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NEW INNOVATION ACTORS

Design and Technology in the Interest of Society

Danish Design Centre

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Preface

This report is a preliminary study of the future role of design in innovation, the innovative landscape and new innovation actors. The Danish Design Centre prepared the report for the Danish Business Authority.

The report is intended as a basis for debate and will be followed up by additional studies of the current and future role of design.

As part of this preliminary study, we visited 38 organisations and conducted more than 50 interviews in Denmark, Europe, the United States and Japan.

Since 2013, the Danish Design Centre has worked with the Danish Business Authority to develop a clearer understanding of the role in design in innovation in companies, among entrepreneurs and in new societal experiments.

There are many indications that the innovative landscape is changing, and that design will play a new role in the future, entering into new constellations with other disciplines and making important contributions to innovation, job creation and growth.

The report will be debated at the international conference Future Design, which is held at the Danish Design Centre on 3 September 2014. Throughout autumn 2014, the information and data collection continues. Additional chapters about design-led start-up environments in the Øresund region and their role for design are under preparation. The Danish Design Centre will publish the final report in early 2015.

The report was written by Chief Operating Officer of the Danish Design Centre Anne Dorthe Josiassen and external consultant Jørgen Rosted. Manager of Policy Analysis Tanja Bisgaard and external consultant Casper Høgenhaven have contributed with case studies and background analyses.

Anne Dorthe Josiassen
Chief Operating Officer

Danish Design Centre, August 2014

There are clear indications that the innovative landscape is changing, and that design will play a new role in the future.

Introduction – Major Challenges in the Fog

In 2012, the Danish government established a committee, the Growth Team for Creative Industries and Design.[1] One element in this effort was a mapping of design firms in the Copenhagen Capital Region. The mapping was based on information from the social media and aimed to build a database where companies looking for project partners could find knowledge about design firms in the region.

The Danish Design Centre continued the effort to develop this database, and The Danish Business Authority suggested basing the initiative on industry's future need to cooperate with design firms and other creative enterprises.

There are clear indications that the innovative landscape is changing, and that design will play a new role in the future. The classic design tasks are not going away; they are changing due to global and technological developments, but they will continue to exist, and design is going to enter into new constellations with other disciplines and play a new role for innovation, job creation and growth.

In connection with the effort aimed at the creative industries, the head of development in a large pharmaceutical company pointed to the need for an experimental lab. The company had the ongoing improvement of its product portfolio well in hand and had several new products in the pipeline, but perhaps that was no longer sufficient. The company was looking for better answers to future challenges, and maybe an experimental lab could facilitate these answers.

The company had outsourced much of its production and had spare production buildings that could easily house several experimental labs, but how would the pharmaceutical company find the creative companies and talents to take part in the experiments? And how should the lab be organised?

1 http://erhvervsstyrelsen.dk/vaekstteam_for_kreative_erhverv

The growing complexity and lack of predictability are phenomena that affect all industries, and all corporate leaders have to find a way to navigate in the fog.

The 2013-edition of the CEO study from Duke University about future leadership challenges, points out that, *"We heard from leader after leader that, though change has always been a significant part of what they have had to deal with, now the pace and nature of it is dramatically different. … Predictability has decreased substantially, so much so that the notion of being able to 'see the future' has almost been lost. And complexity has shot up – everything seems to be interconnected and interrelated. We now live in the 'networked' world, where systems are key and a small change in a distant place, can lead to dramatic effects that could not be foreseen."*[2]

In spring 2014, the founding partners of the innovation and strategy consultancy ReD Associates published *The Moment of Clarity*, which sets the stage with the follow introduction: *"An executive at Intel wakes up every morning with a cold dread over his body. He has spent the majority of his career working toward better laptop engineering, but he can't shake the feeling that laptops themselves will become obsolete in the next few years. Everything he is planning for the future feels wrong."* The first chapter in the book is titled Navigating in a fog.[2]

The growing complexity and lack of predictability are phenomena that affect all industries, and all corporate leaders have to find a way to navigate in the fog.

Jørgen Mads Clausen, chairman of the board of Danfoss A/S and the former CEO of this Danish industrial giant, points out that ubiquitous online connectedness is a crucial aspect of the next big development. *"But that is still a new world to Danfoss, and unless we get a handle on it, another company might simply leave us behind,"* says Jørgen Mads Clausen.

He does not, however expect to see large multinationals spearhead the radical innovations of the future. The leadership in large corporations has to keep a constant eye on the bottom line and respond immediately to any upsets. The major changes are not going to come from the top-down, from the big corporations. Radical innovations, like ubiquitous connectivity, is too risky for the big corporations.

2 Duke Corporate Education 2013 CEO Study: Leading in Context page.
3 Christian Madsbjerg and Mikkel B. Rasmussen, *The Moment of Clarity – Using the Human Sciences to Solve Your Toughest Business Problems*. Harvard Business Review Press, Boston Massachusetts, 2014.

The major innovations have to come from small and medium-sized enterprises working with universities and research labs. The big corporations need to follow their lead and build on the new developments, and, as Jørgen Mads Clausen reflects, *"Maybe Danfoss shouldn't develop the IT add-on themselves but instead need to find the right partners."*

The Danish pump manufacturer Grundfos sees new opportunities in making it easy and appealing to reuse as much as our water supply as possible. The water should be purified and upgraded the required level. That applies both to households and industrial processes. This should be based on local solutions, however, as it is both costly and inefficient transport water over long distances.

The development and introduction of new intelligent water solutions that combine a high level of quality with a more efficient use of water is a highly complex task, however. It requires large-scale experiments and trust-based collaboration among public sector companies, government agencies, universities and private enterprises.

Grundfos is ready to embrace these new ways of collaborating and experi-menting. According to Niels Due Jensen, chairman of the board for The Poul Due Jensen Foundation and the former Group CEO for Grundfos, *"Grundfos has a keen understanding of the need for external competences and partnerships to develop new sustainable water solutions, and of the need to establish partnerships based on close collaboration across scientific disciplines, which is something we haven't needed in the past and therefore have no tradition for."*

Creating radically new and sustainable water solutions also requires deep insights into user behaviours and needs. *"We need designers who understand human needs, and who can help design sustainable water solutions that meet basic human needs in cooperation with forward-looking manufactures,"* says Niels Due Jensen.

"At its best, design solves a problem so well that no one even notices that there ever was a problem."

Mads Øvlisen, former CEO of the Danish pharmaceutical company Novo Nordisk A/S.

In the future, thermostats, pumps and all other products will become more intelligent; they will have to collect information, produce data and receive signals and commands from other products and thus help to optimise complex systems. The Danish industrial company Linak A/S manufactures electric linear actuators for hospital beds and other purposes and is engaged in an ongoing effort to expand the company's business line, for example by making hospital beds more intelligent.

Linak has development partners that help the company deliver what the customers need. One of these partners is a start-up company with knowledge about building sensors into bed sheets. *"It is not enough, however, to deliver what the customers say they need; we should also tell them what's possible,"* says Bent Jensen, founder and CEO of Linak A/S. That puts great demands on Linak's insight into future possibilities, however, and *"if there are companies experimenting with the new technological possibilities, we'd like to join them in that, but how do we find them when we don't even know if they exist?"* asks Bent Jensen.

To ensure acceptable living conditions in the future we need radical changes in the way we use global resources. The way we produce and use energy have to change radically, and the same applies to all earth's other resources.

Anders Eldrup, former permanent secretary in the Danish Ministry of Finance and former CEO of the Danish energy company DONG, is convinced that it will be possible to transform our energy production over the next 30 years to give renewable energy a much more prominent role. He is also convinced that it is possible to retrofit existing buildings to make them substantially more energy-efficient. *"The technological possibilities are there, but it is going to take considerable investments and the cooperation of companies, universities and government. Today, the investments are insufficient, and the cooperation among the many actors needs to improve,"* says Anders Eldrup.

In the cities, the climate and resource challenge is pressing, but the potential for creating sustainable cities with jobs and good living conditions is also very concrete, and both larger urban regions and smaller urban communities are showing considerable interest in taking part in community experiments that may pave the way for new sustainable ways of organising our society.

… and it is this fundamental quality that gives design such a crucial role in creating a new society with decent living conditions.

However, community experiments do not appear out of thin air, *"they require new constellations that make the cooperation among the various actors their top priority,"* says Anders Eldrup, who is currently chairman of the board for Offshore Energy in Esbjerg, chairman of LORC, and the Danish cluster organisation CLEAN.

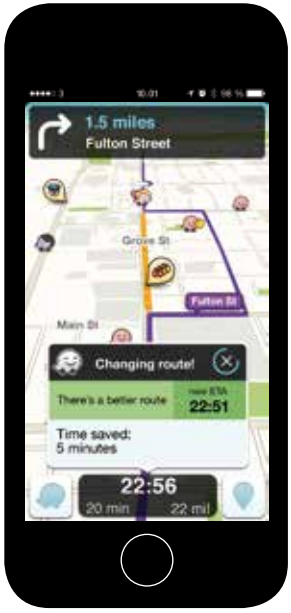
The high degree of social complexity and the virtual impossibility of predicting future challenges pose very difficult conditions for rational action. This affects everybody: companies, institutions and organisations as well as government agencies and political decision-makers.

We are facing a global reality where growing markets and opportunities are emerging in cultures where it is far from certain that past ideas and concepts will apply. We are facing technological possibilities that are so huge and allow for such surprising solutions that no one should assume that what works today will also work tomorrow. And we are facing climate change and dwindling resources, factors that threaten human living conditions.

We cannot turn a blind eye to these challenges, however daunting they may seem. As we have in the past, we need to find solutions, and we should expect the solutions to come from new sources. And fortunately, there are growing indications that this is happening. New actors are entering the stage, presenting new ways of creating change. New solutions need to be put to use, however, if we wish to change society, and that requires well-designed solutions. *"At its best, design solves a problem so well that no one even notices that there ever was a problem,"* says Mads Øvlisen, former CEO of the Danish pharmaceutical company Novo Nordisk A/S. And it is this fundamental quality that gives design such a crucial role in creating a new society with decent living conditions.

Chapter 1.

NEW ACTORS OF INNOVATION



The Waze app.

The Wi-Fi SmartPlug[4] allows you to turn on the light at home, and watch the power consumption, wherever you are. Waze[5] shows you the simplest way from point A to point B, and that means not only the shortest route but whichever is the fastest route right now. Via a smartphone and a Pro Heating Kit[6] you can adjust the temperature in your home wherever you are, and Edyn[7] ensures that the plants in your garden receive the optimum amount of water, without you even having to pick up a watering can.

But smartphone apps are not the only phenomenon indicating the new digital world that is emerging. Doctors can use robots to carry out remote surgery. You can buy a car that brakes automatically if you get too close, and robots can butcher pigs and fillet fish faster and more accurately than industrial workers.

There can no longer be any doubt that we are entering a new digital age by leaps and bounds, and to a high degree, this new age is being shaped by new innovation actors who are currently entering the stage in large numbers.

New Actors

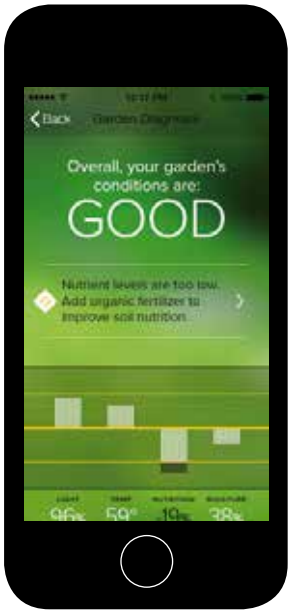
The automated smart home is about to become reality, and this development is not just driven by large multinational corporations. Many of the apps and other smart solutions for the home that are already on the market have been created by start-ups. To take full advantage of smart devices for the home, however, the devices need to be interconnected and able to exchange data, but that is not the case today, because we have yet to develop the 'internet of things'. That requires a common standard, but it is not obvious who should be in charge of defining such a standard.

The first common digital standard was the Global System for Mobile Communications, GSM. It was created by the large European telecommunications companies and the European Commission. There are no indications, however, that the 'internet of things' is going to be created in a top-down fashion. The issues involved are probably too complex. Due to the large and very diverse field of big and small actors, there is no natural hierarchy with a top tier to spear-head such a project.

4 http://www.fmj.co.uk/wi-fi-smartplug-from-northq-with-built-in-metering-temperature-and-humidity-sensors/
5 https://www.waze.com/
6 http://northq.com/pro-heating-kit/
7 http://www.edyn.com/

There are, however, indications that the 'internet of things' may be created from the bottom up, and that initially we are going to see multiple 'internets of things', which are going to compete to reap the network benefits.

The Danish start-up company NorthQ[8] makes intelligent digital solutions for electricity, water and gas, which are the most important elements in home automation[9]. NorthQ has also developed a standard, which other hardware manufacturers can integrate in their products that lets smart devices interconnect and be controlled by a smart unit no matter, which standard manufacturers uses. It will be a surprise if the key actors in building the 'internet of things' prove to be start-ups and small tech firms, but the possibility cannot definitely not be ruled out.



The Edyn app.

Most of us have had our mobile phone battery go flat at an inopportune moment, and then what to do? The next appointment is listed in the mobile calendar, and what was the address again? There is no way to call and ask for directions, because the phone is dead. There is little point in borrowing someone else's phone, because the number is listed under contacts in the dead mobile. And even if it was possible to borrow a charger, who has time to wait for the phone to charge?

