non-research business units is that R&D Research programs have lack of relevance and timeliness are too vague to do plan on it. This generally boils down to typical issues connected with research organization:

- customers frequently can't wait for research phase to be completed
- research takes too long and is hard to estimate
- research topics may become too esoteric and far from application or corporate strategy
- specific goals and metrics are absent
- researchers discover multiple solutions and focus on the complex one which gives the highest performance instead of the quick but slightly less performing one

A challenge for a research manager is how to select the right research agenda, minimize the above issues and satisfy various stakeholders.

In product development there is a number of methodologies to discover innovative product directions. These usually are based on detailed understanding of customer and specific market pains. Contrary, in academic research selection of the project is often based on the in-depth overview of the scientific edge to identify the gaps and interesting research questions which spark scientific curiosity and can potentially lead to a strong impact in a particular field.

Unlike academic environment research in a mission-driven Industrial Research Lab is usually constrained by organization focus and strategy, tight timelines, competitors activity, end users of a solution and other domain-specific constraints. In this respect methodology for selecting Research direction should combine product/market strategy and science focus.

Key Product/Market strategy questions:

- What is the potential size of the market?
- What are the key problems / needs of the market?
- Who are the customers of the resulting research/product?
- Who are the competitors and what domains do they work in?
- Who are the customers of competitors?

Science/Technology questions:

- What are the relevant technology and research trends?
- What are state of the art competitive technologies?
- What are the open questions in the domain and do answering them solve above market problems?
- How complex and feasible is the research?
- Does this fit the team's research capabilities?
- What success looks like and what is the risk? Can we forecast the research results?

Settling down on these and similar questions are typical steps in the initial phase of Commercialization methodologies and frameworks. To this end, the *Investigation stage* in *Goldsmith Technology Commercialization* model (see Table 2) contains Technology

Analysis, Market Needs Assessment and Venture Assessment steps with the objective to assess unique technical/research concept and market/profit potential.

Similarly, *the Imagining phase* in Jolly's Commercialization model (See Fig. 9) has to provide vision that answers a similar set of questions combining technical breakthrough with a potential market opportunity.

It is interesting how this model resonates with the complex process of IBM to identify promising research directions [**Williams2008**]. Here it starts with a Global Technology Outlook materials generated and presented as a report on an annual basis and then converted into a strategy and project plans (See Figure 7).

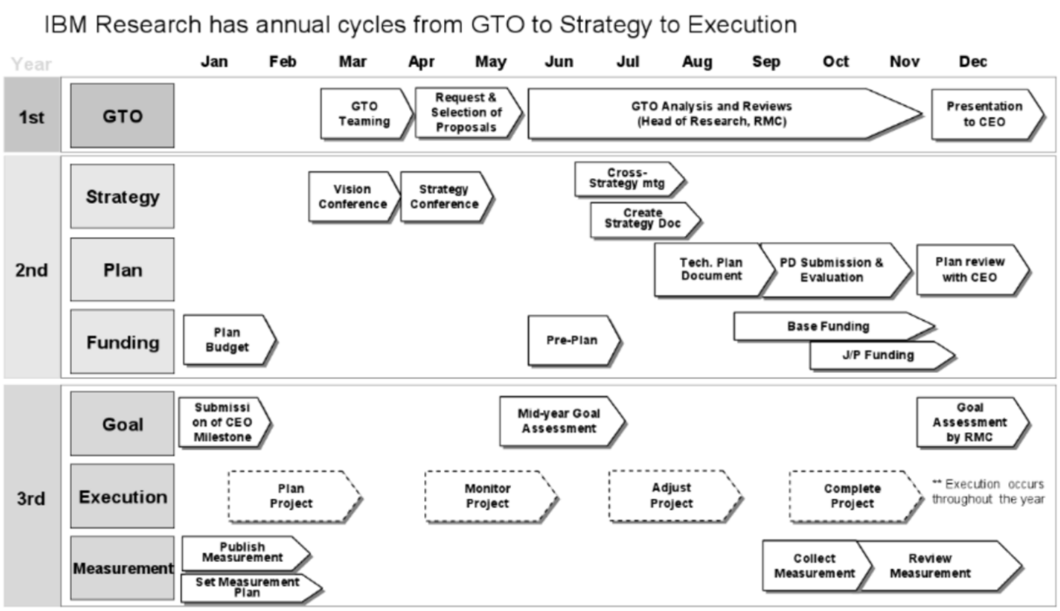


*Figure 7 Annual Research planning cycles at IBM [**Williams2008**]*

In Chapter 4 we will showcase adjustments of this approach in the case of setting up the R&D agenda for the Global Technology Development firm.

3.3 **Strategic research portfolio**

While being connected with the company strategy and product goals is essential to maintain ongoing support from internal stakeholders. Often corporate leadership becomes disappointed and surprised when competitors come up with a new kind of technologies that their own R&D department does not have developed. Hence, an important task of the research manager is to maintain a balanced portfolio of research projects which allows to systematically generate short-term and long-term results and reshuffle priority of the projects.

[**Merten&Ryu1983**] suggest next basic classification of typical R&D activities allowing to determine which buckets need more attention:

- Background research
- Exploratory research
- Development of new commercial products
- Development of existing commercial products
- Technical services

This very much complements standard Horizons framework that allows to answer if the actual research portfolio aligns with the necessary strategy of the R&D organization. Here the typical rule of thumb is 70/20/10 for core development, new products and future research.

3.4 **Technology commercialization**

Technology commercialization is a process that defines a set of necessary steps to invent, develop, and bring technology on the market. The necessity of a clearly defined process gets obvious as many technologies fail because of the mistakes done over the commercialization path – they are incorporated into the products that never get a demand or even don't get incorporated into the product at all. With this understanding the necessary steps provide a vision where the problems start to occur.

While there is no "truly correct" methodology all of them usually contain some sort of Ideation, Incubation, Development and Marketing phases. As described by Markham and Kingon (2004) [**Markham20014**] this is well reflected in TPM-linkage diagram (Technology to Product to Market) highlighting the necessity to create and target multiple markets enabled by particular technology.

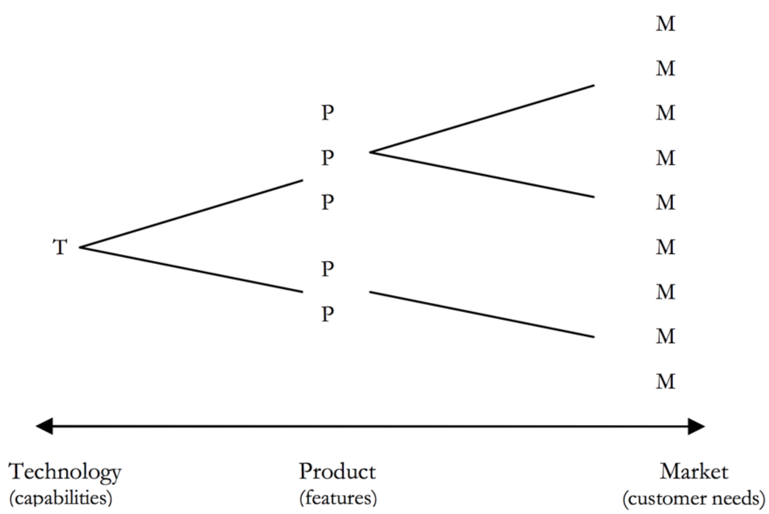


Figure 8 Technology to Product to Market linkage diagram

Here we will consider two common frameworks for technology commercialization by Jolly (1997) and Goldsmith (2002).

