The White Book

Lessons from a four-year journey into design-driven materials innovation

Edited by: Claudio Dell'Era, Stefano Magistretti, Menno van Rijn, Erik Tempelman, Roberto Verganti and Åsa Öberg

light.touch.matters
the product is the interface

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Contents

This book summarizes four years of research towards new, meaningful solutions that combine two emerging materials: Piezo plastics and flexible OLED:s. The work was done by a consortium of product designers, materials researchers and facilitators - eighteen partners in total from nine EU members states - in the EU-funded project Light.Touch.Matters. The resulting lessons for design-driven research & technology development, or D-RTD for short, are captured in this White Book.

In addition to the text, also videos are available to describe the same subject matter, see http://bit.ly/LTM_Interviews

The White Book and videos can be sampled independently or together at the convenience of the reader.

1 The challenge

Re-thinking research and technology development

Erik Tempelman, Associate Professor Industrial Design Engineering

Delft University of Technology*

Material innovations are of profound importance to today's world. Yet, the adoption of new materials takes surprisingly long – typically 15 years or longer. In general, the outcomes of research and technology development are slow to move towards market acceptance. In a world where new cars, phones and TV's appear every year it may not look like it, but the base technologies on which we build our lifestyle change only very slowly. Can't we find ways to speed things up?

"Adoption of new materials typically takes 15 years or longer"

This book is not the first to address that issue, nor will it be the last. But with materials innovation as our starting point, we can perhaps shed some new light on the issue. So, what do we mean with a "new" material, and what are the forces that currently slow down material innovations? To start with the first question: new is not just "improved" - we are talking about genuine breakthroughs here, affecting multiple links of the material supply chain. For instance, novel high strength steels require novel manufacturing and joining solutions for the actual steel parts, this in addition to making the new steels themselves. And what about recycling and end-of-life? This example contains some of the answers to our second question. It takes time to develop the necessary manufacturing technology and to reorganize supply networks. Material innovation, so it seems, is not just about the material itself. If the new material takes an alternative path towards adoption by moving "horizontally" from an established market into a new one, it still moves anything but fast. There may be time-consuming certification work to do - are those new steels also food-safe and suitable for cans, for instance? - and apart from that, ramping up production capacity takes time even if all of the other problems are solved Still, in more ways than one, society can't afford to wait. Innovation must be accelerated - but how, or rather, by whom? This is where designers come in. In the right way, their input helps to get research and technology development outcomes to the market, which is what innovation is all about. Showing this "right way" is the core of this book.

To dispel one notion up front: designers should not be expected to "magically" solve the tough engineering issues that resist the conventional RTD approach. And to dispel another misconception:

* Delft University of Technology is the largest and oldest Dutch technical university. It was founded in 1842 in Delft, The Netherlands. With eight faculties and numerous research institutes, it hosts over 19,000 students (undergraduate and postgraduate), more than 3,300 scientists, and more than 2,200 people in support and management. In Project Light.Touch.Matters, two faculties were involved: Industrial Design Engineering, and Aerospace Engineering (Novel Aerospace Materials Group).

no, designers don’t contribute to innovation just by “making things look good” - design is much more than that. Adding a dash of “design” to the RTD mix won’t work.

So, what can designer bring to the RTD table? Many things, as it turns out. They bring in the end user perspective and express the potential of the new technologies in concepts, prototypes, and demonstrators.

This clarifies base requirements and identifies the manufacturing challenges ahead - simultaneously providing a business perspective, something that typical RTD personnel is ill-equipped to give. Embedded in an RTD process, designers also reveal under-appreciated specifications, or just as importantly, prevent over-specification. Furthermore, with their aptitude for dealing with qualities instead of quantities, designers represent the (often subjective) end user preferences. A final, deeper contribution: Designers, with their end-user perspective and their capability to make ideas tangible, can powerfully stimulate a conversation on what applications are meaningful, and can eventually help identify the most valuable technology developments.

And to quote a certain designer, “One more thing ...”. Embedding designers in RTD teams helps steer innovation, and once you get going, it can be fun, too.