Is the problem big enough to hold a business opportunity? Two young entrepreneurs in Los Angeles felt that it is. They contacted a large telecommunications company, which showed interest in the idea but did not wish to engage in the project until a viable solutions had been outlined. The two young entrepreneurs then contacted a large design firm, but they wanted payment up front.

Instead, the two entrepreneurs founded Rally Power[10]. They had no intention of developing the solution themselves, however; they were looking for business partners who would help them develop a solution for the problem of flat mobile phone batteries. An online search pointed them in the direction of Tomorrow Lab[11] – a start-up in New York, whose website stated that they had skills and experience within the relevant areas.

NQ-9300-EU, Z-wave Smart Plug.

8 http://northq.com/
9 http://en.wikipedia.org/wiki/Home_automation
10 http://www.rallypwr.com/
11 http://tomorrow-lab.com/

The two founders of Rally Power and the six-person staff of Tomorrow Lab engaged in a partnership based on trust and an agreement that they would sort out payment and IP issues later.

Together, the two start-ups have created a solution where the mobile phone is charged with a charging battery that could be rented from kiosks or other types of stores that are found on almost any street corner in the big cities.

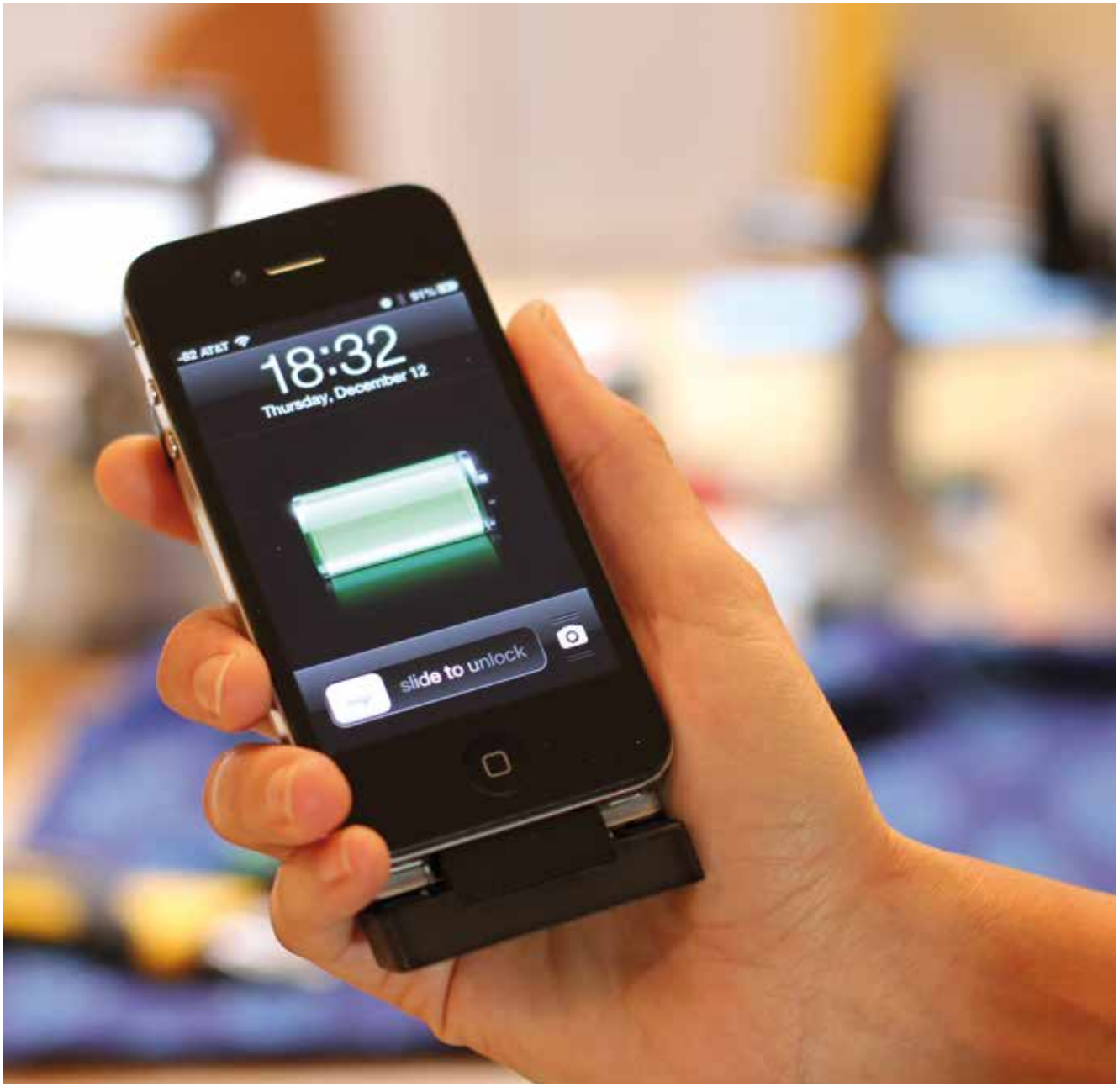
Tomorrow Lab has developed a prototype of the charging battery and is currently developing charging stations for the stores where customers can pick up and drop off the batteries. Rally Power has signed a contract with a Chinese battery manufacturer about the production of the charger battery and is negotiating with an American company about logistic and distribution.

The solution is not yet on the market, but the development process illustrates that it is feasible for two start-ups with limited financial resources to develop a solution that could become big business. Instead of the traditional approach of selling the idea to a big company with the capacity for handling production, distribution and sales, they are planning to use big companies as sub-suppliers.

The considerable innovation capacity of this new type of start-ups has caused big companies to change their strategy. Instead of seeing start-ups as either competitors or sub-suppliers, they are now focusing on the innovation capacity in start-ups and the potential for innovation partnerships.

In 2011, the American telecommunications company AT&T co-founded the innovation unit AT&T Foundry[12] together with Ericsson, Alcatel-Lucent, Cisco, Amdocs, Intel and Microsoft. AT&T Foundry has five facilities: four in the United States and one in Israel, and together, the five Foundries represent a total investment of 100 million US dollars.

12 http://www.att.com/gen/press-room?pid=2949.



Rally Pack charging battery by Rally Powers and Tomorrow Lab.

An important task for AT&T Foundry is to make contact with start-ups; not with the goal of taking over the start-ups or 'simply' buying their services but of seeking inspiration and, if the potential looks promising enough, establishing an innovation partnership.

AT&T Foundry stages 48-hour competitions for coding, the so-called hackathons, which are open to anyone, and which give AT&T Foundry a chance to meet tomorrow's tech stars. AT&T Foundry also organises speed dating with start-ups. Small enterprises that are not already working with AT&T but have something to offer can contact AT&T Foundry and request a speed dating session.

In a speed dating session, the start-up has 7 minutes to convince AT&T Foundry that an innovation partnership would be worthwhile. If the chemistry is good, the start-up may join the Foundry and use AT&T's resources, including AT&T Labs and the crowd-sourcing platform Innovation Pipeline. They may also receive marketing support.

AT&T Foundry invests in start-ups without requiring an ownership share but with the purpose of seeking inspiration for their own projects and engaging in partnerships to enhance AT&T's innovation capacity.

On average, AT&T Foundry meet with around 400 start-ups every year.

"It's a linear go-to-market model. It costs less money, there are fewer pitfalls, and you get a product out the door faster. That's our value," says Craig Lee, director of operations, AT&T Foundry, Plano, Texas.[13]

The international design agency Frog Design, which has its HQ in San Francisco, also works with start-ups. Frog involves start-ups in client projects when the starts-ups have unique competences that are relevant to the project.

Vice President of Venture Design at Frog, Ethan Imboden, who acts as a gatekeeper for Frog's collaboration with start-ups, explains that:

13 http://www.dmagazine.com/publications/d-ceo/2014/january-february/inside-att-special-opsteam? single=1

"There are three reasons why we have begun to work with start-ups. It's good business for Frog; it's fast, and the quality is high; and it strengthens Frog's innovation capability."

A company that is famous for working with start-ups is Google, whose global success has secured the economic muscle to launch large-scale and technologically demanding projects in the innovation unit Google X[14], including Google Glass[15] and the autonomous car[16]. During the first 14 months since the launch in 2012, Google's Advanced Technology and Projects Group (ATAP)[17] has initiated eight projects involving more than 120 companies, 6 universities and experts from 11 countries. ATAP once had a staff just 40[18]. Today, ATAP has close to 100 employees[19] and many more projects and business partners.

Google Glasses. Photo Charlie Brown.

14 http://en.wikipedia.org/wiki/Google_X
15 http://www.google.com/glass/start/
16 http://www.google.com/about/careers/lifeatgoogle/self-driving-car-test-steve-mahan.html
17 https://www.google.com/atap/projecttango/#project
18 'Special Forces' Innovation: How DARPA attacks problems, R. E. Dugan & K. J. Gabriel, Harvard Business Review, October 2013.
19 http://www.theverge.com/2014/1/29/5359068/google-keeping-motorola-advanced-technology-groupproject-ara-phone.

There are many examples that start-ups have begun to act in new ways that help shape the innovation landscape, and there is no doubt that start-ups are going to play an increasingly prominent role in the coming years.

ATAP also cooperates with a large number of start-ups. Thus, during the first 14 months, ATAP screened 2-300 start-ups and signed with more than 100.

To ensure smooth and efficient cooperation with start-ups, ATAP has developed a simplified version of its non-disclosure agreement that can be processed in less than a day rather than the customary weeks and months. To facilitate the process, ATAP has also drawn up contracts that give ATAP access to but not ownership of IP, but which leave room for future negotiations about exclusivity deals.[20]

In its organisational structure, ATAP is inspired by the research programmes in the innovation unit of the American Department of Defense, Defense Advanced Research Projects Agency (DARPA), which also draws on the innovation capacity of start-ups, cf. the discussion of DARPA in Chapter 2. The head of ATAP, Regina E. Dugan, is a former DARPA director.

There are many examples that start-ups have begun to act in new ways that help shape the innovation landscape, and there is no doubt that start-ups are going to play an increasingly prominent role in the coming years.

20 'Special Forces' Innovation: How DARPA attacks problems, R. E. Dugan & K. J. Gabriel, Harvard Business Review, October 2013.

The new types of start-ups are children of the digital age. They were born with design thinking as part of their DNA, and they develop new solutions that are easy to master and use in a complex world.

And the new start-ups are born multidisciplinary with a diverse range of skill sets but with design, user insights and the command of advanced technology as key.

New Type of Start-ups

The new types of start-ups are children of the digital age. They were born with design *thinking* as part of their DNA, and they develop new solutions that are easy to master and *use* in a complex world.

For design-led start-ups, innovation begins with the problem, unlike previous high-tech start-ups, where innovation often began with technology and only later began to look for a problem that the new technology might solve in a way that held a business potential. A design-led start-up can still be high-tech; the difference is that design-led start-ups start with the problem and use technology to deliver a solution.

For a design-led start-up, the solution has to be easy to master and use. Using the solution refers to the obvious situation, such as making a call on a phone, listening to music on the radio or driving a car, while mastery has to do with the ability to take advantage of all the possibilities that the product affords and to do so efficiently. The latter is rarely the case today. Many of the solutions that are on the market are ones that the users can merely use; they do not master them. And that applies to both products and services.

So far, lack of functionality or the absence of intuitive procedures have not been viewed as serious problems but rather as a generational issue. That may change, however, as society becomes more complex, and more smart devices and sophisticated solutions are brought to market. To reap the full benefits of the technological possibilities of the future it is crucial to design solutions that everyone can master and use.

The new type of start-ups is characterised by a different value set than we have seen in the past. Efforts that contribute to a more sustainable and inclusive society are more important than growth and money. Open-source solutions and access to knowledge and resources are more important than ownership. Trust-based cooperation is not the exception but the norm. And the new start-ups are born multidisciplinary with a diverse range of skill sets but with design, user insights and the command of advanced technology as key.

That we are currently seeing this new type of start-ups emerging in such large numbers is a natural consequence of the digital breakthrough, where many have the skills to master and combine the new digital building blocks into surprising new solutions.

The Digital Breakthrough

Digitisation describes phenomena by means of numbers, in its simplest form by representations of zeros and ones. The purpose is to transform phenomena into machine-readable data that can be recorded in an electronic medium, making them easily accessible.

A wide range of phenomena can be digitised. Not just quantitative data but also drawings, photos, sound, music, video, information from sensors and other devices etc.

The invention of microprocessors and their use in computers in the 1960s led to a steep increase in processing power along with declining prices. This increased the use and the role of digitisation.

That is now more than 50 years ago, so why are we talking about facing another digital breakthrough? According to Brynjolfsson and McAfee, we are currently about to enter *The Second Machine Age*[21], because the processing power of computers has now reached such a staggering level that the vast amount of data generated by ever-expanding digitisation can now be utilised in a way that turns the stuff of science fiction into reality.

It is now 50 years ago that the co-founder of Intel Gordon Moore made his prediction about computer processing power. Moore saw that a dollar bought twice as much processing power in 1963 as it had in 1962, and twice again as much in 1964, and Moore predicted that this trend would continue for the next ten years.

Moore's prediction proved more accurate than he had imagined. His law has held now for five decades, and the growth in processing power is now so overwhelming that the human brain has difficulty fully grasping the consequences.