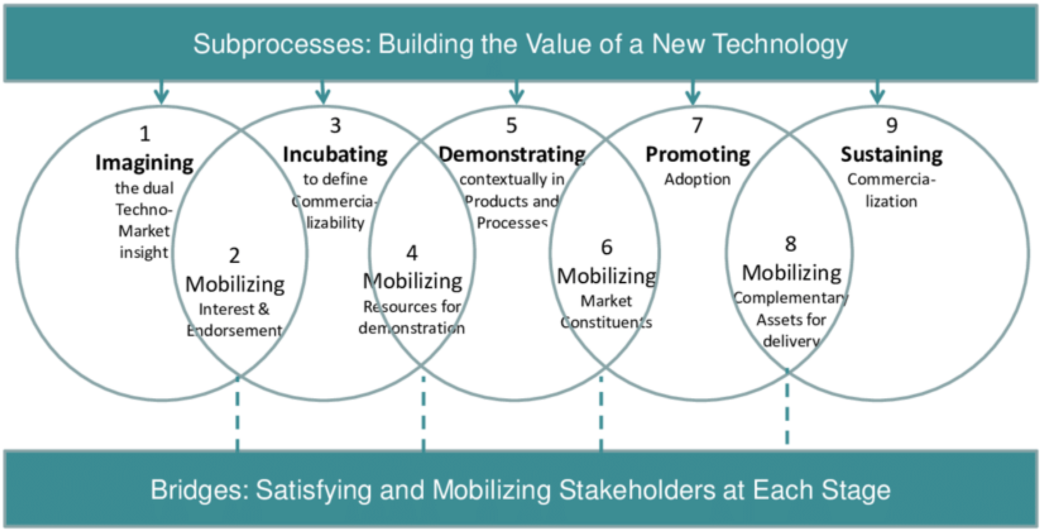


Figure 9 Jolly's Technology Commercialization framework consists of five key subprocesses and four mobilizing bridges.

3.4.1 Jolly's Technology Commercialization framework

The Framework consists of five major steps (1, 3, 5, 7, 9 in Fig. 9) that characterize different activities on the way from idea to market. Each of these steps represent a distinct set of activities that have to be done on the R&D and marketing teams. To reduce the gaps between major stages there should be the overlap steps (2, 4, 6, 8) that are focused on mobilizing the right groups of stakeholders whose mix and interest evolves with the maturity of technology **[Jolly1997]**.

Imagining

This subprocess is important to recognize the value of the technology at the stage of the idea. Here the vision of a technology breakthrough gets combined with the attractive market opportunity. Along with deep technological overview, important activities at this stage are those that allow interactions of researchers with market and potential users of the technology.

Incubating

Here the idea is taken to the realization phase to create the expected value. On one hand this involves deep technological research and development projects to achieve important technical milestones. On the other it is important that already at this stage early use-cases of technology are explored to confirm commercializability.

Demonstrating

Once the necessary technological milestones are reached and the technology is ready to be implemented into verified marketable use-cases, it is important to demonstrate the actual product to stakeholders and users. At this stage R&D moves from research to product development.

As the activity might shift to different groups of people it is important to promote interest and communicate the benefits of technology and corresponding selected use-cases during this phase.

Promoting

Technology products have to be embraced by different types of stakeholders and hence its benefits have to be clearly communicated to different types of customers. According to Jolly the challenge of promotion for many new technologies is twofold. First, one needs to persuade a customer's group to adopt the technology, particularly if it requires new procedures or skills. The other is related to the infrastructure that has to be created to deliver the technology in full advantage.

Sustaining

Once the technology reaches the market it is important to invest into efforts to enhance its use in the marketplace in relation to competitors. In this respect the incremental innovations in design and performance are still important to increase the adoption base.

Here the team has to ensure that technology gets higher adoption as the number of its users grows.

Mobilizing bridges

Importantly between each main subprocess Jolly emphasizes on the necessity of mobilizing activity focused on the work with the stakeholders who support the overlapping phases. This is needed to reduce the risk that some groups will undermine the technology adoption and development. The more radical the technology is – the higher importance is for mobilizing activity.

The above methodology is elaborated in details and examples in the “classic” book [**Jolly1997**] and provides a high-level bird eye view for managers to understand the process and necessary aspects to focus on.

3.4.2 Goldsmith Technology Commercialization Model

Is a case of a more practical framework organized as a structured roadmap with well-defined steps, actions to take and metrics to track. Importantly, it clearly differentiates Technical, Market and Business elements of the process [**Goldsmith1999]**. Table below demonstrates crucial steps of the Goldsmith model.

	Technical Market	Market	Business
CONCEPT PHASE			
Stage 1 Investigation	Step 1 Technology Analysis Define Concept Confirm critical assumptions Survey state of the art ID critical barriers Evaluate applicability Determine technology	Step 2 Market Needs Assessment Conduct market overview pricing structure market barriers risks distribution channels trends and competitors	Step 3 Venture Assessment Estimate profit potential Conduct self, enterprise and commercialization assessments ID professional needs ID capital needs
DEVELOPMENT PHASE			
Stage 2 Feasibility	Step 4 Technical Feasibility Develop working model Test technical features Assess preliminary manufacturability Conduct manufacturing assessment Assess safety & environmental features Finalize designs	Step 5 Market Study ID and quantify: Market size Customers Volume Prices Distribution Competitors	Step 6 Economic Feasibility Formulate financial assumptions Develop pro forma ID seed capital Form advisory team
Stage 3 Development	Step 7 Engineering Prototype Develop Prototype ID materials and processes Conduct tests Develop manufacturing methods	Step 8 Strategic Market Plan ID marketing team Define target market Select market channels Field test	Step 9 Strategic Business Plan Decide venture or license Finalize intellectual property ID management team Select organization structure Write business plan
Stage 4 Introduction	Step 10 Pre-Production Prototype Develop production prototype Determine production process Select manufacturing process Design field support system	Step 11 Market Validation Establish market relationships Conduct limited sales Analyze sales Survey customers	Step 12 Business Start-Up Establish business functions Hire staff Execute contracts Secure first-stage financing

	Demo product features	Refine marketing	

	Technical Market	Market	Business
GROWTH PHASE			
Stage 5 Growth	Step 13 Production Prepare commercial design Establish quality control Construct facilities Conduct full-scale production Finalize internal distribution system	Step 14 Sales and Distribution Expand distribution Analyze competitor response Assess customer satisfaction Assess distribution satisfaction Refine product features	Step 15 Business Growth Monitor enterprise position Hire and train personnel Execute contracts Arrange 2nd & 3rd stage financing Institute vision, mission, and management policies
Stage 6 Maturity	Step 16 Production Support Maximize production Establish after market support, repairs and spares Warranty service Implement training program	Step 17 Market Diversification Develop market retention Establish market scan ID new markets ID new products	Step 18 Business Maturity Establish SWOT Invest profits Monitor product life cycle Monitor business trends Monitor management technologies Implement innovations

