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# The Breakthrough Factory

## *A concept for serial breakthrough innovation*

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One of the key challenges for large corporations looking to achieve "Breakthrough Innovation" is that technology-intensive businesses usually need to research deeply into science in order to find breakthroughs. The challenge is particularly daunting for mature companies. In this article the authors discuss the concept of the Breakthrough Factory as a means of maximizing the probability of Breakthrough Innovation for this type of company.

Most large corporations in the non-digital sectors struggle to find the best way to achieve "Breakthrough Innovation" (as described in "Organizing for Breakthrough Innovation" on page 12). The challenge is especially daunting for mature companies whose products are technically complex and have long lifecycles requiring significant investment to develop further. In such situations companies often set up a small internal team with the aim of focusing on longer term breakthrough innovation. However, these teams often fail to deliver the expected benefits. Either they become disconnected from the core business, or they spend too long pursuing unattractive concepts, or else in order to demonstrate business value they give up on being truly "breakthrough" and instead move towards more short-term, incremental innovation.

One of the key challenges is that technologically-intensive businesses usually need to research deeply into basic science in order to find the breakthroughs, in both their own, and other, industries. This is not easy: How do you identify game-changing future technologies and science that can significantly impact your industry? How do you push this science forward at a fast enough pace to suit a corporate rather than an academic environment? How do you engage with the high caliber specialists required to deliver these milestones for you? And how do you ensure that your company benefits from its investment in terms of being able to systematically produce game-changing technologies and products with at least a degree of continuity?

There is no single model that will address all these issues for every company. However, one model in particular, which we call the "Breakthrough Factory", shows promise. It is especially effective for mature companies in technology-intensive industries that already have well-functioning innovation processes and governance, but find it difficult to stretch beyond producing incremental innovation.

## The Breakthrough Factory

The Breakthrough Factory is a concept aimed at maximizing the probability of delivering breakthrough innovation in mid to large-sized corporations. It leverages science to create the new knowledge required to achieve a specific breakthrough. The concept is most powerful for producing highly novel outcomes in industries where there are high levels of technology intensiveness and complexity, as shown in Table 1.

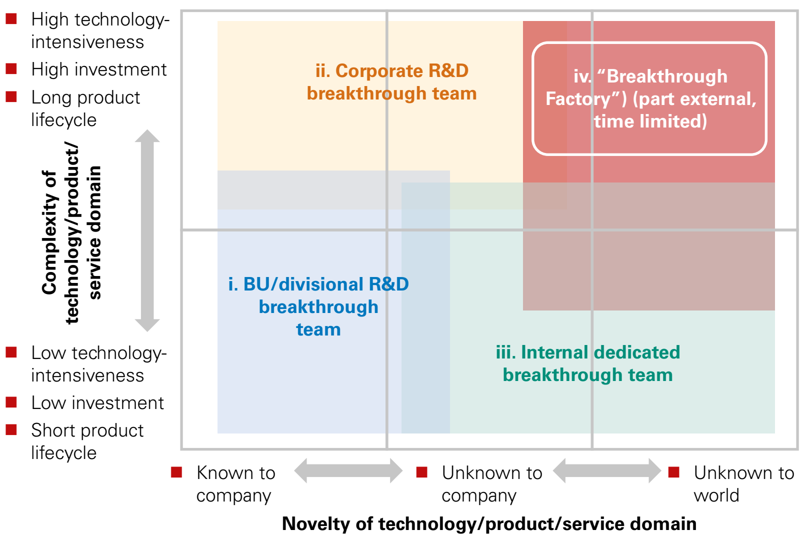



Table 1 **The Breakthrough Factory uses time-limited teams consisting of mainly external resources** *Source: Arthur D. Little analysis*

The core of the concept lies in deploying **use-inspired research** (such as Stokes' theory of "non-linear" innovation) to significantly enhance the probability of creating short-term breakthrough innovations, as illustrated in Table 2. The fundamental concept has been used by the US Defense Advanced Research Programs Agency (DARPA) for several decades to create significant breakthroughs such as the Arpanet (the precursor to the Internet), Global Positioning System (GPS), Micro-mechanical machines (MEMS) and stealth aircraft, amongst others.