In 1996, the supercomputer ASCI Red was ready for service. It was built as part of the U.S. Government's Accelerated Strategic Computing Initiative, and it was the most powerful computer in existence at the time. US dollars and its more than 100 covered cabinets

21 Erik Brynjolfsson and Andrew McAfee, *The Second Machine Age*, New York, W.W. Norton & Company, Inc. 2014.

1,600 square feet of floor space, 80 percent of a standard tennis court. ASCI Red was the first computer to score more than 1 billion floating points[22] per second, and to reach that speed it used 800 kilowatts per hour, the equivalent of 800 households.

Nine years later, in 2005, another computer reached the same speed. That was the Sony PlayStation 3, which cost 500 US dollars.

This development has continued, and the processing power still doubles every year. The figures are now so staggering that it is hard for the human brain to keep up.

Brynjolfsson and McAfee[23] use the old legend about the chessboard to illustrate the difficulty that the human brain has in grasping the concept of continued exponential growth.

When the game of chess was invented in India in the sixth century CE, the proud inventor went to imperial city of Pataliputra to present the board and the game to the emperor. He was so impressed with the challenging but beautiful game that he asked the inventor to choose his own reward. The inventor wanted rice to feed his family and suggested that they use the chessboard to determine the amount of rice he would be paid. The emperor was to place one grain of rice on the first square of the board, two on the next, four on the third and so forth. The emperor was impressed by the humble inventor and his modest request, so he agreed to the proposal.

After 32 squares, the emperor owed the inventor 4 billion grains of rice, the equivalent of a fairly large rice paddy, and the emperor began to have second thoughts about the deal. However, the emperor could still be emperor, and the inventor could still keep his head intact on his shoulders. It was not until they moved into the other half of the chessboard that at least one of them would be in serious trouble.

To meet the inventor's request would require more than 18 quintillion grains of rice. A mount of rice that would dwarf Mount Everest – and more rice than has ever been grown in the history of the world.

22 http://en.wikipedia.org/wiki/Floating_point
23 Op. cit.

After 50 years with Moore's Law in action, we now have so much processing power that things have begun to feel strange, the way they do when we get into the second half of the chessboard. And we can no longer use past experiences to predict the future.

PlayStation 3.

With this growth in processing power, the digitisation process has advanced in leaps and bounds. We are surrounded by a host of products that rely on digital information. That includes our telephones, radios, TVs and cameras, and soon the car will be so thoroughly digitised that it does not even need a driver.

Not only tangible products are digitised, however. Music and speech have been digitised, and soon we will be able to offer artificial digitised vision to people who are blind. Money and payments have been digitised; in fact, generally, there seem to be no limits to digitisation.

The advance of digitisation is not exponential, but it almost feels as if we were entering into the second half of the chessboard. That is due to the huge amounts of data that are generated through digitisation; when they are combined with other data, which is possible due to the massive increase in processing power, the result can lead to some very surprising solutions.

Take Waze[24], for examples, a smartphone app that suggest the fastest and easiest route right now, while traditional route planners only show the route that is generally the fastest. Route planners know your precise location thanks to information from a network of satellites. Route planners also have information about the road system and traffic regulations such as speed limits, one-way streets etc. from dedicated databases. By combining these two sets of data, the app calculates the shortest and, under normal circumstances, fastest way from point A to point B. The Waze route planner is more sophisticated, however: It finds the fastest route right now, because it has access to real-time data from other travellers using Waze. As more and more people use Waze in a given area, the information becomes increasingly rich, and the calculation of the fastest route and the estimated time of arrival become increasingly reliable. Thus, Waze becomes more valuable to the individual user the more users it has.

24 Op. cit.

The Google Car, prototype.

The example of the route planner illustrates the unique quality of digital information, which is that it is not diminished when we use it, and that more people can use it at the same time. Furthermore, the marginal cost associated with reproducing digital information is close to zero, just as the cost of transmitting information over long distances is limited.

The vast amounts of data stemming from digitisation and the low transaction and transmission costs combined with the huge processing power at our disposal make it possible to create solutions and systems that seemed unthinkable just a few years ago.

One example is the self-driving car that Google X is about to test on the road in California. The car is equipped with sensors that monitor the environment all around the car and process the generated information so quickly that the car is able to respond rationally and faster than a human driver.

The most impressive features are that the autonomous car is able to register all objects and determine whether they are moving, and if so, in which direction and at what speed – and then process all this information so rapidly that the car can make a rational decision concerning its own speed and direction as fast as any human. Google expects the autonomous car to be on the market by the end of this decade.

Huge processing power, increasing digitisation and vast amounts of data make it possible to build intelligent systems that are capable of improving our living standards and make production and consumption more sustainable and thus enable the plant to support a growing global population.

Digital Building Blocks

There is little doubt that the coming years will bring an 'internet of things' as well as 'smart cities', which use technology and data to become both more sustainable and more human, with room for all.

Intelligent power grids – smartgrids – will help stabilise our energy consumption and enable us to rely on renewable power sources, and the automation of our homes and other buildings will improve our indoor climate and improve security while reducing our consumption of electricity, gas and water.

Welcome to TheSmarterCity, IBM.

The water supply can be optimised and made safer, ensuring high quality standards and reducing the waste and consumption of water. Industrial water consumption can be reduced with the introduction of quality-assured reclaimed water where the water quality is measured online and in real time.

Intelligent traffic systems can increase the number of people who can pass through a certain stretch of road, reduce CO_2 emissions and improve traffic safety.

Hospitals will become automated. The hospital bed is going to monitor and transmit data about the patient's conditions, and tiny sensors are going to ensure that patients receive their prescribed medication, eliminating the risk of mix-ups.

The sky is the limit. But who is going to develop these solutions, and how? Is it all so complicated that only a few super-experts can play a part, or has technology become so accessible that larger segments can be involved?

The innovative process may be seen as a series of technological breakthroughs followed by gradual improvements, which over time take advantage of the full potential of the original technological breakthrough. Technological breakthroughs are not a clear-cut concept; still, a distinction is made between general purpose technology (GPT), which is crucial for the productivity in many sectors, and lesser technological breakthroughs that only impact a single sector or a small number of sectors.

The steam engine and electricity are examples of GPT, as is information and communication technology (ICT). Technological breakthroughs occur at irregular intervals as the result of intensive research, which is usually funded by the government or charitable foundations. Gradual improvements, incremental innovations, occur on an ongoing basis, and without the flow of countless incremental innovations, society's benefit from technological breakthroughs would be limited.

25 Op. cit.

According to Brynjolfsson and McAfee[25], ICT has led to radically new ways of combining ideas, as both new and old ideas can be mixed in ways that were not possible in the past.

Google's autonomous car breathes new life into an old GPT: the internal combustion engine. Combining a conventional car with a high-speed computer, a bunch of sensors and rich map and street data, enabled by digitisation, results in a self-driving car that is straight off the pages of a science fiction novel.

The Waze route planner combines sensors, data transmission equipment (the mobile phone) and the GPS system. None of these technologies were invented by the company that launched Waze; what they did is put them together in a new way, using existing technologies and data as building blocks.

Digitisation provides a vast amount of data that can be used for a wide range of purposes, and information can be reproduced and reused endlessly, because the process is not rivalising. As a result of these two key properties, the number of valuable building blocks has exploded. Brynjolfsson and McAfee[26] call it their 'innovation-as-building-block' view of the world, and since the building blocks are not used up but build continually on each other, the result is a growing number of new possible combinations and even more innovation.

Technological breakthroughs are rare and are created by the few, but incremental innovations are for the many, and with increased digitisation and the increase in data and processing power, there are building blocks enough for creativity and ideas to flourish.

26 Op. cit.

Chapter 2.

NEW WAYS TO INNOVATE

Designers with many different competences play a key role in the new companies, which are backed by new forms of venture capital.

Multinational corporations face an existential challenge unless they respond, and they are responding by engaging in experimental partnerships with the new innovation actors.

The 'internet of things' is not here yet, but it is on the way, and at the same time we are seeing a wealth of new surprising solutions created by the impressive innovation capacity of starts-ups – often in effective global partnerships. New types of enterprises are emerging, and even small companies and start-ups take on hardware production.

Designers with many different competences play a key role in the new companies, which are backed by new forms of venture capital. Universities offer new combinations of education programmes and entrepreneurial activities aimed at incubating talents for the new emerging design-led start-up environments.

Multinational corporations are challenged in their existence if they do not respond, but they do, by engaging in experimental partnerships with the new innovation actors.

Building Blocks and the Importance of Interfaces

In the late seventies, the Danish thermostat manufacturer Danfoss launched a thermostat with a temperature sensor that made it possible to maintain a stable room temperature by automatically regulating the heat output. Operating the thermostat and selecting the desired room temperature, however, require the user's physical presence.

Z-Wawe, Zensys

27 Op.cit.

Today, home-owners with a Danfoss thermostat can regulate the temperature via the internet using the Pro Heating Kit.[27] The product was created by the Danish start-up NorthQ, which also makes similar products for the Danish energy company DONG.

NorthQ relies on technologies – building blocks – from other companies. To digitise data from radiator gauges, electricity meters and water meters they use chips from several American companies like Broadcom.[28] To control the devices NorthQ uses the wireless communication protocol Z-Wave[29] from the former Danish company Zensys, which also makes it possible to exchange information between the devices and to make adjustments without any input from the user.

There are products on the market that offer similar functions as Z-Wave, but they have a different way of handling data, which means that devices f rom different manufacturers cannot be connected without further adaptations, and that shared data is not an option.

Danfoss Pro Heating Kit.

28 http://www.broadcom.com/products/wiced/wifi/
29 http://da.wikipedia.org/wiki/Z-Wave

The value of automation would be bigger for the end-user if all data were open and based on the same format, so that all the smart devices in the home could exchange signals. That would make it possible for the user to optimise the consumption of electricity, gas and water using relatively simple commands.

The makers of smart devices for the home would also benefit from standardised, open and easily accessible data. Today, the manufacturers provide information about the properties of the individual product, but it is difficult for the user to ensure a good basis for decision-making when it comes to investments in 'home automation' that would lead to a reduced and more sustainable use of electricity, heating, gas, water etc.

Theodore Ullrich, Anne Dorthe Josiassen, Jørgen Rosted, Pepin Gelardi, Dean DiPetro.

Open and easily accessible data make it possible to construct models and simulations that give both manufacturers and users specific facts about the benefits of investing in smarter devices and solutions and making them cooperate as efficiently as possible.

30 https://nest.com/

Today, there is no shared and easy access to data. Some manufacturers keep their data to themselves, and the manufacturers of smart devices use different standards and protocols. Open and standardised data are a condition for creating the 'internet of things' and reaping the network benefits of home automation.

NorthQ has created a standard and protocols that can be used to harmonise data, and NorthQ also offers to host common databases. Other companies offer the same, and the global competition will determine the outcome.

Tomorrow Lab – a start-up based in New York – has developed a temperature regulator with the same function as NorthQ's, and so has Nest, which was recently bought up by Google[30]. Companies like NorthQ, Tomorrow Lab and Nest naturally compete on price, but they also compete on quality – the quality of both the technical solution and the interface.

Tomorrow Lab, New York.

30 https://nest.com/

Making products that can be both mastered and used is the designer's most important task. When this is achieved, of course it benefits both the user and the manufacturer, but it also benefits society.

The technical solution has to exist, but once that is in place, it can be difficult to stand out from the competition simply by virtue of marginally better technical quality. This means that much of the competition comes to revolve around the interface. How easy is it for the user to maser and use the product? Does it require long and complicated user manuals to get started, or can the product be used straight out of the box because the user masters all the functions intuitively and with ease instead of just using the most essential functions?

NorthQ makes interfaces for both the app user and the manufacturer of smart devices. The quality of both interfaces is an important competitive parameter, which NorthQ founder Christian von Scholten predicts is going take on even greater importance in the future. That is why NorthQ plans to hire interaction designers to develop interfaces in dialogue with the users.

Making products that can be both mastered and used is the designer's most important task. When this is achieved, of course it benefits both the user and the manufacturer, but it also benefits society, because the automation of homes and other buildings is a key condition for the creation of a sustainable society.

Oblong Industries[31] in Los Angeles was founded with goal of creating the next generation of computing interfaces. The company was founded in 2006 and consists of designers, programmers and hardware engineers. Oblong Industries has developed programs capable of handling and visualising large data sets (big data) in multiple dimensions. Oblong Industries has also developed a technology platform that gives multiple users simultaneous access to multiple screens.

Oblong Industries was born multidisciplinary, and according to Vice President David Kung, who is in charge of business development, a new breed of specially trained designers who are capable of creating graphic design in the software code is a key competence for Oblong Industries. The education programme is only offered in a handful of universities, among them MIT and UCLA, University of California Los Angeles.

31 http://www.oblong.com/

The automation of homes and workplaces is a major challenge that is going to require the involvement of a wide range of companies across multiple sectors, but the ability to generate ideas and combine the many digital building blocks in a way that is useful to people is going to be the deciding factor. The automation of home and workplaces is just one among many examples of what the new digital age is going to bring. We are already seeing a similar development in many other areas, including transportation, commerce, media, entertainment, education and healthcare.

Capability and Culture

For many years, it has been a challenge for the pharmaceutical industry to ensure medication compliance. Before a new drug is approved its efficacy has to be tested on humans. In these trials, test subjects take the drug in the manner prescribed by the pharmaceutical company, but once the drug is marketed, and real-life conditions apply, that is rarely the case. Studies have found that the efficacy is often only half of what is achievable. It is therefore natural that the development of solutions to ensure compliance is a high priority.