3.5 Ecosystem management

Ability of a firm to commercialize new technology to large extent depends not only on a product or technology development, but also on the ability of the firm to successfully manage the innovation ecosystem of partners. R&D ecosystems are unusual from a standard business ecosystem point of view as such that they operate in emerging and not yet stabilized environments of technologies and vertical industries. Pellikka et.al. argues that a successful ecosystem can provide early signals of technological and industrial reconfiguration or “technology shock”. [**Pellikka2016**]

Players in R&D or deep-technology ecosystems usually come from more diverse sectors which have their own priorities. From the point of enterprise, the important links are connections to startups via corporate VC, technology partners and collaborators, equipment vendors, customers and academic institutions that provide ideas and access to high-profile talent. Such links are different from typical business networks in the sense that they are not necessary formally defined by contracts and relationships grow with the maturity of collaboration. In this sense ecosystem management is very much an exercise in diplomacy and negotiations rather than business strategy and direction [**Portincaso2019**].

In this sense direct profitability and revenue generated via partnerships cannot be good measure for the value generated in the ecosystem. The players contribute with various forms of currencies that as a whole makes the network stronger and can be in the long-term monetized via commercial operations. The important exchange currencies are [**Portincaso2019**]:

- Knowledge exchange
- Data exchange
- Skills and expertise
- Contacts
- Market access

In this respect, to establish ecosystem strategy managers need to focus on 5 essential framework-like steps: Vision, Environment, Goals, Resources, Organizations & Systems

[**Pellikka2016**].

Vision	• What is my company bringing to the ecosystem? • What do we get from the ecosystem? • What is the suitable form of interactions to achieve our goals?
Environment	• How our actions impact our partners? • What collaboration models exist and which one is the best for our innovation model? • What are the current values in the ecosystem and how they can change in the future?
Goals	• What are key objectives and metrics to track?
Resources	• Which ecosystem players are responsible for which assets? (People, ideas, materials, funds)
Systems	• What is operational scope for tasks performed within the ecosystem? • How to effectively govern ecosystem activities?

Finally, once the company is about to lead the ecosystem, it has to go over the number of steps [**Pellikka2016**]

1. Develop a vision and promote it across key players
2. Build a sufficiently open and modular architecture to facilitate ecosystem-wide adoption and innovation
3. Carefully manage links between participants such that they are beneficial for all the parties
4. Evolve the ecosystems in reaction to competing clusters

SERVICE R&D CASE STUDY

This chapter provides a case-study of implementation of above approaches within the transformation of the R&D department of a Global Technology Consulting firm.

Company has 40+ offices across Europe, North America and South East Asia with 8000+ associates that provide services in Technology Consulting, User Experience design and Software development. Engineering-wise the company consists of independent Delivery and CTO organizations. The latter accommodates so-called Centers of Excellence incubating resources in high-demand horizontal technologies and rare skills (IoT, DevOps, BigData, Architecture Consulting, Business Analysis, UX Design, etc.) and providing consulting services to customer of the Delivery organization that hosts resources with commodity software development expertise which are most of the time allocated to customers projects.

R&D department was present here for almost ten years. Formed from an engineering unit it was initially focused on advanced development and incubating new services with some success in seeding Experience Design and Security Consulting expertise that grew into independent CoE's. Otherwise it provided occasional advanced engineering and low-fidelity marketing wow-demo support. Being somewhat disconnected from the rest of organization and lacking a clear functional role the unit was at different times accommodated at different business organizations from CTO to Business Development.

With the latest transition back to CTO organization and change in the management the need of the transformation arose. Here the questions were:

- What is the proper model and role of R&D in a service organization? Are there any good examples?
- How R&D differs from advanced development?

- What kind of people belong to R&D rather than other Centers of Excellence?
- How such organization should be managed and what would be the correct metrics of success?

3.6 Transformation roadmap

The transformational map for the R&D unit (see Fig. 10) is based on 6 months milestones with a two-year goal for establishing essential processes. It started form a necessity of a Change period and Stabilization period with further focus on embracing best practices in Research portfolio management, service Research and Ecosystem management.

The goal of the transformation is to obtain efficient R&D unit that embraces best industry practices (Service R&D, Revenue from Technology Commercialization, Ecosystem management) and provides well quantifiable value for the parent company.

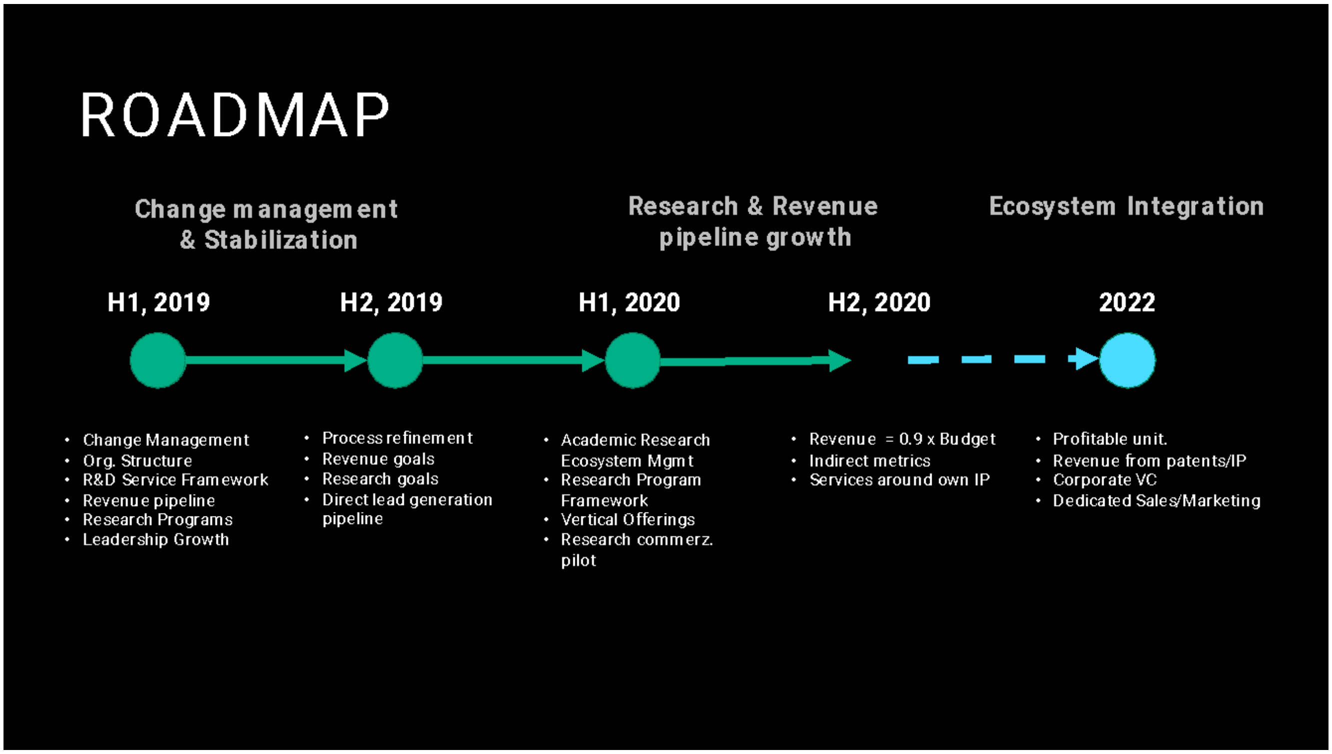


Figure 10 Transformation roadmap for the R&D unit. From Change management and stabilization to revenue pipeline growth and ecosystem integration.