Erik Tempelman, Delft June 2016

Question: What are the challenges corporations can overcome applying the Design-driven Research & Technology Development (D-RTD) approach?

Menno van Rijn
Managing Partner

Francesc Rullan,
Managing Partner

Bax & Willems*

While Europe has a leading position in science and research worldwide, the innovation performance of its industrial ecosystem is lagging behind, being outperformed by the US and overtaken by China. Studies such as the Innovation Scoreboard show there is a deep Innovation Gap: strong scientific output, but limited market uptake. The European Commission concludes that developments in science and technology in Europe do not result in sufficient innovation, that is, creation of sustainable, profitable new business. The substantial R&D investments of companies lead to extensive IPR portfolios of scientific discoveries and innovative technologies, but these are not low and ineffective in making their way to the market in the form of new breakthrough products or services: the figures show that the percentage of patents leading to commercialized products is low.

Public policy at all levels is actively targeting this European Innovation Gap, with the aim of improving the commercialisation of scientific developments and extracting more value from public and private investments in R&D. The D-RTD approach described in this white book can help bridge the Innovation Gap, actively promoted by the European Commission, and improve the return on investment of science and technology developments. By involving designers and design thinkers as facilitators at the intersection of science and society, the D-RTD approach drives the creation of new technological components, their applications in products, and even the creation of new businesses. Thus, D-RTD aims to improve the effectiveness and efficiency of the technology-to-market cycle. The D-RTD approach is specifically targeted at reconnecting the technology-focused pure R&D performers with market- and end-user oriented business actors.

"Science and technology in Europe do not result in sufficient innovation"

Key technological breakthroughs, such as composite materials and digital photography, have taken over 20 years to come to the mar-

* Bax & Willems is an experienced consultancy firm dedicated to defining and facilitating Open Innovation strategies for large industrial corporations as well as smaller high-tech companies, research institutes, and governments. They are based in Spain, but with origins in The Netherlands where they still have an extensive network of clients. Founded in 1987 in The Hague, they have evolved into the present company Bax & Willems Consulting Venturing with headquarters in Barcelona. Over the past 20 years B&W have accumulated substantial experience and an extensive toolbox to facilitate Open Innovation, create and manage a portfolio of ventures, opportunities, and R&D projects.

ket. In view of the huge investments needed to develop such technologies, R&D performers need to carefully select which technologies and applications to pursue - and which performance aspects to focus on. In this complex and uncertain landscape, D-RTD adds value through a multidisciplinary focus on science, engineering, marketing and business. Its unique iterative design approach is precisely tailored to the uncertainties of the technology-to-market cycle.

D-RTD adds value by envisaging future applications, expressing the unique end user value proposition inherent in the technology in the technology, and steering the research and technology development direction towards market introduction of meaningful products and services. Furthermore, new business can be created by entrepreneurial designers or design thinkers based on technology spun out of larger corporations or coming out of academic research. This is stimulated by an increasingly entrepreneurial culture, better policies, and improved strategies for technology transfer, and complemented by alternative financing opportunities, such as crowd funding. Similarly and because of its proximity to the end users, the D-RTD approach may have strong societal benefit such as non-profit initiatives and public services.

How can material scientists and designers interact along the technology development?

Erik Tempelman
Associate Professor in Industrial Design Engineering
Delft University of Technology

Watch the video on Youtube at
http://bit.ly/LTM_Interview_TempelmanE_Part1

How can corporations extract more value from their emerging technologies by envisioning meaningful applications?

Roberto Verganti
Full Professor in Leadership and Innovation
Politecnico di Milano