AdhereTech, Web-Connected Medication Adherence Bottle.

Tomorrow Lab has tackled this task in a new way with the use of digital building blocks. Tomorrow Lab has developed a pill bottle that counts the number of pills in the bottle, and if the patient misses a scheduled pill, the bottle reminds the user. The reminder is delivered wirelessly to the user's mobile phone or another platform. This is probably the first pill bottle that is able to keep track of its own content.

Tomorrow Lab created the technical solution using existing digital building blocks and developed the necessary added software in-house. Tomorrow Lab also developed a functional interface that makes it possible to adjust the settings for the pill bottle and receive messages via one's mobile phone.

Tomorrow Lab consists of six people – product developers, software developers and interaction designers. The company is born multidisciplinary, and all the disciplines are included throughout the innovation process, which includes four stages.

First, they identify the problem at hand and outline possible solutions. Next, they experiment with various technical solutions and examine user needs. The final stage is product development, which takes place in an interactive design process with quick mock-ups and user dialogues, resulting in prototypes that undergo user testing.

The difference between Tomorrow Lab and a traditional but sophisticated design agency is not so much in the tasks they take on or the innovation process they engage in; the main difference is the corporate culture that characterises Tomorrow Lab.

Tomorrow Lab is convinced that innovation happens more efficiently in small start-up companies, and that what the company lacks in size and capacity it more than makes up for with network approaches and by using big companies as sub-suppliers when necessary.

The reason why it is more efficient to develop new products in small entrepreneurial companies, according to Tomorrow Lab, is that the culture and the incentive structure are different. Start-ups have to succeed, since failure poses an existential threat. This means that start-ups have a stronger motivation and desire to work harder and be more creative but also more focused. The entrepreneurial culture that characterises Tomorrow Lab is a quality that both partners and employees wish to preserve, even when no one would call Tomorrow Lab a start-up any more. Thus, we may see more small innovative companies that remain small and innovative even after they have achieved global success. No one at Tomorrow Lab can se themselves working in a big corporation.

Entrepreneurial Models

Prehype[32], another New York start-up, is an interesting and clear example of the involvement of entrepreneurs and product developers in development projects for big corporations. The clients are typically multinational corporations that contact the firm to develop new business areas or breathe new life into stagnating business areas.

32 http://prehype.com/

Prehype has developed a unique business model where new digital solutions are used to develop new business areas. What Prehype delivers is a new company complete with management, product and clients! It is up to the client company to decide whether the new company should have its own life within the group, be converted into a new business area within the client company or be sold off.

The development process at Prehype takes place in three stages with a tree-stage payment scheme.

In Stage One, an idea team is assembled, consisting of partners, employees and perhaps entrepreneurs from Prehype's network. The resulting ideas are continually debated with the client, until one or a few ideas are selected for further exploration. According to Prehype, the main problem is not to generate enough ideas but to decide which ideas to present to the client.

Stage One only lasts three to four months. Prehype draws up a consultancy contract with the client for Stage One, and Prehype pays the external product developers and entrepreneurs involved in the idea stage.

In Stage Two, Prehype assembles an innovation team to handle the transition from idea to business model and product. The team is selected among Prehype's extensive network of entrepreneurs and product developers. Prehype is in charge of the process, but the actual development work is carried out by the team. Results from the development process are discussed continually with the client company, and normally, employees from the client company are involved in testing prototypes and thus in shaping the end-result to match the client company's corporate culture, brand position etc.

Stage Two rarely lasts more than 12 months, but the duration depends on the specific development task. In Stage Two, the client pays Prehype a pre-arranged monthly fee, which is the same regardless of the content of the project. The entrepreneurial development team is paid by the client.

Stage Three is the implementation stage and involves forming the new company with management, staff, production and clients. Prehype has the overall

responsibility, but key members of the development team are often also involved in the start-up phase for the new company. Far from all projects proceed to Stage Three and develop into a viable company. In the few years that Prehype has existed, about 20 percent of the projects have matured to become viable companies.

In Stage Three, Prehype continues to receive a monthly fee. The innovation team is paid by the client, which also makes a market budget available. At the beginning of Stage Three, the parties also agree on a bonus, which depends on success in Stage Three. An example of a bonus arrangement may be that Prehype requires a certain bonus amount, which the client agrees to, subject to certain conditions, for example a specific number of users if the project concerns an online solution. The bonus is split fifty-fifty between Prehype and the develop-ment team.

One of the outcomes of Prehype's innovation model is Newsmart[33], an online solution for learning business English. The client was News Corp, which is part of Murdoch's media group. News Corp sells newspapers, magazines, trade books etc. and wanted ideas that would utilise the print media products to make the digital media more profitable.

News Corp also publishes trade books for English courses, and one of the ideas that came up during the idea stage was to combine reading a newspaper article with learning business English.

The idea proved viable and turned into Newsmart. Subscribers to Newsmart receive a digital version of Wall Street Journal, and while they read, the course module gives them task and assignments to improve their business English.

The innovation team created a software program that inserts learning examples in selected articles from the day's edition of the Wall Street Journal. Some are standard examples that can be used repeatedly, and which have been developed in cooperation with professional English teachers. Other learning examples are made for selected articles that are expected to have a high readership. They are also prepared by experienced English teachers the night before publication.

33 www.getnewsmart.com.

Newsmart website.

Interest in Newsmart has been considerable, especially from multinational corporations, which buy the product for their employees in cases where it is relevant for the staff both to read the Wall Street Journal and to improve their English skills.

Prehype's innovation model is flexible and offers good opportunities for assembling innovation teams with exactly the right competences for the given project and for utilising the culture and the incentive structure that characterise start-up environments.

NorthQ, Oblong Industries, Tomorrow Lab and Prehype are examples of a new type of companies that have certain commonalities despite their differences. The are born multidisciplinary, they preserve the entrepreneurial culture to maintain their innovative edge, and they are able to work with digital building blocks to create solutions which the users are able to master and use. When a design-led start-up lacks some of the necessary competences to handle a given task they find project partners in the communities that they are all a part of.

Success for the many design-led start-ups is also rubbing off on existing companies seeking to take advantage of the innovation capacity in start-ups.

Google ATAP, AT&T Foundry and Frog Design are examples of this phenomenon, cf. Chapter 1. Another example is Undercurrent[34], a modestly sized consultancy firm in New York.

In recent years, Undercurrent has begun to use start-ups in its efforts to make existing companies more innovative. Undercurrent has offices in New York and Los Angeles.

Undercurrent's innovation consultancy is not about traditional business development but offers suggestions for bringing new innovative competences into the client company. This could involve adding new people to the staff, establishing an independent in-house innovation lab or launching new start-ups that are tied into the company.

Undercurrent, New York.

Some 80 percent of Undercurrent's turnover comes from innovation processes inside big corporations, and the remaining 20 percent from creating new companies and tying them into the big corporations; the latter area is growing.

A crucial factor in Undercurrent's business model is their access to a large network of entrepreneurs and creative talents from a wide range of professions. This factor has caused Undercurrent itself to undergo a transformation, and today their corporate culture increasingly resembles the design-led start-ups they work with.

In the Los Angeles office, the transformation has made Undercurrent a part of the emerging design-led start-up community. In this process, Undercurrent has added employees to the staff who has strong design skills and master the digital technology.

Bud Caddell, Jørgen Rosted.

34 http://www.undercurrent.com/

Companies at Undercurrent.

The Google Way

Google has established two innovation units, which are organised fairly differently. Google X[35] takes on large-scale technology projects; thus Head of Google X, Astro Teller says, *"Identify some really big problems that Google might be able to solve by applying technology in a radically new way … projects are evaluated on their potential for big impact, rather than immediate profit."* [36]

In May 2012, Google bought Motorola Mobility. They sold the company to Lenovo in January 2014 but kept the innovation unit Advanced Technology and Projects Group (ATAP)37. ATAP has a fairly small staff consisting mainly of experts in charge of the development programmes that ATAP initiates and of administrative staff, including experts on contract law. The actual development work is carried out by external partners from bigger companies, universities and small high-tech companies and start-ups.

One of ATAP's ambitious projects is ARA[38], a modular mobile phone that the user will be able to modify and upgrade as needed. Google ATAP expects to launch the ARA phone in January 2015 at a retail price around 50 US dollars for the basic model.

The basic model consists of a 'skeleton' and a set of basic modules, including a processor, a screen and a battery. Additional modules can be added, for example a camera or a more powerful battery. The modules are held together by powerful magnets, which can be activated or deactivated by pushing an application on the phone. The skeleton is going to be available in three sizes, the largest the size of a tablet. The basic modules fit all three sizes.[39]

The phone will use Google's operating system Android, and users will be able to go online, read e-mails, install apps etc. as on other smartphones or tablets.

35 Op. cit.
36 http://www.google.com/about/
37 Op. cit.
38 http://www.projectara.com/
39 http://newdealdesign.com/projects/project-ara

The modular approach offers a range of possibilities, for example to set up a device for children which can only be used to play games and watch or make photos and videos but not to make phone calls. As the children get older, it can be upgraded to a smartphone. The modular phone also does not become obsolete, like other smartphones, since the user can buy updated versions of the individual modules as they come out.

Google ATAP also intends to let the user customise the phone by designing one side of the modules. The module can then be 3D-printed via Google's website and shipped.

Google ATAP aims to make software and hardware data accessible to enable others to develop both software and modules. The possibilities are legion, but some of the ideas that have been mentioned include a module that measures blood sugar levels and a module that can be used as a car key.[40]

Project ARA has a Google project team of only three people and a two-year deadline, which is quite unheard of. Others, including Motorola, have previously attempted to develop a modular mobile phone, but the complexity made the expected development time and the associated costs so high that the project was not feasible.

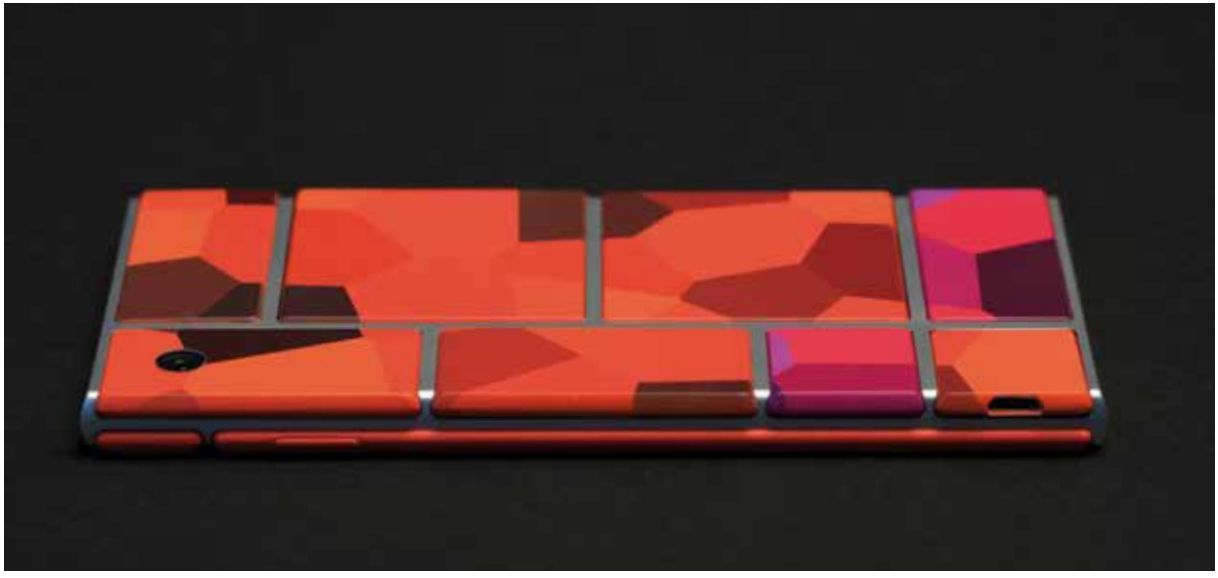
According to Paul Eremenko, head of project at Google ATAP, the prohibitively high development costs are due to a linear innovation process and a high overhead. Involving external partners, many of them small tech firms and start-ups with a high innovation capacity, and keeping the overhead low, help reduce the costs and make the project realistic.

The ARA project involves a total of 20 project partners consisting of 150 persons from 3 continents. Among the partners are Massachusetts Institute of Technology (MIT) and Carnegie Mellon University[42], the 3D printer company 3D Systems[43] and Phonebloks, which specialises in power efficiency.

40 http://www.theverge.com/2014/6/26/5845930/google-turns-on-its-crazy-modular-phone-in-public-forthe-first-time
41 http://wonderfulengineering.com/google-ready-to-launch-modular-smartphone-in-january-2015-for-50/
42 http://hexus.net/ce/news/mobile-phones/68813-google-plans-100k-prize-best-new-project-ara-module/
43 http://www.forbes.com/companies/3d-systems/

Two start-ups are also involved in the project: New Deal Design,[44] which designed the skeleton of the phone and the concept for combining the modules, and the software company NK Labs, where founders Ara Knaian and Seth Newburg are responsible for 15 engineers working on both electronic, mechanical and software aspects.

Eremenko says about the project partners, "*They're absolute superstars in their field… Creative, out-of-the-box, do-anything kind of guys. I could never, ever get them to work [for Google, red.] full time, move across the country, et cetera, et cetera. There was no way in the traditional model to capture that mindshare.*"



ARA, modular mobile phone.