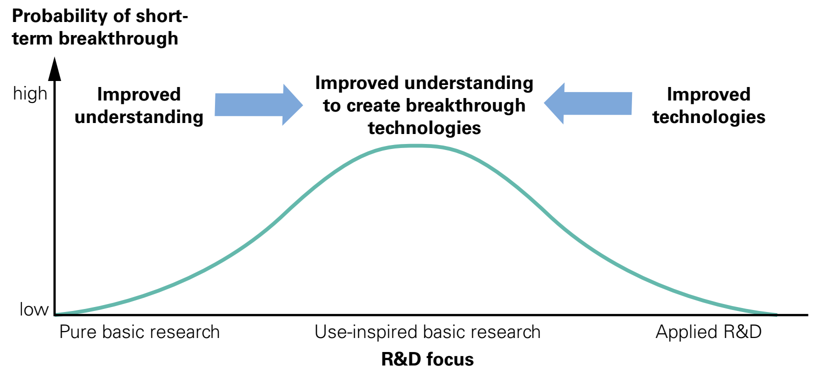


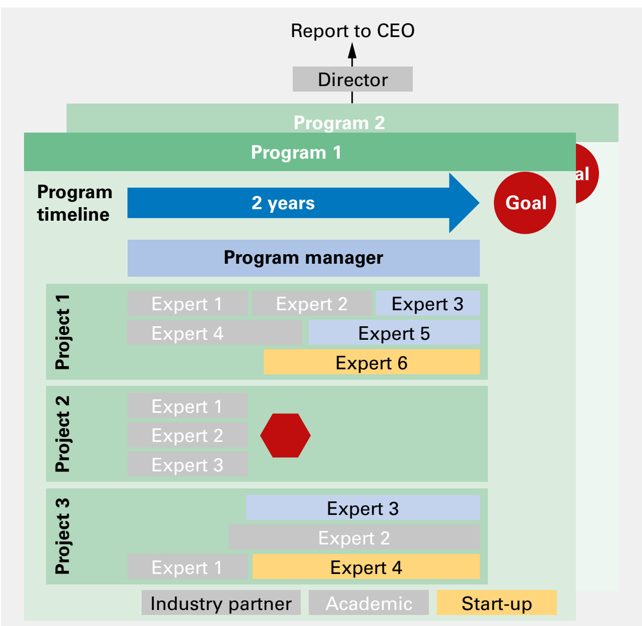

Table 2 **Increasing the probability of short-term breakthrough innovations by employing use-inspired research** *Source: Arthur D. Little analysis*

Corporate R&D has a predominant focus on user-needs, rather than trying to build the fundamental understanding needed to create breakthroughs (as shown in the right hand section of Table 2). These R&D efforts use existing technologies to create improvements through added functionality/features. Hence there is only a limited element of surprise, the key ingredient to produce a breakthrough, in the final outcome. On the contrary, projects with a focus on pure, basic research build upon existing insight with the ambition of enhancing understanding and expanding fundamental knowledge. In this case there is a potential to create a large element of surprise, but as the projects are completely decoupled from user-needs, any commercial breakthrough is likely to take a very long time.

In use-inspired basic research, the focus is on improving fundamental understanding in order to create technologies and products to meet a specific customer need. Here, basic science is used to create the element of surprise, but always carried out with a well-defined target in mind. The Breakthrough Factory is devoted solely to use-inspired basic research that maximizes the probability of short-term breakthrough innovations. Hence it is strongly objective-driven, combines market pull and technology/science push, and is subject to stringent time constraints, even though the projects always include some degree of basic research. Box 1 shows an example of how such research was used to create the world's lightest and strongest materials.

## Organizing for autonomy

Organizationally, the Breakthrough Factory is an autonomous unit within a corporation, which reports directly to the CEO, as shown in Table 3. The factory only employs limited numbers of permanent employees, mainly a Director and a few administrative support staff. The remaining organization is built on temporarily contracted staff, both from within the company and from the outside. The internally recruited staff are key for future knowledge transfer, while the externally recruited staff are critical to achieve the required depth in science and technology.