Watch the video on Youtube at
http://bit.ly/LTM_Interview_VergantiR

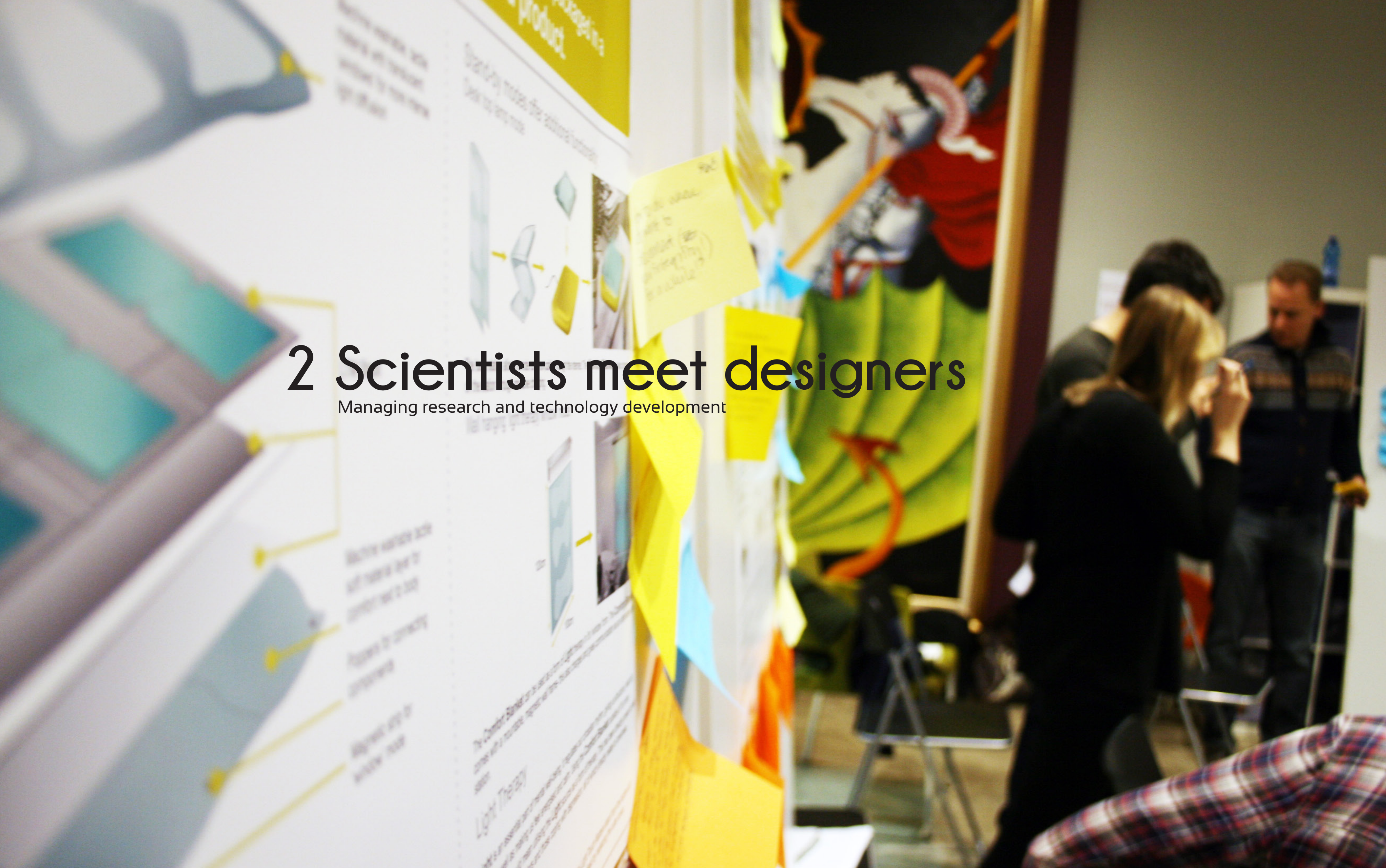
What are the challenges corporations can overcome by applying the Design-driven Research and Technology Development (D-RTD) approach?

Menno van Rijn
Managing Partner
Bax & Willems

Watch the video on Youtube at
http://bit.ly/LTM_Interview_vanRijnM

2 Scientists meet designers

Managing research and technology development



Claudio
Dell'Era
Assistant
Professor
Design
Strategy

Stefano
Magistretti,
PhD
Candidate
Innovation
Management

Politecnico di
Milano*

Given that purely science-based innovation is a long-term process requiring substantial investments, society is well-served with an approach towards selecting base technologies and supporting their development into building blocks. With the right design input, this approach guides the creation of applications and further, into products and systems with sustainable end user value - and it includes several different approaches.