44 http://gigaom.com/2014/05/13/project-aras-secret-weapon-a-smaller-phone/

Hardware Production

Small companies and start-ups can produce and distribute software, but in many cases, new software solutions also require the production of new hardware. This applies from Google's ARA mobile phone to Tomorrow Lab's pill bottle and NorthQ's electricity meter and thermostat adjuster. In fact, the bulk of NorthQ's earnings stem from the production and sale of hardware.

Previously, the production and sale of hardware were dominated by big corporations, because the production process was complicated and costly and required a considerable production capital, but that has changed, and today, small companies and start-ups are no longer excluded. The CEO of Dragon Innovation[45] in Boston, Scott N. Miller, points to several factors that have made it easier for start-ups to take on hardware manufacturing.

Globalisation and decreasing production costs in the new economies have made manufacturing cheaper. Furthermore, many components have also gone down in price. This includes electronic components, where the price has dropped substantially. In recent years, for example, the price of accelerometers has dropped from 300 US dollars to 1 US dollar. Furthermore, new technologies, not least 3D printing, have made prototyping easier, and global communication and cooperation about production have become simpler and cheaper thanks to online programs like GitHub[46], Grabcad[47] and Upverter[48].

The savings from new technologies and software tools mean that it requires less capital and is less demanding for start-ups to take on the production of hardware; still, it remains major challenge, fraught with risk.

Dragon Innovation specialises in helping small companies and start-ups with the production of hardware. The company was founded in 2006 by a group of hardware experts and has some 20 employees, including people in Shanghai, who can be close to production.

45 http://www.dragoninnovation.com/
46 https://github.com/
47 http://grabcad.com/
48 https://upverter.com/

Dragon Innovation can help start-ups move from the first prototype to production. The process normally begins with a request for quote and a bill of materials based on the entrepreneur's prototype.

Dragon Innovation helps start-ups find the right manufacturer and check whether price and quality are acceptable, and the schedule realistic. If necessary, Dragon Innovation can also place employees at the manufacturing plant, for example in China.

Dragon Innovations has managed to involve experienced manufacturing companies to advise start-ups. This includes General Electrics' Idea Works department[49], Qualcomm[50], Freescale[51] and Arrow[52], who make their years of experience available to start-ups.

Before start-ups decide to initiate production they can have a production review drawn up, Dragon Certification. The fee is 5,000 US dollars.

Dragon Innovation also offers to help start-ups with funding. Dragon Innovation has a crowd-funding platform, where financial investors with an interest in hardware can invest in the advertised projects. Dragon Innovation charges a 5 percent success fee if the start-up raises the necessary capital on Dragon Innovation's platform and 2 percent if it is raised on a different platform.

Dragon Innovation's many start-up clients include the 3D printer company Makerbot[53], with an estimated turnover in 2013 of 75 million US dollars. Pepple's smart-watches for iPhones and Androids, which had more than 100,000 watches made in China already the first year. Pepples' 2013 turnover was around 60 million US dollars.

49 http://www.geideaworks.com/
50 http://www.qualcomm.com/
51 http://www.freescale.com/
52 http://www.arrow.com/
53 http://www.makerbot.com/

Capital for Design-Led Start-ups

Dragon Innovation's combination of innovation consultancy with venture capital funding is not unique. Frog Design and the consultancy firm Undercurrent also offer venture capital to the starts-ups they work with.

A new initiative to provide venture capital is Designer Fund[54] in the San Francisco Bay Area. The fund was established in 2011 by Dave McClure, who is a partner in 500 Startups[55], and is headed by Enrique Allen, who also comes from 500 Startups and teaches at Stanford d.school[56].

The purpose of this seed fund is to help designers set up companies that contribute to a more sustainable society by means of new technology in collaborative project involving designers, engineers and business people. Or, to quote a statement from the fund, *"No longer can design just be an outsourced add on, limited to occasionally putting 'lipstick on a pig', tech moves so fast that it's a continuous process of iteration for designers to prioritize solving the right strategic problems, contexts and use cases for their company to prosper."*[57]

The capital for Designer Fund comes from individual designers who each put in 50,000 US dollars and are willing to act as business angels to start-ups that receive capital from Designer Fund. In addition, a number of venture capital companies have also invested in Designer Fund, including Khosla Ventures, North Bridge Venture Partners, Kleiner Perkins Caufield Byers, KKLD, Venture51 and Quest Venture Partners.

Designer Fund accepts applications from designers who start up their own company or who are part of partner team establishing a new company. The main focus is on entrepreneurs in the San Francisco Bay Area, but Designer Fund has also helped entrepreneurs in other American cities, including New York, Boston and Los Angeles.

54 http://designerfund.com/
55 http://500.co/
56 http://dschool.stanford.edu/
57 http://thenextweb.com/insider/2011/12/01/the-designer-fund-puts-seed-money-into-startups-withdesigner-founders/

Designer Fund invests in start-ups in three stages: Incubation, Seed and Stage A, and has a large group of mentors to draw on from companies like YouTube, Facebook, Google, Twitter, Path, Flipboard, Pinterest, Cooper, IDEO and Frog.

Designers who receive funding and advice from Designer Fund are expected to 'repay' the community by either becoming mentors or putting money into the fund.

Designer Fund also operates the exchange programme Bridge, which connects experienced designers and selected start-ups. Design-led starts-ups in the San Francisco Bay Area can apply to programme, and Designer Fund selects and pays the experienced designers who act as mentors and teachers in the programme.

During the three-month programme, experienced designers work in the start-up companies, and in weekly workshops the experienced designers share their experiences with specific topics and areas. This offers start-ups an opportunity to acquire valuable knowledge about approaching design tasks that is otherwise only available through one's own successes and, not least, failures.

Entrepreneurial Talents

Capital and talent are key conditions for creating strong new ecosystems. In the United States, business angels, venture capital and charitable foundations have demonstrated for decades that they know how to spot and take advantage of new opportunities. The best American universities also have a long tradition for being out in front and promoting the right talent, almost before the market has realised the demand. That seems still to be the case.

A good example is CITRIS, Center for Information Technology Research in the Interest of Society[58]. CITRIS was founded in 2001 at University of California Berkeley in the San Francisco Bay Area, but also involves researchers from other publicly funded universities in Northern California. CITRIS' goal is to engage researchers across university departments to cooperate on using information technology for the greater good.

58 http://citris-uc.org/

The research at CITRIS so far has focused on five areas: energy, health care, infrastructure, traffic and data & democracy. In all five areas, the research has produced interesting results, which clearly demonstrate that the advanced application of information technology can lead to new solutions that are in the interest of society. One example is the surgical robot system The RAVEN and the smart energy solution Connected Corridors. However, according to Senior Adviser and Director of Health Care, Steven DeMello, it has been necessary to review the experiences of the past fifteen years and reorganise CITRIS.

The research projects that CITRIS takes on range from the low-hanging fruit to radical change. So far, most of the projects have been somewhere in between. The projects have had a level of technological complexity that required a multidisciplinary approach, but often the funding and the allotted time were too modest to realise a sufficient potential. Although the outcome did, of course, bring new insights, the result was rarely concrete enough to be implemented.

In the future, CITRIS' projects have to set out with a better understanding of the problem to be solved. A problem should be understood rationally and be informed by data to lead to a useful solution that can be implemented and have an impact. Essentially, to create solutions that change human behaviour requires a practical understanding of what people do, and why they do it.

"In practice," says Steven DeMello, "these solutions always combine hardware and software." On this basis, CITRIS is currently building a new university eco-system to promote talents and start-ups that are capable of bringing research results into society.

The new ecosystem has two pillars: Invention Infrastructure and Business Infrastructure, as illustrated in Figure 1.

Invention Infrastruture	Business Infrastructure
• Invention Lab • Nano Lab • Social Apps Lab • Invention Studio	• Business Incubator • Mentoring • Teaching

Figure 1.

Invention Infrastructure involves teaching and experiments and is open to students from all departments at UC Berkeley and the other universities that are part of CITRIS. The goal is to attract students from disciplines that are relevant for working with digital building blocks and creating solutions that can be mastered and used.

Invention Lab is education programmes; Nano Lab is learning about developing tiny physical units; Social Apps is learning about developing software programs; and Invention Studio works with digital building blocks, mock-ups and prototypes.

Business Infrastructure is for students who are part of the activities in Invention Infrastructure and wish to be entrepreneurs. Business Infrastructure offers the usual incubator activities, such as business advice and courses about the development of business models etc.

The new ecosystem should be open and collaborate with both companies and venture capital investors. Companies should be able to bring in a challenge, and students, start-ups and faculty members should offer advice and engage in innovation partnerships. However, the initiative goes both ways. If ideas for new solutions come up, the effort should be to find companies that are interested in a collaboration to realise the solutions.

CITRIS, Center for Information Technology Research in the Interest of Society, Berkeley, California.

According to Steven DeMello, the goal of the new ecosystem is to promote the right talents but also to help build a strong design-led start-up scene in the San Francisco Bay Area to ensure that research and technology development at UC Berkeley and the other involved universities contribute to CITRIS' mission statement of using information technology research in the interest of society.

The new ecosystem is neither intended nor expected to lead to radical innovations. The talents and start-ups produced by the new ecosystem are expected to use existing but advanced technology to create new solutions in the interest of society.

The resources that CITRIS puts into the new ecosystem come from a re-allocation of resources. Thus, projects that lie in between the low-hanging fruit level and the more radical solutions, have a lower priority, and resources have instead been allocated to constructing the ecosystem and promoting a smaller number of bigger technological innovations.

CITIRS has selected two areas where it is developing new IT solutions aimed at promoting breakthrough innovation and systemic changes. One area is healthcare, where CITRIS has initiated a research project to develop new IT solutions which nurses, patients and relatives can use to ensure a more individual and patient-centred course of treatment than doctors and hospitals have been able to offer so far. The tools are based on large sets of health data – general as well as patient-specific data.

The second priority area is energy, where CITRIS has launched a research project aimed at developing new IT solutions to control energy consumption in buildings as well as systems to control and stabilise energy systems based on renewable energy sources.

CITRIS has an annual budget of just over 20 million US dollars; 4-5 million US dollars come from the State of California, 6-9 million US dollars from federal budgets and 6-9 million US dollars from charitable foundations and private companies.

CITRIS is not alone in restructuring education programmes to focus on entrepreneurs. 30 weeks is a new 30-week experimental educational programme aimed at stimulating talented designers to found their own companies.[59]

30 weeks was created by a number of design schools in New York – Parsons The New School for Design, Pratt, School of Visual Arts and The Cooper Union – in cooperation with Hyper Island and Google.

The 30-week programme is a mix of education programme and start-up incubator. The curriculum was created by Hyper Island with input from the design schools in New York and offers crash courses in business and courses in product design and engineering. The teachers are experienced designers, engineers, business managers and venture capitalists.

30 weeks is based in a shared office space in Dumbo, Brooklyn and has room for 20 students, whose applications are assessed in part on their idea for a design project that may form the basis for a start-up. The fee is 10,000 US dollars, and the students are guaranteed full IPR for products and ideas.

The Copenhagen Institute of Interactive Design (CIID) is a one-year education programme in interactive design. CIID has an international faculty made up of experienced designers and technology experts. The annual enrolment is 25 students, who come from all over the world. CIID also has a research department and a consultancy unit that works with several big corporations including Intel, LEGO, Novo Nordisk, Toyota and Tetra Pak. In 2014, CIID has established an incubator, NEST, and the intention is to involve start-ups from NEST in CIID's innovative collaboration with the client companies.

CIID, Copenhagen Institute of Interactive Design, Copenhagen.

59 http://www.fastcodesign.com/3031619/30weeks-an-experimental-new-design-school-backed-bygoogle?partner=newsletter
60 http://ciid.dk/

Chapter 3

CITIES AS LABORATORIES FOR CHANGE

In 2011, the City of Copenhagen invited EU tenders for Intelligent Transportation Systems (ITS) and intelligent traffic signals. The task was to record the number of cars and their speed in real time and to use this information to control the traffic signals for an optimum traffic flow. That would both reduce driving time and reduce CO_2 emissions. The contract was won by the Dutch firm Maris B.V., which subsequently established an office in Denmark.

Together with the Copenhagen Capital Region, the City of Copenhagen has been involved in an EU-wide tender process to establish a digital infrastructure for big data, where consortiums with the participation of some of the world's leading companies in the field of IT and the use of big data compete to create a broker to convey data between public and private data-owners and companies wishing to use big data.

The Copenhagen utilities company HOFOR, has set up an investment programme to deal with the consequences of extreme downpours. The programme was developed and will be implemented in cooperation with private companies.

The City of Copenhagen's innovative tender project for intelligent traffic regulation, investments in digital infrastructure and countering the consequences of extreme downpours are just a few among many examples that the City of Copenhagen and the Copenhagen Capital Region are involving private companies in meeting global challenges and realising the city's goal of being CO_2-neutral in 2050. The Copenhagen examples are not unique; we are seeing similar initiatives in other cities and metropolitan regions.

At the same time, big cities are seeing the emergence of new start-up environments that act as a dynamic and innovative talent base. The new start-ups cluster in the abandoned industrial areas of big cities or worn-down residential neighbourhoods where the rent is low, and where open and creative environments can be set up at limited costs.

This phenomenon is a consequence of technological and global developments with innovation as a competitive parameter, which finds optimum conditions in big cities with universities, research labs, hospitals and multinational corporations with development departments.