3.7 The business model

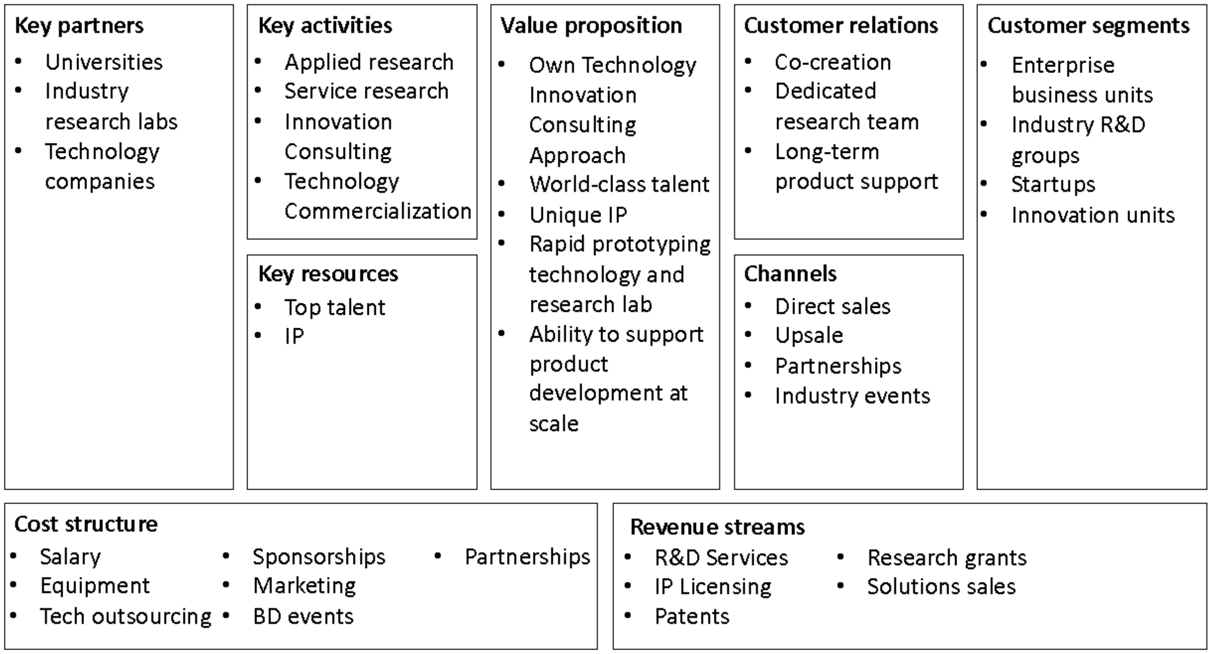
For a business model author combined elements of Service R&D models outlined in a Chapter 2 for Technology Development firms and IBM.

Here the **key activities** are:

1. **Applied Research.** R&D performs continuous in-house Horizon 2-3 Research and Ecosystem Management in a small number of technology domains that may have highest impact in the next 2-5 years. Team accumulates expertise, know-how and IP artifacts for further commercialization and to stay few steps ahead of the customers in given domains.
1. **Services.** The team provides **Technology Development**, **Lab Research**, **Consulting** and **Commercialization** services. This mainly concerns the areas in which researchers gained competitive edge during in-depth research phase.
2. **Technology Commercialization.** IP artifacts are further commercialized into repeatable solutions and services built on top of such solutions, licensing or via the co-development of Customer products based on the internal IP.

Secondary in-house activities are:

1. **Market differentiation** via ecosystem management, deep-tech solutions and demos. These are generated during demand validation step in a Technology Commercialization process.
2. **Pre-sales** support
3. **Up-sales** via Innovation Consulting service for existing customers of Delivery organization.



The **Value Proposition** is refined based on competitor's analysis for the typical customer segments. The R&D lab offers Technology R&D and Consulting Services with the differentiation based on repeatable success of building technologies and solutions for different verticals. Owning a portfolio of technologies and world-class research talent behind it the lab allows to save time and costs associated with Commercialization of technology-based products.

It is important that the lab exchanges and develops the ideas with the number of **Key partners** In Academic and Technology research labs. This enhances adoption of new ideas and allows to attract top talent in the field.

3.8 Organizational structure

To optimize team performance for the above business model it was important to split the responsibilities between Research, Product development and Technology

Commercialization. In this respect, the purely “engineering” team was split into Product team focused on Commercialization activity and a number of Research teams focused on in-depth research in different domains and corresponding horizontal offerings development.

The challenge of organizational structure transformation was that existing R&D already been set up into multiple internal communication channels (Marketing department, HR Marketing, Sales and Delivery organization) of a matrix organization. Adding here communication with ecosystem partners, direct access to market and service communication with customers would create multiple new links and hence it was important to reduce possible bottlenecks or reduce importance of some interactions.

In this respect, the priority was given to Customer interactions, business development communication with Sales and Delivery, External partnerships and direct interaction with the market. Currently partnerships are driven ad-hoc by Research leads and Product team members, but in the future maintaining the ecosystem links would require a partnership program manager.

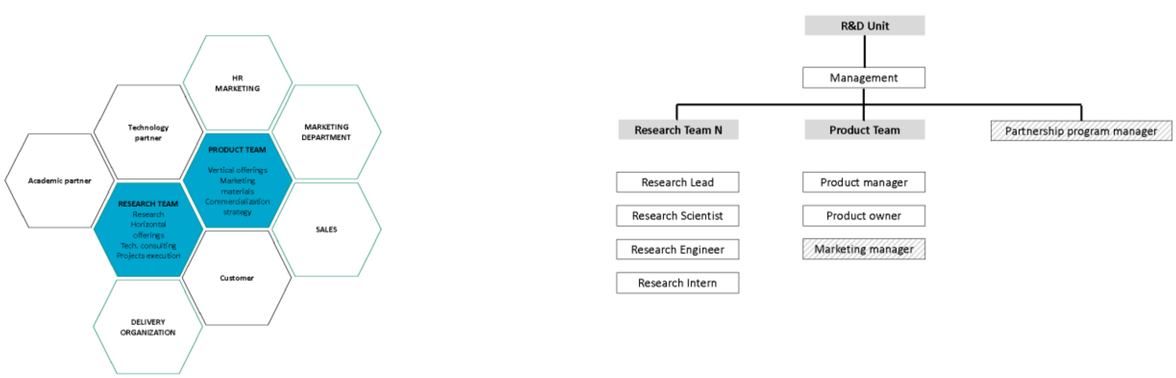
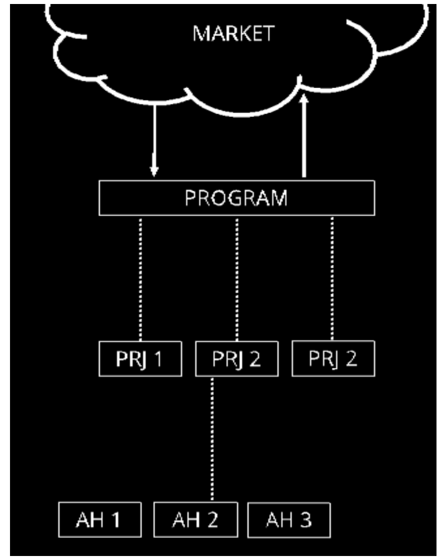