On the one hand, a science-to-market process traditionally moves through a step-wise development moving between technology development, done by scientists and engineers, and market demand formulation, done by marketers and salesmen. Development is defined according to roadmaps, technology foresights, and forecasts. More specifically, the so-called Technology Future Analysis (TFA) represents a set of systematic processes aimed at providing judgements about emerging technologies, development pathways, and potential future impacts of a technology. TFA is composed of a group of techniques such as Technology Forecasting, Technology Roadmapping and Technology Foresight that have proven to be useful to understand whether or not to invest in a particular technology, levering on the probability of growth and opportunities of success of the latter. Thus, it is a linear and technology-driven approach, based on predictions of future markets that are impossible to be verified upfront, especially for new technologies that will disrupt existing markets or create new ones.

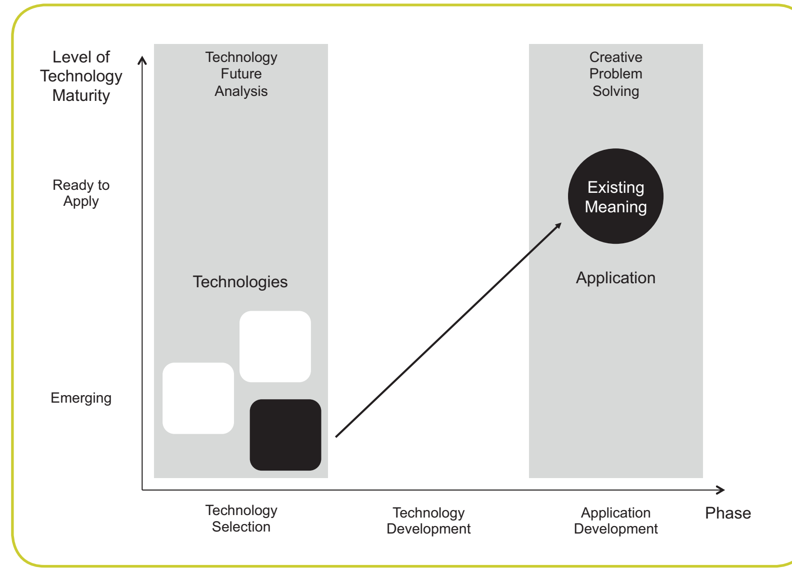
"Customers hardly help in anticipating possible radical changes"

On the other hand, user-centred design and - more recently - design thinking have emerged as alternative approaches, and have quickly gained dominance at the application development stage. These approaches take as their starting point a deep analysis of user needs. By using ethnographic methods and observation, and therefore by becoming much closer to users, companies can come to better understand user needs. Next, through creative problem-solving sessions, they may address the mismatch between existing needs and existing products. The first approach is defined as technology-driven considering that technological evolution steers the following development of applications (see picture 2.1). The second approach is driven by emerging market needs.

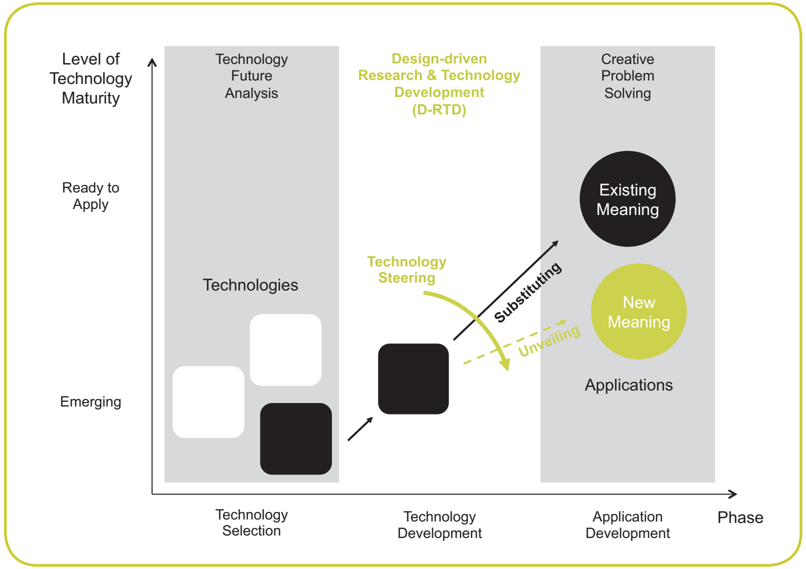
Radical innovation, however, clearly requires a different process. Indeed, customers hardly help in anticipating possible radical changes because the socio-cultural context in which they are currently immersed makes them inclined to interpretations that are in