Cities in Change

The New York-based consultancy Undercurrent opened an office in Los Angeles a few years ago, cf. Chapter 2, because Undercurrent wanted to be closer to the new and rapidly growing start-up environments in Los Angeles. Los Angeles was not exactly slated to become the scene of start-up environments. According to Director Bud Caddell of Undercurrent, Los Angeles was *"the last place to go"* for someone with an interest in start-ups, and there was definitely no way to convince people from New York to go to Los Angeles. That has changed.

An important part of the business scene in Los Angeles is the film industry and the diverse industries that emerge to service the film industry, which in recent years has been under pressure from new media and from other cities, in part because technology has become more important than the physical production facilities. The support industry, which provides content to the film industry, among other things, was also expected to come under pressure, but that did not happen. On the contrary, the competences and creative ideas that are such an important aspect of the film scene proved to be a good match for the new technological and business opportunities that are emerging.[61]

The necessary venture capital followed, as soon as the new opportunities arose. Initially, it came from San Francisco, which probably has more venture capital than talent. When it proved a success to invest in the creative talent base from the film scene, the effect rubbed off on other areas too, and today, Los Angeles has several successful start-up environments. However, the considerable success led to a shortage of entrepreneurs and software experts, who are a must for many multidisciplinary start-ups. The great opportunities attracted experts from other regions, even from New York, including Undercurrent, which contributes both with venture capital and by bringing outside experts.

61 http://www.businessinsider.com/los-angeles-tech-startups-2012-9

Santa Monica Station.

Metropolitan Los Angeles has 10 million residents and covers several separate districts including Los Angeles Down Town, Santa Monica, Pasadena, Beverly Hills and Hollywood. These areas all have old city centres and dilapidated former industrial areas, where the start-up environments have emerged.

The areas are connected by wide highways, but at certain times of day it can take up to three hours to get from one area to another. Due to the urban sprawl and the over-burdened infrastructure, many relate initially only to their own area and only later to Los Angeles, which has caused the individual innovation districts to develop their own ecosystems and a surprisingly low degree of mutual contact and cooperation.

In 2008, and before the innovation districts really took shape, Los Angeles decided by popular vote to raise the real estate sales tax and use the revenue to fund a public transportation system. The tax increase was put in place for a 30-year period with the goal of giving Los Angeles a state-of-the-art rail and bus network.

The financial crisis a few years later led to a push to complete the transportation project in 10 years rather than 30. Los Angeles applied for a low-interest loan from the innovation programme under the US Department of Transportation, TIFIA. Congress was against the request, however. A majority argued that granting a low-interest loan to Los Angeles would be favouring a particular urban community, so the loan fell through. However, the mayor of Los Angeles managed to secure broad national support for a new bill which did pass through Congress. The bill allowed the Department of Transportation to help an urban community help it self and established that a loan like the one requested by Los Angeles should not be seen as favouring an urban community but rather as help for self-help.

As one of the first results of the transportation project, a rail link is now under construction between Santa Monica and Down Town Los Angeles, which will connect two of the biggest innovation districts in Los Angeles. Many – certainly in Los Angeles – expect that if the innovation districts are connected and eventually form a connected ecosystem, it may become one of the strongest in the United States.

The Expo Line Santa Monica-Down Town Los Angeles rail link.

The development in Los Angeles is a good example of the big changes happening in many American cities and metropolitan areas, where local actors launch vibrant initiatives that promote and enhance the cities' existing advantages by promoting start-up environments and innovative companies. Other good examples include New York City's announcement of a public tender for a world-class tech university and north-eastern Ohio's establishment of a strong development network with support from major financial resources, especially from charitable foundations.[62]

Similar initiatives are seen in cities and metropolitan areas all over the world. An important driver of this development is the substantial population growth in big cities around the world and the need to meet global challenges. Cities and metropolitan areas have a big potential for taking matters into their own hands and do not need to wait for national legislation, even if national and federal initiatives can make a difference; sometimes a crucial difference.

We need major structural changes if a large urban community is to ensure an economic development that provides jobs for all and socially acceptable living conditions and meets global challenges such as climate change and dwindling resources, which pose a long-term threat against our living conditions. It is not enough to create good conditions for business; to create a sustainable society we need radical innovation in the way we design our cities – our energy systems, water supply and transportation systems – as well as the way in which we manufacture and use nature's resources.

This is not a task that can be handled by politicians and the public sector alone. Their involvement is necessary, but changes on this scale require contributions from many other actors as well. That includes organisations, universities and charitable foundations. Not least, we need to mobilise the knowledge and innovative capacity that exist in private companies and in the new start-ups in metropolitan innovation districts. Achieving this is no easy task.

62 Bruce Katz and Jennifer Bradley, *The Metropolitan Revolustion – How Cities and Metros Are Fixing Our broken Politics and Fragile Economy.* Brookings Institution Press, Washington 2013.

On a national and federal level, the past four to five decades have seen the launch of countless innovation programmes that have supported often very ambitious innovation projects but with mixed results. Far too many innovation projects have not made the difficult transition from the concept stage to real life; often, the money has run out, and no one has had enough faith in the concept to fund the project themselves. The many failed projects have rarely, however, inspired radically new approaches.

It is crucial that cities and metropolitan areas find new ways to organise large-scale innovation projects. Cities and metropolitan areas need to become laboratories for major changes and be ready to undertake community experiments with considerable risks and flaws and a potential lack of results; that is the necessary price.

It is interesting to note the many initiatives underway right now aimed at finding new approaches. In recent years, a handful of American cities have appointed a Chief Innovation Officer. One of them is San Francisco, which in 2012 established the Mayor's Office of Civic Innovation (MOCI)[63] to involve tech firms in addressing the challenges facing the city.

MOCI has helped make the vast amounts of urban data accessible to companies, and more than 100 companies are currently using big data for innovative projects. One example is the use of big data to help solve San Francisco's considerable traffic problems. This effort has included Google, among others, which has provided traffic information based on Google Maps.

63 http://innovatesf.com/

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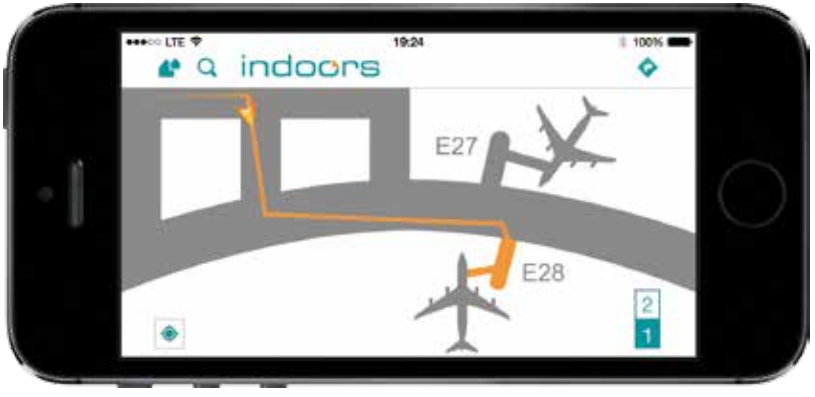
MOCI also runs the programme San Francisco Entrepreneurship in Residence, which aims to involve new start-ups in the use of new technology to solve the city's problems. The first stage of the programme was launched in March 2014 with the involvement of six tech firms selected to take part in a 16-week project. The six companies take part in an incubator process, each working on their own specific project in close cooperation with employees from relevant private or public institutions.

The company Birdi[64] collaborates with the U.S. Department of Public Health on air quality and health issues. Birdi has developed a smoke alarm that also monitors other emergency situations, for example fire or elevated carbon monoxide levels in the air, before these issues become a threat to public health and offers recommendations to the citizens on how to deal with a given situation. When a fire is detected, Birdi contacts the fire department. Birdi is controlled by the owner's smartphone.

Indoo.rs[65] works to improve wayfinding services in cooperation with San Francisco International Airport. The company aims to make it possible to find one's way in a building the same way we use GPS to navigate a city.



Ondoo.rs navigation service for San Francisco International Airport.

64 http://getbirdi.com/
65 http://indoo.rs/

The new innovation zones in San Francisco, a partnership between the Exploratorium and Yerba Buena Community Benefit District, an exhibit on Market Street. Photo: San Francisco Planning Department.

Synthicity[66] makes 3D simulation tools for urban planning in cooperation with San Francisco's Planning Department. The company's solutions help urban planners, designers, architects, real estate brokers and others simulate urban planning and visualise future scenarios in 3D and thus make the right decisions.

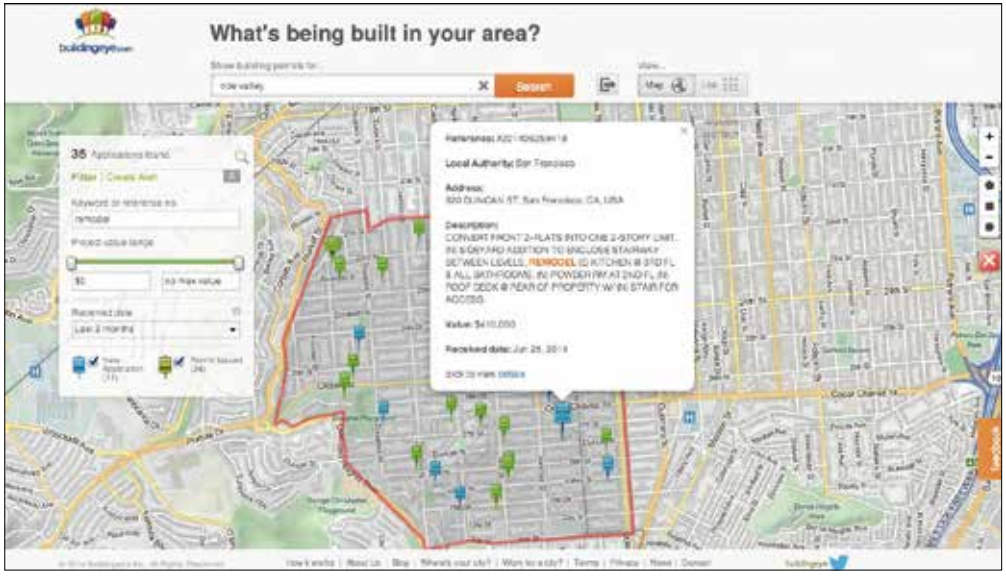
BuildingEye[67] cooperates with San Francisco Municipal Transportation Agency to create a real-time map of all current building permits in San Francisco. Users will be able to click on a map and have direct access to information about a given project. BuildingEye's real-time map is still at an early stage of development, but once it is ready it will be a powerful tool, not only for urban developers and City employees but also for concerned citizens who wish to know what is happening in their local area.

ReGroup[68] cooperates with the Department of Emergency Management on developing ways of communicating with the citizens in emergency situations. ReGroup's software lets groups of citizens send messages to each other via social platforms, text messages, own websites and voice mail.

MobilePD[69] cooperates with the San Francisco Police Department on safety issues. The company's apps make it easier for citizens to communicate with each other and to tip off or alert the police and each other. The MobilePD app also makes it easier for citizens to send evidence of crime, for example smartphone videos, directly to the police.

Critics of the programme have argued that the City of San Francisco does not benefit directly from the partnerships: *"Basically, you're giving a company access to government resources for the company to profit from … The City then has to pay for the use of an app that the company made with city resources,"* argues John Avalos of The San Francisco Board of Supervisors.

66 http://www.synthicity.com/
67 https://buildingeye.com/
68 http://www.regroup.com/
69 http://gomobilepd.com/



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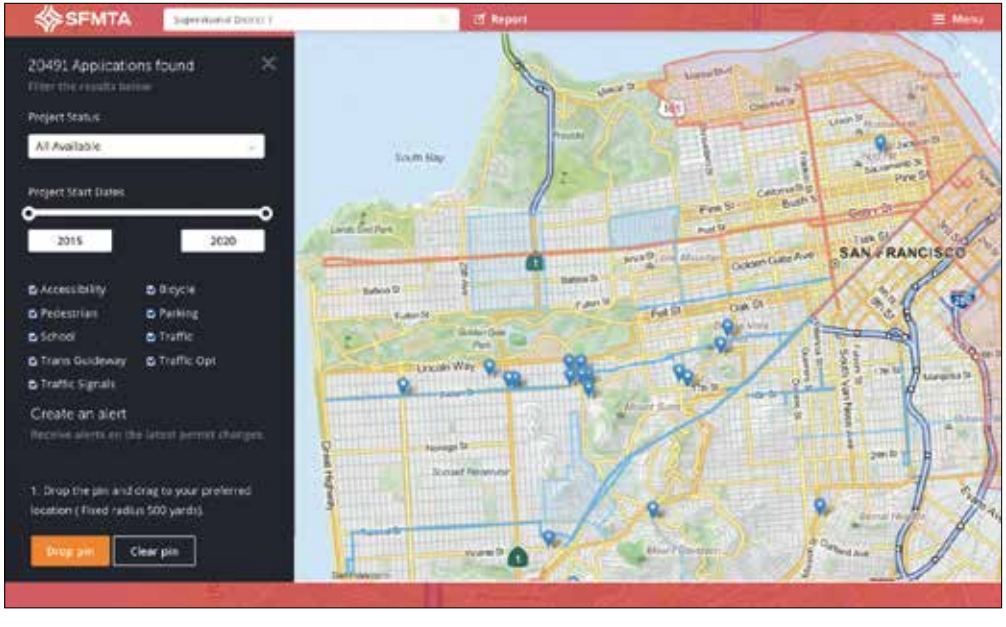


© *BuildingEye Inc.*

MOCI rejects the criticism: *"I think this is a very exciting program and there's a lot of benefit … Far from gaining 'nothing' the City in fact gets far more than the participants. They apply their proven innovation and skills to public challenges for free, and hopefully that will lead to improved outcomes and more efficient service delivery for the areas of city government where we direct them to focus,"* says Jay Nath, San Francisco's Chief Innovation Officer and head of MOCI. [70]

The DARPA Way

Chapter 2 describes Google ATAP's cooperation with external partners in the innovation process. The way that the Google ATAP projects are organised and managed is strongly inspired by the experiences from the United States' Defense Advanced Research Projects Agency (DARPA), and Google has stated explicitly that they seek to use DARPA's innovation model to develop new technologies and solutions to serve civilian purposes, the same way that DARPA serves the United States' military.