Figure 11 (left) The diagram of interactions of R&D unit (blue) with other internal (pale green) and external (grey) stakeholders. (right) The R&D unit is structured as a number of focused Research group and a single Product team. While currently ecosystem *management is done by the management team in the future a dedicated manager is considered for this role.*

3.9 **Research portfolio organization**



Research is a long-term endeavor and success builds on incremental steps and results of a sequence of projects. In this respect it is convenient to structure research using the concept of Research program that is common in academia and science-intense industry labs like IBM. The concept immediately allows to separate activity and their success on different time scales, i.e. the project can be failed, but it may still benefit the program.

Here **Research program** is an umbrella vision to advance competence in a given direction and link research to specific market problems. It may consist of multiple research projects or partnership activities. The Goal is to make a company competitive in a defined domain. In our context we consider a 6+ months period and it is common than the program is renewed annually.

Research project is a planned and scoped activity **within the Program** with clearly defined objectives and deliverables, target markets and portrait of target person. The usual project duration is between 1 and 3 months.

Finally, due to uncertainty it is common that short **ad-hoc tactical tasks** can become a mini-project. For instance, to verify hypotheses necessary for a success of the project. Such tactical research may also fall into the program, and it is important to keep a number of such activities under control. Such that it does not detour the team from the defined strategy.

3.9.1 What to research?

Answering “What to research?” question and organization of a portfolio of internal research and customer projects is one of the key management activities.

To this end, to define annual Research Programs author composed a multi-step framework in the spirit of above “What to research?” Chapter and concept phase of Goldsmith model. This takes into account both Technology novelty and interest questions and Product/Marketing strategy and allows the team to filter a large number of ideas at the early ideation phase, before the actual development started.

Shift from the pure “interest” and “just-because-we-can” research to focus on what will advance customers and the strategic technology domain was the major transformation for the R&D unit.

Step 1 – Ideation

Here the research team does a daily or few days workshop to perform broad literature review, market analysis and trends and identify potential areas of research that can enable solutions that tackle market problems.

Step 2 – Hypothesis pitch

Once several high rank ideas are selected, it is important that the team can clearly articulate its importance, provide a number of a fresh research questions that are worth to look at and finally project how success of this program may look like, i.e. developing new technology for fast image processing to target optical inspection market. At this stage necessary program leadership and alliances between researchers are formed. Hence, if the team cannot convincingly present the idea and defend it during the discussion – it is discarded.

Steps 3-4 – Competitors and Customer analysis

Once the idea is defended the necessary exercise is to perform in-depth competitions (industry companies or other research teams) and customer analysis (who are the customers of competitors?). This allows the research team to assess its own capabilities against the competitors and refine further research topics to reduce the overlap and satisfy customer needs. At this stage the Research team bonds up with a representative from a Product team to perform such analysis.

If the competition is too high and our own capabilities do not allow us to win any potential customer group – the proposed research program is discarded.

Step 5-6-7 – Value proposition, Research business model

Here program leadership together with members of a product team articulate a hypothesis Value Proposition and define necessary partnerships, resources and channels for success.

Finally, a clear value for the Global company has to be articulated and used for internal communication and promotion among stakeholders in the company.

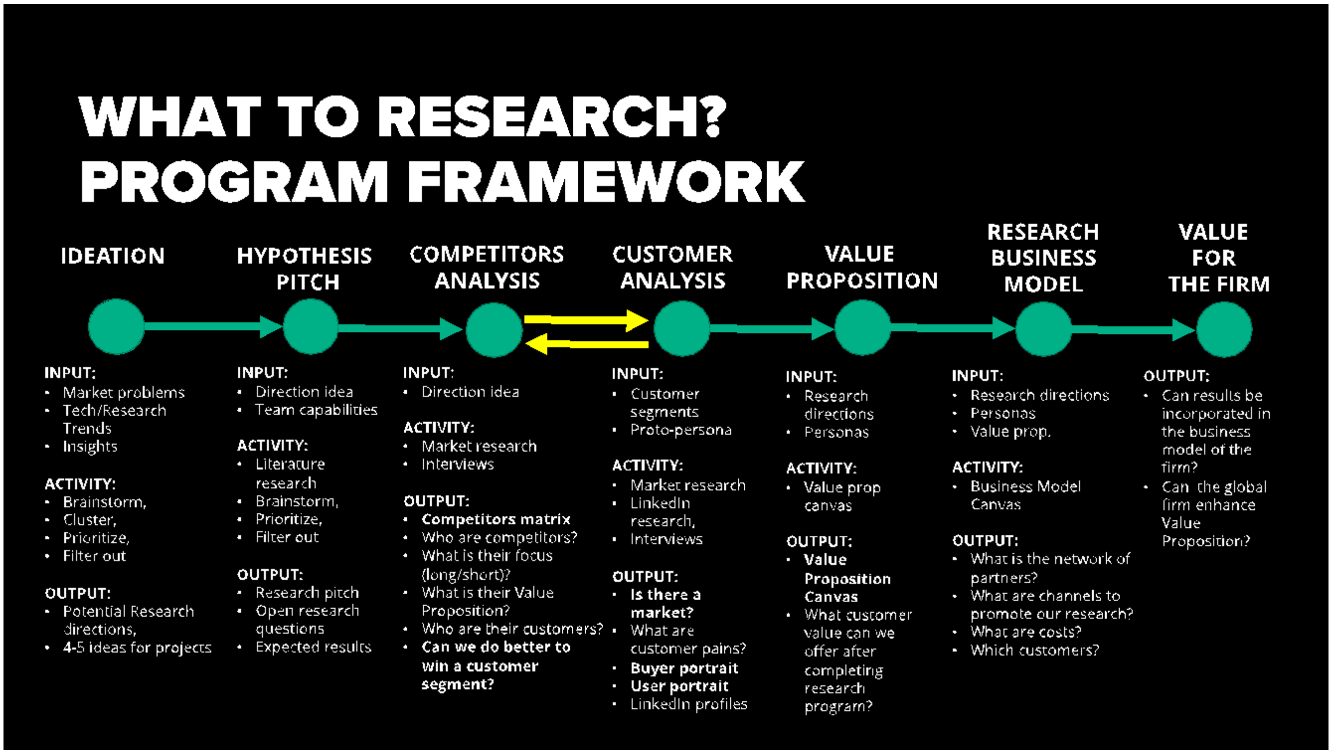


Figure 12 Research program ideation framework allows researchers to nail down possible most impactful research directions and early on visualize the success of the research program.