* Politecnico di Milano is a scientific-technological university which trains engineers, architects and industrial designers since 1863. The University has always focused on the quality and innovation of its teaching and research, developing a fruitful relationship with the worlds of business and productionby means of experimental research and technological transfer. The Department of Management, Economics and Industrial Engineering (DIG) of Politecnico di Milano with the main objective to perform research pursued through collaborations with leading Italian and international schools and institutions.

line with what is happening today. Radical changes instead ask for radically new interpretations of what a product is meant for, which can be understood only by looking at things from a broader perspective. Already at the first stages of technological development, it is necessary to take into account that "technologies offer opportunities", which, as the semiologist Giampaolo Proni says, "are of course not infinite, but are greater in number than those imagined by early developers". Many of these opportunities are likely very far from the primary object of the research, and might prove to be useless and meaningless at the end. Some of them will represent a technology substitution, deriving from the companies' research and technology development activities; again other opportunities are driven by the market, resulting in a new product development as a direct consequence of explicit needs expressed by the consumers. But the real challenge lies in finding those RTD opportunities that unlock radically new applications. That involves research and analysis in unusual fields, with unusual customers, and towards unusual (but powerful) meanings.



2.1 A traditional step-wise development process is linear and convergent. When one technology has been selected explorations take place within this specific domain. Common tools to explore and decide include the Technology Future Analysis and Creative Problem Solving techniques.



2.2 A radical innovation process keeps broad perspectives by exploring several alternatives in every phase.

D-RTD is tailored for precisely that challenge. It works through fast iterative processes, using experimentation, prototyping and demonstration to rapidly conceptualise, prototype and validate different application paths. User cases, mock-ups with analogous technologies and simulated functionality, are deployed to test feasibility, assess user perception, and explore added value for science and technology discoveries not yet on the market. With the right design input, this approach gives insights into what future developments may yield. For technologies that are already close to the market, D-RTD can help find the unique value proposition that best exploits the technology's characteristics.

Question: How can design influence or eventually steer the new materials development?

Pim Groen,
Professor
of SMART
Materials at
Aerospace
Engineering

Delft University
of Technology

Industrial research and RTD in the field of materials in the past started from curiosity, but also from the need for new functionalities or improved performance, which possibly resulted in new products. This way of working is the typical technology push method. A good example here is the research on magnetic materials, which enabled the development of the flexible tape recording technology, resulting in the video and the compact cassette. Another traditional driver for materials RTD was the demand for materials (or technologies) with unavailable or unknown properties. For instance, as early as during the industrial revolution there emerged a need for casting metals, which in turn initiated research on refractory materials and ceramics required for high temperature crucibles. It is interesting to note that a century later, these refractory ceramics enabled the development of highly efficient lighting sources: in high intensity discharge lamps these materials are used as a plasma envelope, while in today's LEDs, a similar materials is used as a heat sink. So, the pay-off of materials RTD can come only much later, and through very different applications than initially foreseen. Yet another example of materials RTD in an industrial setting is the work on high temperature superconductors at the end of the 1980's. The 1986 breakthrough on superconductivity at room temperature boosted research in the large industrial laboratories with the aim to claim IPR, come to an improved understanding, and find new applications. However, when the fundamental understanding emerged that the limits were reached and that application temperatures are limited, this superconductivity hype ended quickly.

More recently, materials RTD is also being done in the "open innovation" or "shared research" mode. Here, various companies work together with a research institute, sharing costs. Good examples of this approach are imec, in Leuven, Belgium, working on long-term semiconductor technology and TNO-Holst Centre, Eindhoven, the

> "Recently, materials RTD is done in the "open innovation" or "shared research" mode"

Netherlands, which is focused on flexible electronics. In this co-operation, the research work is performed along a joint roadmap defined by the participating companies. In all these cases, the materials RTD work enables new applications and products.