In recent years, there has been growing interest in DARPA's innovation approach, and in articles, former employees of DARPA have debated what the unique properties of the DARPA model are that are responsible for producing so many and such big concrete results that it far exceeds what is normally achieved in innovation programmes. Is the explanation 'simply' that DARPA has more generous economic resources, or is the success also explained by the way in which the programmes are organised and managed – and if so, is it something that others might learn from? [71]

The direct occasion for establishing DARPA was the Soviet Union's launch of the world's first satellite, Sputnik. This signalled a technological capacity that shocked the government of the United States. One of the responses was the establishment of DARPA *"with a mission of preventing technological surprise from adversely affecting our country while creating surprises for U.S. adversaries."*[72]

70 http://www.sfexaminer.com/sanfrancisco/sf-opens-doors-to-public-tech-incubator-expecting-noreturn/Content?oid=2800720
71 http://hbr.org/2013/10/special-forces-innovation-how-darpa-attacks-problems/ar/1
72 Driving Technological Surprise: DARPA's Mission in a Changing World, www.darpa.mil

In the just over 50 years since DARPA was founded, we have seen huge technological advances, and in many cases, DARPA has made key contributions to major global changes. To quote DARPA's presentation of its own achievements:

"DARPA created materials science as a field by investing in this cross-disciplinary area in its earliest years. The revolution in information technology traces many of its roots to DARPA's work in the ARPAnet, computing, graphics, integrated circuit design, client/server architectures, artificial intelligence, and communications. DARPA demonstrated positioning from satellites and miniaturized receivers, leading to today's omnipresent global positioning system (GPS) capabilities. Aircraft stealth technology originated in DARPA inspiration and investment, as did unmanned aerial vehicles (UAVs). In every case, many other organizations — across the private sector, the Military Services, and other agencies — were critical to realizing these technologies and using them to change our world. But in every case, DARPA's early investments explored and showed what was possible and began a revolution in capability."[73]

A key reason for DARPA's success is of course economic resources. DARPA has an annual budget of 3 billion US dollars. Economic resources alone do not explain the success, however. Other research or innovation institutions have had similar or even greater economic resources without similar achievements to show for it.

Four main organisational and managerial characteristics deserve to be highlighted as essential factors in DARPA's outstanding achievements. First, DARPA has created a culture that allows for unconventional thinking and risk-taking. Second, the programmes are headed by leading experts in their field, who are temporarily attached to DARPA but still retain both the responsibility and the possibility of making independent decisions. Third, the individuals and teams taking part in the programmes compete with each other, while coordination is assured by the programme manager. And fourth, the task is well-defined, and throughout the process it is clear who is ultimately going to implement the solution: the Department of Denfense (DoD).

73 Op. cit.

In its own assessments, DARPA points to the independent programme managers as a crucial element in the successful innovation model. DARPA's programme portfolio is created in a bottom-up process, where DARPA's programme managers continually suggest new programmes in areas where they see a possibility for revolutionising changes. This bottom-up approach, in DARPA's own view, is important for a number of reasons. An effective programme manager is someone who is close to the critical challenges and technological possibilities in his or her field, and this personal inspiration and the chance to realise an idea is the spark that can light a big fire. According to DARPA, new insights rarely come from group think but from individuals with ideas and the will to succeed.[74]

DARPA's management meets regularly with the Department of Defense (DoD) to discuss a variety of challenges and technological possibilities, and ultimately, it is DARPA's leadership that decides which programmes to initiate, and what budget to allocate for the individual programme.

DARPA distinguishes between two types of programmes. One is about developing a new technology to serve as the basis for new military solutions; the other is about using existing technology or combinations of existing technologies in new ways, again, to create new military solutions. DARPA finds partners and structures the work based on very complicated procedures, which aim to ensure an open and fair treatment of all. The goal for DARPA is to find the best actors and allow them to compete to find the best solution but also to share experiences along the way.

All programmes aim to develop a finished prototype or a demonstration project, while it is up to the DoD whether the new solution is implemented. Thus, the DoD is in charge of putting a new solution into production and introducing it in the military. DARPA's task is exclusively to develop new solutions, and there are examples that the DoD initially rejected a new solution, which was then applied in the private sector only to find its way back to the military later. Among these examples are drones and high-definition screens.[75]

74 Op. cit.
75 DDC's interview from April 2014 with Scott Ulrey, Deputy Director, Contracts Management Office, DARPA

DARPA is a small, flexible and relatively flat organisation with 220 employees and just one layer of management in between the programme managers and top management. Of the 220 employees, 120 are programme managers or other experts. DARPA is thus completely dependent on cooperating with others and works with a large number of partners, including leading universities and the R&D departments of big corporations as well as small and medium-sized tech firms and start-ups. In recent years, small tech firms and start-ups have become increasingly important actors in the programmes, and Deputy Director of DARPA Scott Ulrey expects small tech firms and start-to play an even bigger role in the future.

As a supplement to this chapter, see a more detailed description of DARPA's approach in Appendix 1.

CLEAN Innovation Model

The Danish cluster organisation CLEAN uses an innovation model, the CLEAN model, which is inspired by DARPA's methods. The model was developed in 2011-12 for Copenhagen Cleantech Cluster, which has since merged with Lean Energy to form CLEAN.[76]

The CLEAN model is developed with the purpose of effecting structural changes by means of systemic innovation. Thus, the goal is not to go after the low-hanging fruit, such as the optimisation of traffic signals that was mentioned in the first part of this chapter. That may produce important results, but the task is simple enough that the City of Copenhagen can announce its own tender process, and the company that wins the contract is able to develop and implement a state-of-the-art solution that already exists in other cities around the world.

The CLEAN model instead aims to create solutions that are superior to existing state-of-the-art solutions and thus set new environmental standards. In many cases, that means that the task and the desired solution have a degree of complexity that requires the combined efforts of several companies and organisations, since no single company or organisation will possess the necessary competences.

76 http://www.cphcleantech.com/

This high degree of complexity also means that standard tender methods are not applicable, because the party preparing the tender material lacks the necessary knowledge about the existing possibilities and therefore cannot specify a sufficiently detailed brief. CLEAN wants to work with leading international companies and leading universities in the projects but also wants to include small tech firms and start-ups in order to benefit from their creativity and innovative capability.

The CLEAN model has four key characteristics. As already mentioned, the desired environmental solution should be superior to the existing solutions. If good solutions already exist, and the task is to implement one of these state-of-the-art solutions the task is more manageable, and it is not necessary to use the CLEAN model.

Second, one or more 'clients' need to state that they want see a solution to the environmental issue in question and are therefore prepared to take part in the entire innovation process and ultimately implement the best solution..

Third, the critical aspects of the process are managed by a specially selected person with broad experience within the given environmental area. That includes experience from both the private and the public sector, as both sectors usually have to be involved in new complex environmental solutions.

Fourth, consortiums of companies, universities and organisations compete to come up with the best solution, while ideas and possibilities are discussed and coordinated with the client or clients who are ultimately responsible for implementing the wining solution.

The CLEAN model can be used in relation to issues where a new and better solution requires the development of a new technology as well as issues where existing technologies or combinations of existing technologies are used to create new and better solutions. However, the model should be seen as a general framework for the innovation process, while specific elements or stages in process need to be adapted to the issue at hand.

The CLEAN model operates with four general stages.

In Stage One, the environmental issue that CLEAN is used to address is selected. Anyone can make suggestions, but ultimately, the board of CLEAN decides whether to address a given issue. CLEAN is not an actor that can ensure the implementation of new solutions. CLEAN is a mediator that structures innovation processes. In Stage One, it is therefore crucial that the 'client' or 'clients' who can implement a new solution state that they are willing to take part in the process and ensure the implementation of the new solution. Further, actors from all the elements in the value chain that need to be involved in a new solution also have to state their willingness to be involved.

Stage Two explores why the environmental issue has not already found a satisfactory solution. Are market failures or entrenched habits and practices in market actors preventing the development of better solutions? Or are government requirements and regulation blocking better solutions? Or is it simply not economically profitable to improve the way that the environmental challenge is currently handled? Whatever the barriers are, a realistic way of eliminating them has to be found to make it meaningful to proceed to the next stage; otherwise, the process has to be stopped.

If it is obvious that it is necessary to change regulations to achieve a better solution the regulatory agencies have to declare their willingness to be involved in the process and to adjust the regulation. If the development and the implementation of a new solution is risky and requires more venture capital than the market can deliver, that problem has to be solved before the process can continue. If, on the other hand, the main obstacle is rigidity or market barriers, which has often proved to be the case, changing current practices may be a key task for the next stage.

Stage Three is the actual innovation stage, where a new concept is created. In the CLEAN model this happens in a public competition among selected consortiums of companies, universities and organisations. To ensure an open and fair competition, the process adheres to EU's regulations for tenders.

The process begins with a pre-qualifying round where the task is presented, and where it is specified what competences the consortiums must have to take part in the process. When the participating consortiums have been selected, the task should be specified further in a process involving direct contact between the selected consortiums and the clients requesting the new solution.

A competitive dialogue allows for in-depth discussions. Usually, it begins with consortiums' presentation of an outline of a new solution – a new concept. The clients consider this, and the dialogue continues until the clients have acquired sufficient insight in the costs and possibilities to draw up the final and detailed tender material.

In Stage Four, the winning concept is found, and a contract is signed with the winning consortium to go carry out the proposal.

The process, which is organised by CLEAN with the involvement of the necessary experts, should be expected to take three to four years, depending on issue, but as mentioned earlier, the CLEAN model was not developed until 2011, so there is still limited experience to draw on in this regard.

The first issue that the Copenhagen Cleantech Cluster, now CLEAN, addressed was establishing a digital infrastructure for the use of big data. Since then, CLEAN has addressed the issue of waste as a resource and a better and safer use of water. Recently, CLEAN has begun to examine whether the association should address the issue of a more efficient use of biomass.

The projects in the use of waste as a resource is about to move to Stage Three, while better and safer water use and a more efficient use of biomass are still in Stage One, and the digital infrastructure project is about to move to Stage Four, which involves drawing up a contract with the winning consortium to build and operate the digital infrastructure.

The tender material for the pre-qualification of consortiums wishing to bid on the contract for establishing a digital infrastructure for the use of big data emphasised that the participating consortiums should have access to *"creative/ innovative competencies and proven experiences in relation to user friendly interfaces and collaborative innovation models."*[77]

It was further specified in the final tender material that a key criterion for selecting the winning proposal is that the creation of the digital infrastructure should stimulate innovation and job creation in the creative talent base of start-ups in the Copenhagen Capital Region.[78]

Several international companies and several Danish universities have bid on the contract for a digital infrastructure, but the consortiums have also included small tech firms and start-ups, including two design-led start-ups based in Copenhagen – Social Action[79] and Leapcraft[80].