3.9.2 Portfolio organization

To organize a portfolio of research projects the author uses the 3-Horizons framework along with the grouping activities into the five categories following Merten and Ryu 1983.

- Background research
- Exploratory research
- Development of new commercial activities
- Development of existing commercial activities
- Research services

In terms of number of projects the resulting distribution is pictured below.

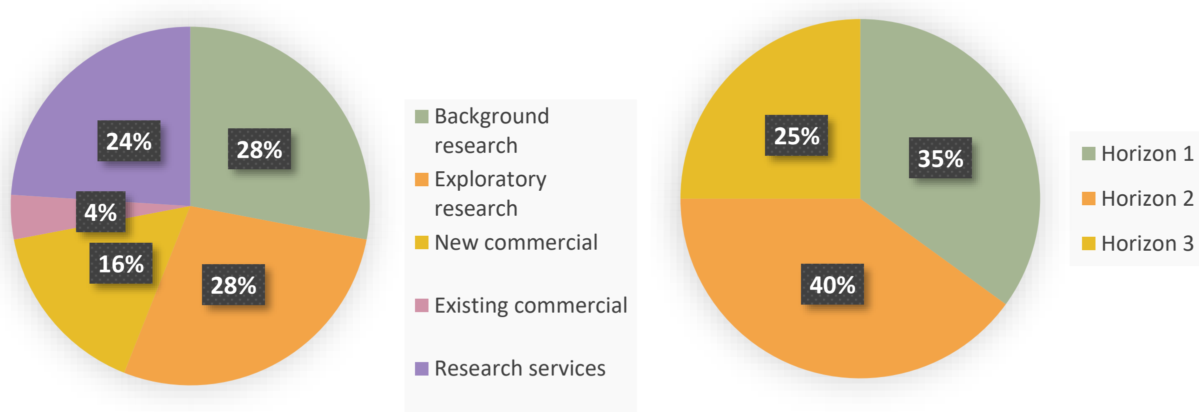


Figure 13 Distribution of the projects portfolio over the categories (left) and Horizons(right)

From the number of projects the largest bucket is of new and existing commercial tracks in the form of pre-sales or up-sales. However, in terms of the time spent this can be counted as 1/4 of a typical research project from other buckets. After renormalizing this boils down to almost equal time spent towards the background research, research services and exploratory research.

While the Background research is of the similar weight as Exploratory the majority of the former is done outside the main R&D team via the Academic partnerships and internships.

To form a **Horizons view**, the presale activities were removed from the consideration. In this sense the current portfolio forms the largest component in the Horizon 2 research activities with customer projects and commercialization use-cases mainly falling into Horizon 1 in the form of research intensive advanced development projects. Nevertheless, the team invested significant attention into the prospective technology of Horizon 3 focusing here on partnerships with academic research labs.

3.10 **Technology commercialization in a service firm**

A well designed research program allows one to quickly reach an edge in some particular domain and build a portfolio of IP artifacts. However, without the further active steps in the commercialization the results will see little to no adoption, which is quite common in case of academic research.

In this sense the most important step in the transformation of R&D was establishing a well-defined commercialization framework.

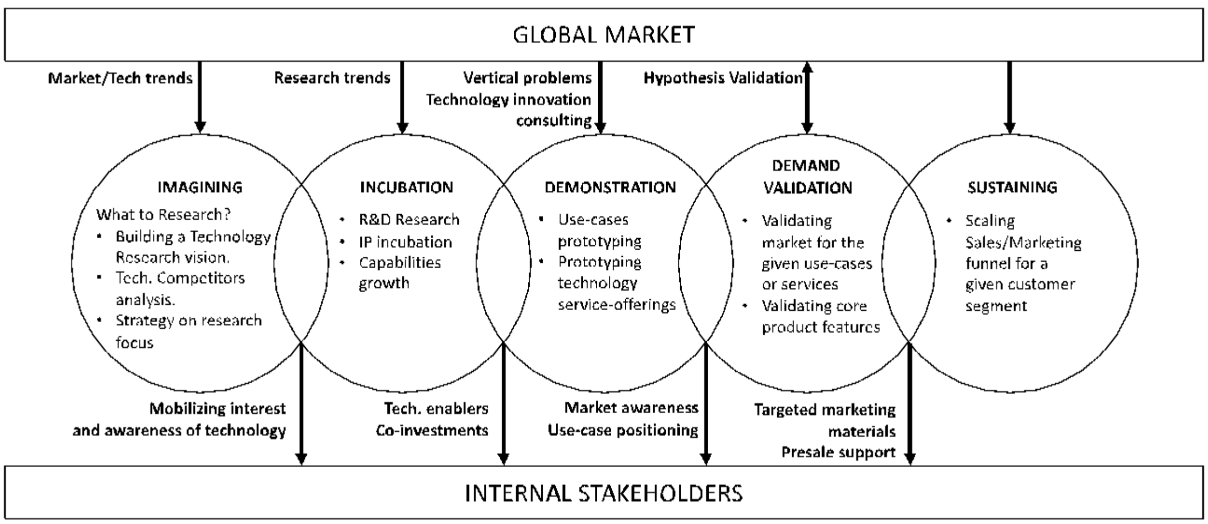


Figure 14 Technology commercialization framework for the service R&D unit.

The resulting process in our R&D department is similar to Jolly's framework with some adjustments for the particular case see Fig 14. Here we have 5 subprocesses to move technology from ideation to actual customers of technology or solutions with a big enough market. The framework clarifies actions that have to be performed by the Research and Product team at different stages.

IMAGING

This is essentially the Program definition step described above where the Research team is focused on technology and scientific excellence of a research and Product team verifies that there is a potential market.

Mobilization of the interest of various stakeholders is done via multiple blogs and concept articles spread inhouse or via a number of digital channels.

INCUBATION

Here the Research team performs research that results in a number of technology IP artifacts (see Fig 15) and grows competence in a particular domain by creating and presenting and validating them at industry events.

The Product team assists researchers in:

- identifying possible channels to promote and validate research,
- identifying stakeholders and possible customer persona for the technology development service offering
- preparing and validating technology service offering

The further mobilization of new stakeholders is needed to attract additional investments and support from Delivery and Sales organizations. Here the detailed market research and competitive analysis of technology provides a lot of value.