Product designers typically work at the other end of the spectrum. New products are designed starting from existing materials and mature technologies for manufacturing and integration. It's a challenge to bring their ways of working together with those used in materials RTD - even more difficult is arriving at new innovations where the designer give input for the directions that materials research takes. In the Light.Touch.Matters, we experimented with such a consortium, bringing together product designers and materials researchers. At the start of the project is was clear that there was a bridge to cross between the various disciplines. The discussions were quite abstract regarding what was and what was not possible. This changed slowly to a dialogue where directions for materials RTD could be distilled out of the discussions. One thing which came out clearly was the wish to have the possibility for colour change inside the foreseen products. Another point, related to the first, was to have a transparent lighting source. Within both topics, solutions were being investigated during later phases of the project. What helped a lot in the communication of the different "blood types" of competences was to work with demonstrators to visualize the discussions. Another outcome might be the learning experience of the researchers involved, have a more multidisciplinary way of thinking and a clearer focus on real products. Both material scientists and designers benefit from the complementary attitudes and approaches transforming diversity to richer interpretative capabilities.

How can design influence or eventually steer new materials development?

Pim Groen
Professor of SMART Materials
Aerospace Engineering - Delft University of Technology

Watch the video on Youtube at
http://bit.ly/LTM_Interview_GroenP

How does Prysmian drive technology development by envisioning new applications?

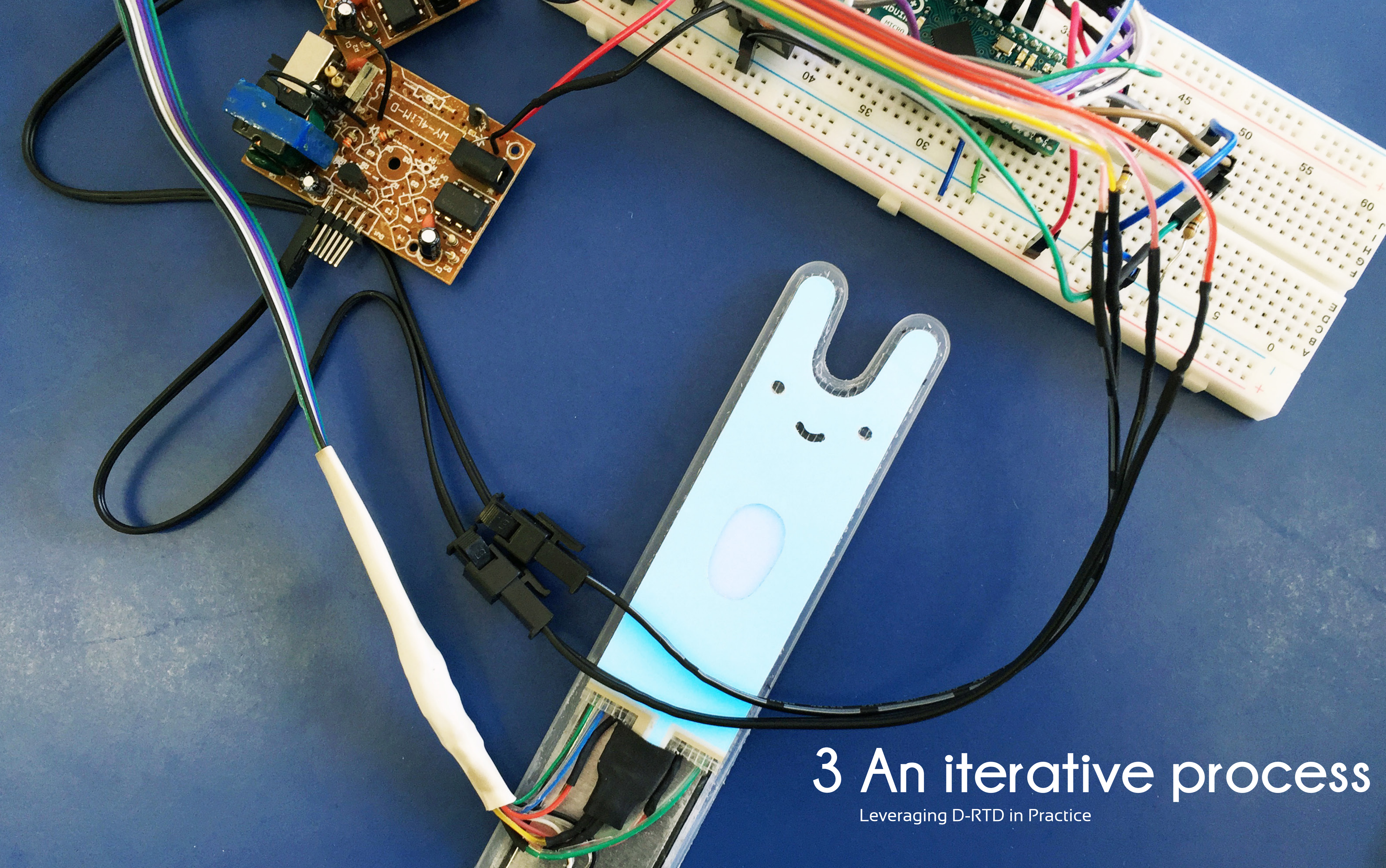
Marcelo De Araujo Andrade
Group Research & Development Director
Prysmian Group