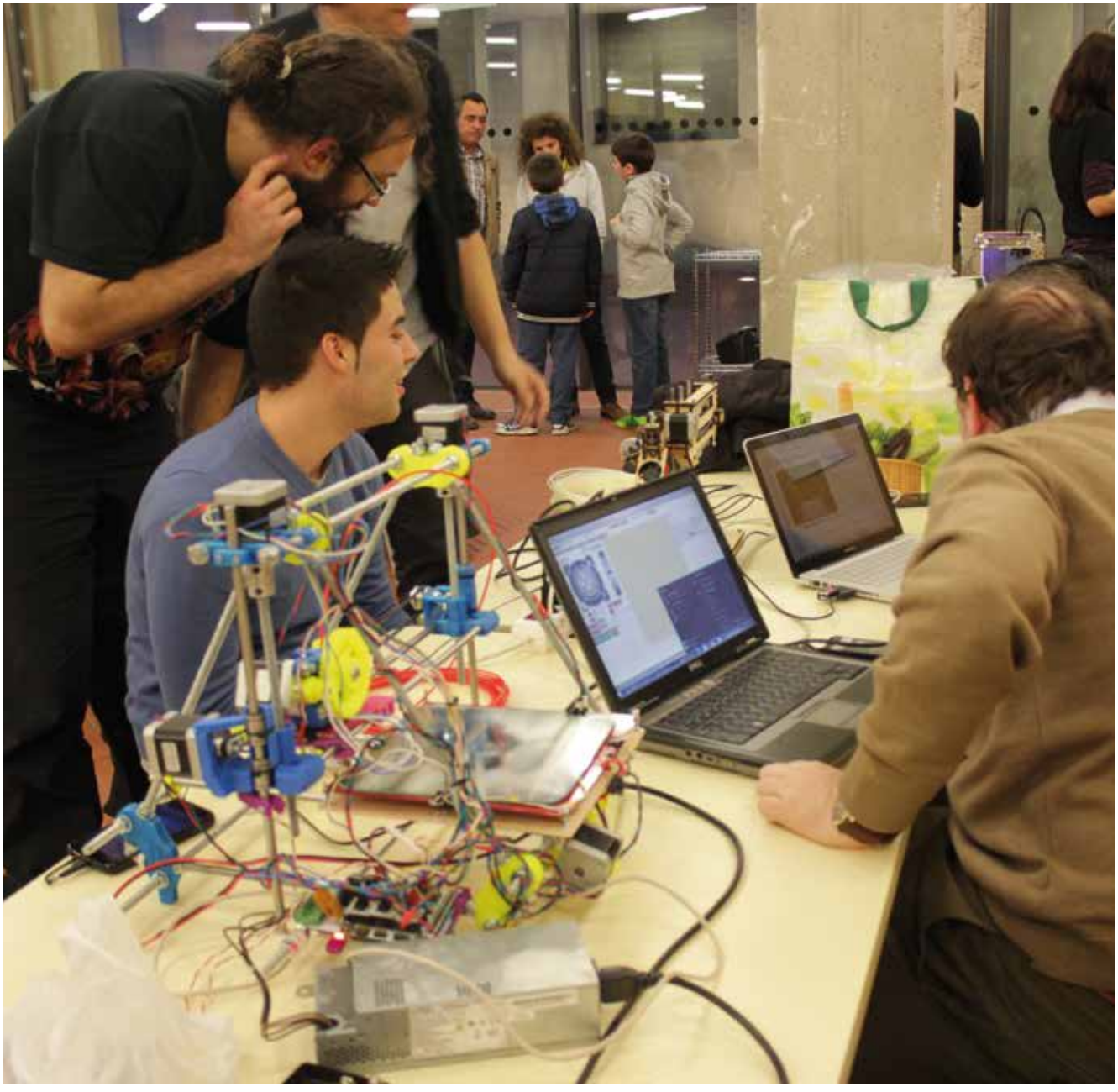
Medialab-Prado

Medialab-Prado[81] is a programme under the Department of Arts, Sports and Tourism in Madrid. The programme was established in 2000 with the purpose of promoting the capacity of designers and creative talents to combine creativity and technology in order to help develop new answers to the challenges faced by society.

The programme is intended as a citizens' lab for the production of, research into and communication of cultural projects to address community challenges in Madrid while also exploring new kinds of community experiments. The citizens' lab works as an open platform and involves people with a variety of profiles, including the arts, science and technology and with various levels of specialisation, form experts to novices.

Programme activities includes workshops, seminars and debates as well as working groups, exhibitions, conferences and other events such as concerts and performances.

77 http://www.cphcleantech.com/media/2432918/ccc%20big%20data%20infrastructure,%20prequalification%20material.pdf
78 Op. cit.
79 http://www.socialaction.dk/
80 http://leapcraft.dk/
81 http://medialab-prado.es/



Medialab-Prado, Madrid. Photo Medialab-Prado CC BY-SA 2.0.

Medialab-Prado also has a number of specific programmes aiming to promote the development of new creative talents who master the use of new and advanced technology, including the programme 'INTERACTIVOS?'[82]

INTERACTIVOS? is an educational, research-oriented and production platform for designers and creative talents within the use of technology. The goal of the programme is to expand the use of digital and electronic software tools for artists and designers.

The programme has engaged in collaboration with institutions outside Spain with a view to expanding the programme and creating an international network for new creative talents who master the use of technology. One of these partners is Birmingham City University, which collaborates with Medielab-Prado in the INTERACTIVOS? programme with the goal of bringing artists, designers, researchers and digital developers from Birmingham together to address specific local community challenges by combining art, design and technology.[83]

82 http://medialab-prado.es/interactivos
83 http://www.bcu.ac.uk/news-events/news/interactivos-birmingham-set-to-transform-the-way-we-think

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APPENDIX 1

About DARPA

The Defence Advanced Research Projects Agency (DARPA) was founded in 1958 and is the central research and development organization of the US Department of Defence (DoD) with the mission of creating radical innovation and breakthrough technologies for national security[i].

DARPA is a small, flexible and relatively flat organization with 120 technical staff, 220 total employees, and only one level of management between the program managers and the director of the agency. The organization responds to military needs and is funded by the DoD with an annual budget of US$ 3 billion.

The projects taking on by DARPA are finite in duration, and last between 4-6 years. For the most part, DARPA emphasizes high technical payoffs for which success may provide dramatic advances in military capabilities. This usually entails taking high risks and focusing investments in a few critical areas. In this sense, DARPA is more like an investment firm since it has no long-term investments.

DARPA has limited overhead and no laboratories or facilities. The organization invests about 97 pct. of its funds at organizations outside of DARPA[ii]. DARPA works with a range of universities, government labs, large companies and small companies. Some of the small companies might be start-ups that are recruited from universities.

The DARPA Innovation Model

DARPA's innovation model is based on Intelligent Public Demand designed to respond to the military needs of the DoD. Senior military personnel meet regularly with the Executive Board of DARPA to discuss military challenges, which require development of next generation technologies. Once a challenge is identified and the board of directors decide to fund a project, DARPA hires an external program manager to run the project[iii]. The external program manager is usually an external expert hired to lead the innovation process. When selecting the project manager DARPA looks for someone with great passion for the relevant technological area and who has shown a talent for being innovative.

The program manager is given authority and freedom to take the necessary risks related to the project. It is commonly accepted that mistakes are part of the process of developing radical solutions. Most administrative tasks related to the project are taken care of by DARPA's administrative team. This means that the program manager can focus 100 pct. on the project and the solutions that need to be developed.

Before a project starts a set of very strict investment criteria are assessed. There are seven key questions that must be answered by each program manager:

1. What are you trying to accomplish?
2. How is it done today and what are the limitations?
3. What is truly new in your approach that will remove current limitations and improve performance? By how much? A factor of 10? 100? More?
4. If successful, what difference will it make and to whom?
5. What are the midterm exams, final exams, or full-scale applications required to prove your hypothesis? When will they be done?
6. What is the DARPA 'exit strategy?' Who will take the technologies that you have developed and turn them into a new capability or a real product?
7. How much will it cost?

When the seven key questions have been answered positively, it is important to determine the type of project. DARPA distinguishes between two types of projects:

A. *Projects that need to develop new technology. These projects are focused on solving long-standing problems through new scientific development:* Uncover an emerging defence need that existing technologies cannot address.

B. *Projects that can develop new solutions based on existing technology. These projects are focused on new possibilities created by scientific advances:* Recognise that a scientific field has emerged or reached an inflection point, and that existing technology can solve, often in a new way, a practical problem of importance.

Having identified the type of project the innovation process usually starts with identifying relevant companies and research institutions. The program manager preferably has an extensive network among relevant participants for the project due to his or her expertise in the field. Together with DARPA's network of leading technology companies and leading universities it is ensured that the program manager always has access to the most relevant experts. Often the most relevant companies are found among start-ups.

When planning the innovation process all program managers at DARPA applies the so-called 'end-game' approach, which makes the program manager focus strictly on the important problems, and keeping a clear exit strategy in mind. In contrast to the standard research method of performing an A to B road map, DARPA programs typically run by first defining the product or process and the anticipated technology needs. By applying the 'end-game' approach, the program manager can better identify relevant companies and research institutions and the research teams can better coordinate their efforts and a higher rate of return on technology development can be realized.

Since all DARPA programs focus on developing radical innovation in a limited time period between 4-6 years, it is important to create the right incentives for the parties involved in order for them to perform their best in a fast pace. To create the right incentives for the involved parties, DARPA uses a set of strategic contracting vehicles, or solicitations.

DARPA has three main solicitation methods for research and development:

1. *Broad Agency Announcements (BAA):* BAAs are a competitive solicitation procedure used to obtain proposals for basic and applied research. The type of research solicited under BAAs attempt to increase knowledge in science and/or advance the state-of-the-art compared to practical application of knowledge[iv]. There are two types of BAAs; 1) DARPA Office wide BAAs where each DARPA technical office has a BAA open for one year or more and cover a broad range of topics, 2) DARPA Program Specific BAAs, usually open for 45 days.

2. *Request for Proposal (RFP):* RFPs are a formal competitive means of soliciting proposals in response to government requirements for supplies and services in excess of the simplified acquisition threshold or where there is a common statement of work[v]. The procurement of contracts can be done through competitive or non-competitive negotiation[vi].

3. *Research Announcements (RA):* to award grants or cooperative agreements[vii].

Alternative ways to create incentives for participation in developing new technological solutions are:

1. *Prize competitions.* This alternative is less costly than the three main types of solicitation, and it is used to create excitement around specific missions and thereby attract talent that compete to solve the problems DARPA have identified[viii].

2. *Other Transactions Authorities (OTA)* The OTAs are used when DARPA is working with other research organisations – particularly from industry – where it might be necessary to offer incentives that are not only based on covering costs, but rather on issues such as ownership of IPR.

   In some projects covered by OTAs firms bring their own R&D funding into the projects where they anticipate there is a commercial opportunity. DARPA works together with the company, sharing the development costs, while the firm retains the IPR. The company invites DARPA into its R&D work, allowing DARPA to have access to cutting-edge technology it would not otherwise be able to access[ix].

When DARPA has received proposals for project type A or B, DARPA typically chooses 8-10 of the best ideas, and let them all work and compete on solving the problem at the same time. The program manager organises workshops that are typically 3-day meetings with an agenda, presentations of the different ideas and solutions, social networking etc. to allow the different teams to meet and identify possible synergies[x]. The participating teams are allowed to form partnerships but this will always happen voluntarily and will never be forced by DARPA.

During the program there is frequent contact between technology developers and technology users, with the DARPA program manager playing the role of 'technology midwife' at times, ensuring that useful discoveries will move more rapidly from the research laboratory into the marketplace to secure the exit strategy.

Once the project has developed the desired solution, the solution is handed over to the DoD and the project ends.

What is special about the DARPA model?

There seems to be three main driving forces employed by DARPA that are crucial in order to accelerate breakthrough technical innovation: Exit Strategy; Game Theory; and Program Managers.

Exit strategy
As the central research and development organization of the DoD, DARPA has a very tight connection with the DoD, which is highly beneficial for the success of the innovation processes carried out by DARPA. It is always clear who the customer is (the DoD), and because the customer is known, it gives DARPA the opportunity to work out a clear exit-strategy from the beginning of each project, which allows the project to be extremely focused. This is very important and in contrast to the standard process of developing breakthrough technological innovation.

The other important issue in relation to the exit strategy is that the problem has to be solved within a fixed timeframe. The customer (the DoD) will take over once DARPA has developed the new solution and by doing that the success criteria for DARPA is achieved. However complex and advanced some of the developed solutions may be, there is always a clear path to follow and an explicit exit strategy to aim for. This simplifies the innovation process and helps the program manager to focus strictly on the problem to solve and the process.

Game theory

Program management at DARPA is a very proactive activity, which can somehow be related to game theory or playing a game of multidimensional chess. The program manager always knows what the goal is (the exit strategy), but there are many ways to reach the goal and there are many different actors in the game or on the way to reach the goal.

A program manager often starts with many different independent companies or research groups with different useful capabilities. It is important that there are always different parties competing on solving the problem. This intensifies the incentives and the excitement. However, at the same time it is a challenge to constantly make the parties move in the right direction. Therefore DARPA has to create the right incentives through different contracts. It is also a challenge that the target is constantly moving. The DARPA program manager has to deal with both emerging technologies and constantly changing customer demands (the DoD). As in a game of chess the proactive player usually win, and at DARPA it is usually the proactive program manager who is most successful.

Program manager

DARPA program managers have a great degree of freedom and are given the responsibility and authority of making decisions that affect the project. They have easy access to decision-makers to ensure that there is constant progress in the project. Program managers are relived of any tasks related to office politics and administration, such as contracting, making budgets and so on.

The DARPA program managers must be proactive 'techno-scouts' constantly searching for the next big technological opportunity. He or she is constantly talking to potential new contractors as well as possible users of any new capability. Efforts are highly focused, and goals and needs are clearly understood by all up front. To accomplish this, DARPA program managers are given both the responsibility and the authority to act.

The program manager's quality performance is rewarded with increased funding. In order to accomplish this, DARPA has highly flexible contracting and hiring practices that are atypical of most of the federal government. DARPA contract agents can issue contracts, grants and various other transactions. Staff can be hired from industry quickly, at wages substantially above those of typical government employees.

i DARPAs approach to innovation and its reflection in industry, L.H. Dubois, SRI International, 2003
ii The DARPA model for Advanced Concepts Developments, Fostering visions for the future: A review of the NASA Institute for Advanced Concepts, 2009
iii Interview with Scott Ulrey, Deputy Director, DARPA, 2014
iv http://www.darpa.mil/Opportunities/Contract_Management/Solicitation_Methods.aspx
v http://www.darpa.mil/Opportunities/Contract_Management/Solicitation_Methods.aspx
vi Doing Business with DARPA, 2012
vii http://www.darpa.mil/Opportunities/Contract_Management/Solicitation_Methods.aspx
viii A well known example is the Red Balloon challenge.
ix Assessing the use of "Other Transactions" Authority for Prototype Projects, RAND, March 2000
x Interview with Scott Ulrey, Deputy Director, DARPA, 2014