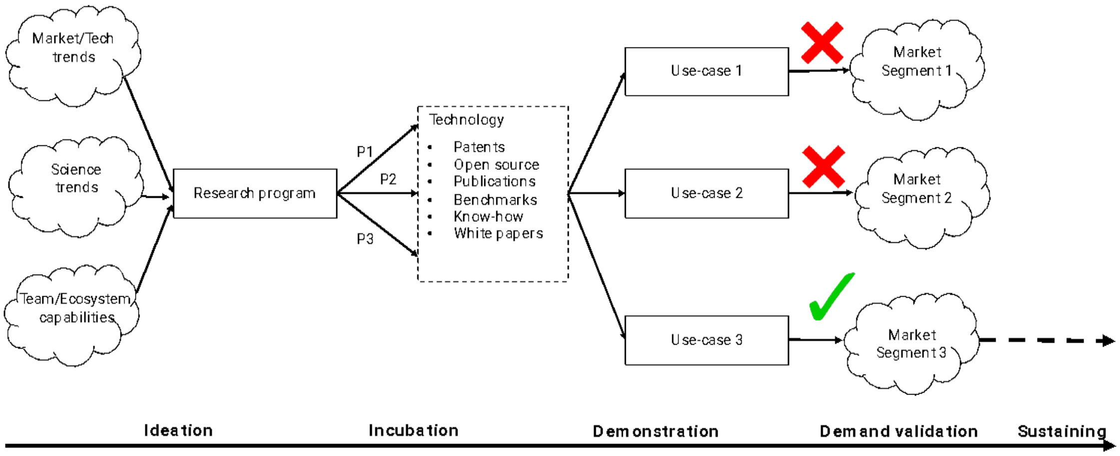


Figure 15 Research Commercialization diagram.

DEMONSTRATION AND DEMAND VALIDATION

Here the Product team takes the leadership in communication with the market in a number of verticals and identifying problems in which the developed technology enables disruptive solutions.

Before building prototypes, hypotheses are verified via interviews, blog posts, workshops or fake landing pages. The successful prototype is developed further into the MVP and is supported by marketing campaigns targeted on specific customer segments.

SUSTAINING

Finally, the use-cases that passed the earlier stages reach the sustaining phase during which a cross-company team supports the launch of internal product or solutions focused services.

3.11 Financial model concept

Best practices of Service R&D firms combine IP generation with service research and licensing. To demonstrate this concept below is the example budget table of a hypothetical R&D unit that starts to grow revenue pipeline from scratch.

The dynamics in the table for 2019-2020 period reflects the dynamics of a R&D unit in a Global Technology Consulting firm considered in this case-study (The exact numbers are dimensionless and rescaled).

1. To keep research projects running the maximum utilization rate for the R&D unit is set to 0.3. Spending another 1/3 of the time on commercial activities (see pie charts above) saves approximately 1/3 time on pure research activities. In cooperation with academic and technology partners such an amount of resources is sufficient to generate IP for further commercialization.

2. The Account Profit Margin (APM) is kept rather high (0.6) as research can be considered as a high-margin work. The margin is growing with time as more research would reuse parts of the in-house IP, increasing the resulting efficiency.

3. The supporting and marketing costs equal 40% of the salary budget. With the overall budget growing 30% percent YoY.

4. The licensing fee stands for the hypothetical fee for an artifact used within a customer solution. For example, fee for a specific SDK for edge image processing charged per camera device.

From the table below, we see two observations.

1. Pure service research component is poorly scalable. But without in-house 30% of pure research component research team quickly becomes obsolete in terms of fresh ideas and unique set of technologies in hands. Hence, here the only possibility to scale up the revenue is increasing the profit margin – this already has a limited room to rise.

2. Licensing scheme allows to detach possible generated revenue from the number of researchers in the team. Here the scaling becomes dependent on the marketing efforts and could be natural via gradual injecting of own in-house technologies into service projects.

The cartoon scheme in the table below showcases that even with a relatively small number of sold licenses the unit can quickly reach breakeven point.

Table 2 Naive budget example to demonstrate poor scaling of service components in comparison to IP licensing scheme.

Naïve budget example	**H1 2019**	**H2 2019**	**H1 2020**	**H2 2020**	**H1 2021**	**H2 2021**	**H1 2022**	**H2 2022**
Salary Budget	10000	10000	13000	13000	16900	16900	21970	21970
Service Utilization	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Account Profit Margin	0.6	0.6	0.65	0.7	0.7	0.75	0.75	0.8
Service Revenue	5000	7500	11142.86	13000	16900	20280	26364	32955
Supporting Costs	1000	1000	1300	1300	1690	1690	2197	2197
Sales & Marketing Costs	3000	3000	3900	3900	5070	5070	6591	6591
IP Licence fee	50	50	50	50	50	50	50	50
Licenses sold	0	0	0	10	40	160	640	640

Licensing Revenue	0	0	0	500	2000	8000	32000	32000
Total Costs	14000	14000	18200	18200	23660	23660	30758	30758
Total Revenue	5000	7500	11142.86	13500	18900	28280	58364	64955
Gross Profit	-9000	-6500	-7057.14	-4700	-4760	4620	27606	34197

3.12 **Ecosystem management**

Ecosystem management is crucial for the successful R&D and one of the **first actions to perform** in this transformation effort **was to establish a set of strategic technology partnerships with a number of academic institutions and technology firms**.

- This allowed them to quickly gain access to some bleeding edge technologies and immediately focus on practical use-cases for commercialization and service offerings.

- It allowed to quickly ramp-up the engineering team into the research team via collaboration on projects driven by tech or academic partners.

- A strategic partnership with one of the research labs allowed to move a number of background basic research projects into a well suitable academic environment, while the team focused on further commercialization of the results.

- Participation in collaboration networks increases the credibility of a research team and serves as a strong differentiator in comparison to competitors in the Technology Consulting space.

Figure 16 A WorldHaptics2019 conference participant interacts with touchable bio-hologram - an in-house technology developed in partnership with a leader in mid-air haptics space [https://ieeexplore.ieee.org/abstract/document/8951913]

3.13 **Transformation results**

As was discussed in Chapters 2 and 3, the success of R&D organization has to be tracked not only by standard ROI measurements, but via a number of additional metrics to track activity on different fronts.

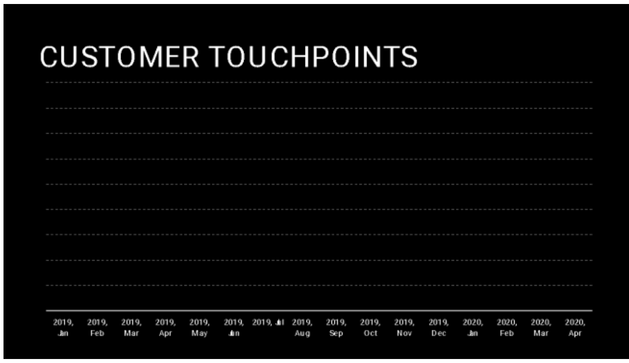
Here the metrics were defined for different aspects of R&D activities:

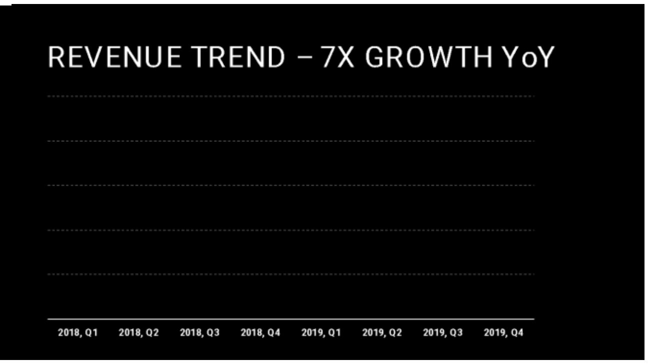
- Direct metrics (Revenue and Budget)
- Sale support (Number of touchpoints, MQL leads and closed deals)
- Access to new markets (MQLs and new offerings)
- Research and Commercialization (Number and quality of artifacts, MQLs, implementation of developed technology in the projects, licensing revenue)
- Indirect metrics (indirect revenue, percentage of new logos with R&D presale participation)

First and quick effect of Transformation was that R&D started to generate a number of quality MQL leads during the Research programs Commercialization activities and particularly via pitching at industry events. Unlike rather vague company messages these pitches were around particular focused directions that eventually generated better discussion points and interest from customers.