**Breakthrough Factory in brief**

- An autonomous unit within a company, which operates directly under the CEO
- Runs a set of use-inspired basic research programs with a clear objective of solving a pressing issue or satisfying a well-defined market need
- Each program is time-limited and temporary – it either delivers a result or else it stops quickly, with no collateral damage
- Programs are mainly performed by temporary expert staffing – competence is constantly shifting depending on the needs
- Allows companies to utilize the very best people, even though they may not have the normal profile of full-time staff (most avid scientists would not want to be a "staffer" anyway)

Table 3 **Organizational structure of the Breakthrough Factory and example of a multi-project program**

*Source: Arthur D. Little analysis*

### Box 1: Use-inspired research to achieve ambitious goals in a short time frame

By definition use-inspired research means that a certain level of basic science must be performed. This creates the element of surprise needed to reach very ambitious goals. However, performing basic research in a corporate setting and in a very short time frame requires new ways of thinking and working.

The need for new lightweight materials is a pressing, industry-wide challenge, as such materials are required to enable the next generation of energy efficient aircraft, cars, trucks, and construction materials. A traditional R&D approach would be to invest significantly in basic science, such as by developing new metal alloys and tailoring new polymer chemistries to produce higher strength versions (see Table 4). This process usually takes decades and is not likely to result in a performance increase of more than a few percent.

In a use-inspired research program at DARPA, the first task was to build a fundamental understanding of how a material's strength is scaled with its weight using basic science. Researchers asked fundamental questions, including "What variables govern the strength of a material?" and "How can we manipulate them to create new material properties?". Through an initial seed project with a small group of world-leading scientists, DARPA acquired the scientific knowledge to map the "material-property space" which defines the physical limitations in creating new materials, and gives answers to the question of what type of materials can theoretically be achieved, and how it can be done (see Table 4). This fundamental understanding of material behavior resulted in the development of a new class of ultra-lightweight, foam-like materials, which can be up to 100 times lighter than conventional metals, in as little as 2 years. The new materials have a range of applications where high performance and low weight are key to being competitive. As an example, each kilogram of structural mass in an aircraft is estimated to be worth $500. This is why aircraft manufacturers constantly strive to find new lightweight materials such as the ultra-light, foam-like materials developed by DARPA.

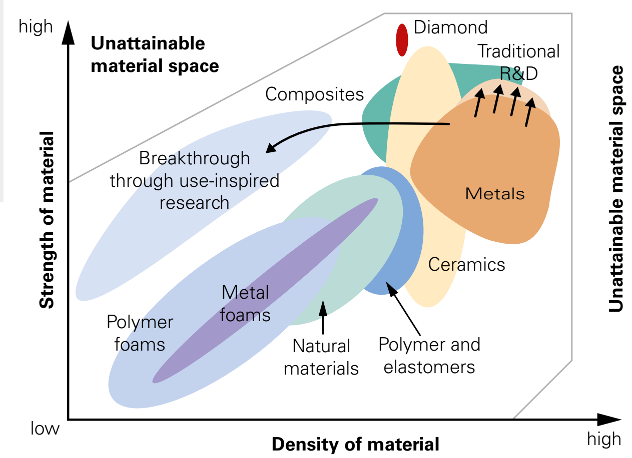



Table 4 **Material-property space chart and ultra-light, foam-like materials**

*Source: Courtesy of University of Cambridge, UK*

## Strictly time-limited programs and contracts

The factory runs a number of parallel programs which all have a well-defined objective of either solving a pressing market issue (which is generally known but no solution exists), or finding potential applications for emerging science and technology. Each project is led by a Program Manager who is typically given a 2-4 year period to reach the objective of the program, see Table 3. The Program Managers, being experts in their respective fields, are expected to plan the route to reach the objective by clearly identifying the critical scientific hurdles that need to be overcome. He/she will then make use of high caliber temporary staffing from academia, startups and other organizations, to overcome the hurdles and generate knowledge in a target-oriented, fast-paced manner. Every single temporary employee within a program will be there to solve a specific task over a limited time period, and once the task has been solved (or been proven to be unfeasible to solve within the given time constraints) the employee will either be reassigned to a different task or leave the program.