Second, during the competitor analysis we identified that developing Technology Innovation Consulting capabilities would be a good initial point for growing the service pipeline for the team. To this end a number of team members were selected as prospective consultants and were trained to interact directly with customers. The team developed its own branded Technology Innovation Framework that allows it to efficiently run workshops with the customers, identify potential future technology solutions and then develop and scale them with the research and engineering team.

Third, by restructuring the team, growing leadership and identifying consulting-level members the number of **customer touchpoints** rapidly grew from nearly 4 in January 2019 to 17 in March 2020. This as well as focus on a set of narrow domains with a corresponding portfolio of case studies allowed it to win a number of service R&D deals that lead to more than 700% increase in revenue. While these are not yet licensing or product deals, most of them were built around technology competence and artifacts developed within the research programs. Working on such projects further contributes to competence, domain understanding and corresponding IP development.





Fourth is the Culture. We aimed to hire new members with a proven research background and preferably international research experience. This gave positive examples to the team in work ethics and approaches. A lot of internal tips and tricks were grabbed from successful examples in academia – knowledge sharing seminars, journal clubs, literature overviews, quick search for open research questions, contributions to scientific conferences. The final research artifacts outcomes in terms of whitepapers and research papers was almost 10x higher than during the previous years.

Adding some of these approaches to customers' projects allowed them to highly impress customers with proactiveness in finding solutions to their problems.

3.14 **Challenges**

Transformation of an existing team is usually a challenging task that along with standard change management complexity is related to the natural capabilities of the existing team and already installed culture.

The complexity of the existing transformation was manifold.

1. The team initially had the wrong assumption that R&D research is a-priory non-commercializable, unpredictable and cannot be packed in a service offering. The research directions had little to no market component, guided mainly by the strength

of initial demonstration effect and “just because we can” approach.

Here the solution was in communicating effectiveness of the technology commercialization methodology and successful cases of research results submitted to top tier research conferences. This in turn allowed them to bring in customers who focused particularly on such solutions.

2. Instead of integrating into the ecosystem the team was considered as a black box without much idea validation and interactions with other players.

3. Large fraction of the team had a pure engineering background with little to no research experience and corresponding network components. Hence finding a good research topic, taking a leadership and reporting on it was a non-trivial exercise in the first months after the transition. Here an important strategy was to carefully select new hires that could bring in an actual research DNA.

4. Changing the “black box” perception within the organization turned out to be a challenging task on its own. R&D leadership team participated in multiple cross company events to educate colleagues on a new vision and possibilities to embed R&D services into various customer offerings.

5. The crucial challenge appeared in misalignment between R&D long-term focus and tactical focus of Sales, Marketing and Delivery organizations.

4 CONCLUSIONS

1. Setting up an R&D organization is a complex and long-term game. The research results may sometimes remain invisible or in a successful case could affect each and every department in the company. Successful R&D departments have many commonalities in terms of typical technology development and commercialization activities and managing people, ideas, funds and culture. This concerns all types of organizations from academic labs to industry research departments and service research labs.

Having multiple positive examples, it is worth reusing and adapting common models for R&D organization, technology commercialization frameworks and necessary metrics rather than reinventing them from scratch.

2. One of the commonalities between different R&D labs is the kind of people working in research. Usually with the background in hard science such individuals run via self-selection already during the graduate times resulting in ability to work highly autonomously and presence of strong internal motivation. This, however, leads to more complex team dynamics and management of such groups. Selecting the right individuals for R&D team based on careful assessment of soft and hard skills is one of the crucial activities for the manager. At the same time, it is important for R&D manager to share some of these qualities and be able to provide visionary support for the team members.

The successful approach in the provided case study was to hire individuals with extensive international experience, i.e. graduate and post-graduate studies, internships or work experience at global high-tech companies. This in most times guarantees high adaptability of the person, understanding of cultural differences and good problem-solving skills.

3. Focus is the crucial quality for the successful research team and with the multiplication of new trends, external and internal drivers it can be easily lost. R&D team needs to have a well-defined strategy and vision of how the few focus areas fit into the global technology and market trends.

Selecting the right research topic based on early validation of the market trends and user pains is in the core of most technology commercialization frameworks. It also provides a strong drive and feel of purpose for the research team working on new technology.

4. Service R&D serves as a fuel to multiple technology clusters across the world. Providing expertise on repeatable development of new technologies and access to scientific insights such firms allow to reduce technology and market uncertainty both for large enterprises and for growing startups.

A good Research Program provides unique technology artifacts and IP. It is both a useful start to develop new service offerings around it and licensing schemes for service R&D as well as to boost new product development in the product company.
A successful partnership ecosystem can allow to speed up building a technology portfolio and provide access to rare expertise.

5. It is not enough to brainstorm a good idea or even develop new technology. If no steps are done to bring it to market it will die and never get the necessary attention. Technology commercialization provides a complex set of steps and actions at different stages of technology research maturity.

It is important to constantly mobilize both internal and external stakeholders, i.e. budget owners, customers, sales and marketing organization to ensure that results of R&D research actually reach market and bring the maximum value.

6. To embrace the value of R&D, the R&D strategy should be a company-wide strategy with all the necessary support being available for a successful technology commercialization process.

For the established organization that struggles to grow R&D it is important that Marketing, Sales, Product and Delivery business units have some KPIs and objectives that are well aligned with the objectives of R&D strategy.

The corresponding Sales and Marketing organizations should have dedicated resources to address narrow market segments.

7. Service R&D units in the larger organizations may sometimes have a somewhat orthogonal focus to the main firm. This is reflected in necessity for quick hypotheses validation in the custom market segment, necessity for pilot projects, etc. In this respect many of the successful R&D service firms act as independent entities even if they are a part of the larger parent company.

Spinning off a separate venture like Continuum (EPAM), Cambridge Consultants (Altran), PARC (Xerox) provides significantly more freedom for efficient technology commercialization and piloting. On the other hand, it is important to maintain strong enough connections for further scaling and maintenance, using the resources of the parent firm.

8. Finally, as demonstrated in the cartoon budget table above, the pure Service R&D component is poorly scalable due to lower availability of such high-skilled talent and necessity to keep utilization rather low.

Commercialization of IP not only via research services but via licensing schemes allows to detach actual profitability of a unit from a number of employees in it.

In the large technology consulting firms this is somewhat compensated also via indirect ROI in the form of further scaling of projects via commodity engineering services.

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