A program can be as small as 1-2 academic researchers and 1-2 startups, or it can range to more fully-fledged programs involving multiple university research groups and SMEs. Program Managers are recruited by the Breakthrough Factory Director once the overall strategy of the factory has been defined and the different strategic areas in which the Director wants to make progress are set. The candidates to become Program Managers are assessed based on their personal achievements, their contact network in the related scientific field, and how they recommend designing the program to create a specific breakthrough.

Time-limited and use-inspired basic research projects are scarcely found in the corporate world. One example is however Google's Advance Technology and Projects group (ATAP), which has achieved significant breakthroughs in a very short period of time, see highlights in Box 2.

## Value generation in multiple dimensions

In addition to being a growth engine that systematically provides breakthroughs, the Breakthrough Factory is an opportunity to reinforce brand image and strengthen market position as an innovation leader. The Breakthrough Factory is used both as a way to hedge against technological disruptions and to move into currently unex-

### Box 2: Google ATAP

Google ATAP is a stand-alone unit, under the leadership of a former DARPA Director, which employs use-inspired research programs to create breakthrough products. Originally set-up by Motorola and later acquired by Google, the unit focuses on the Telecoms industry and consists of a relatively small staff but with a large network of partners from countries around the globe. All Google ATAP programs results in products that are scalable and possible to commercialize. They currently have several ongoing programs. Below we highlight achievements in two of them.

**Project Ara:** The idea behind Ara is to make Hardware and Software equal for mobile phones, essentially by making hardware "Apps". The user should be able to add modules to incrementally upgrade their phones and tailor it to their specific needs. The main challenge of producing such a modular phone is to ensure that it is not bulky, slow, costly, power-hungry or simply ugly. Furthermore, the modular interface needs to be simple enough so that it is easily accessible to hardware developers outside the telecoms industry. With only a handful of employees at Google ATAP, Project Ara has used a network of specialists to push science forward in many fields, covering everything from novel electro-permanent magnets that can latch components, to designing antennas that can be moved and reconfigured. The result is a fantastically slim, appealing and fully customizable phone, created in just a few years.

**Project Tango:** The idea behind Tango is to develop a sensor that can see the world in three dimensions (3D) in the same way as the human eye does. Tango is a multi-camera tablet with the ability to create a 3D rendering (map) of its user's surroundings. It can be used for improved indoor navigation for the visually impaired, it can provide step-by-step directions within stores as well as to create more immersive videogames. The small ATAP staff has worked with universities, research labs and industrial partners spanning nine countries in order to build on the last decade of research in robotics and computer vision and concentrate that technology into a unique mobile device.


Picture by lightwise / 123RF



plored businesses with a large market potential. It also provides attractive development opportunities for talented scientists and engineers within the company and a "home" for radical ideas which are not likely to be pursued within the more incrementally focused R&D departments of an organization.

With its relatively small permanent staff and high degree of temporary resources the Breakthrough Factory can be extremely flexible and responsive to changing circumstances and opportunities. The same goes for the funding of the programs. Despite the high technical uncertainty the financial stakes are limited thanks to the tight time constraints imposed and iterative approach of generating knowledge and demonstrating progress.

## Insights for the executive

The core characteristics of the Breakthrough Factory, as summarized in Table 3, offer promising opportunities for mature companies in technology intensive industries that already have well-functioning innovation processes and governance, but find it challenging to stretch beyond incremental innovation.

Experience shows that setting up and successfully operating a Breakthrough Factory requires careful attention to the very aspects that make the concept unique:

- Independence from the rest of the organization
- Use-inspired research (pushing science and technology to solve an acute need/problem)
- Lean and flexible organization made up of temporary resources and networks of universities, startups and other SMEs
- Encouraging failure and promoting knowledge creation
- Strict follow-up of progress in terms of knowledge creation with funding linked to progress and the ability to deliver results within a defined time window.

Once up and running the Breakthrough Factory is an effective and cost-efficient model to systematically generate a pipeline of breakthrough innovations, driving growth and hedging against disruption.

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