Watch the video on Youtube at
http://bit.ly/LTM_Interview_AndradeM

How can designers contribute to the technology development?

Emilio Genovesi
CEO
Material ConneXion Italy

Watch the video on Youtube at
http://bit.ly/LTM_Interview_GenovesiE



3 An iterative process

Leveraging D-RTD in Practice

Erik Tempelman, Associate Professor Industrial Design Engineering

Delft University of Technology

Emerging technologies are, by definition, highly fluid in what they may one day deliver. Their precise affordances to design are initially unknown. So, how can designers provide meaningful input to the development of these technologies – how to make it all "technology-anchored, yet design-driven"? By far the best way to involve designers in anything is to let them do what they do best: designing. This chapter explains what this means for putting design-driven RTD into practice.

"How to make it all "technology-anchored, yet design-driven?"

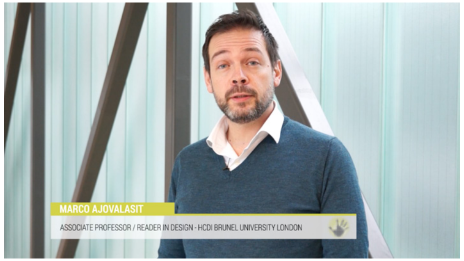
At the start of a D-RTD project, the researchers should make their expectations of the emerging technology they are developing explicit. This must be done in a way that is understandable to non-experts - preferably with visuals and short lists of targeted specifications, not through large amounts of text. Comparisons to similar, existing technologies are welcome also, because these can be used as "stand-in" samples. In the LTM project for instance, electroluminescent materials were used as stand-ins for flexible OLEDs, along with (rigid) glass OLEDs to show the output light's quality. These initial specifications are the input for the first of several "design cycles". They are best presented during a plenary workshop and through informal "Q&A", i.e. question-and-answer sessions. After this point, both the technology stream and the design stream can essentially go separate ways until their next joint meeting, where intermediate results are shared and critically reviewed. The designers will have done what they excel at: making many conceptual designs (of products, systems or services) that make use of the emerging technology's expected features and functions. This first batch of designs can now be assessed regarding technological feasibility, end user value, and other dimensions of interest. Of course, this assessment will be largely paper-based: at best, first prototypes will involve the stand-in technologies, not the emerging technology that are at this point still under development. This however will not be a critical issue. The assessment will reveal that many designs are not feasible, or indeed that some miss the point altogether - but that too is not critical: what matters is that this first "design iteration" helps everyone understand what the technology is really about, and what it can bring to end users. Some designs will be spot-on, and will challenge the initial specifications: unforeseen issues will come to light (for instance, what about eco-impact at product level, or how to integrate the technology?), new target markets can be found, and over-specification of the technology will be exposed - sometimes harshly so.

Be ready for another Q&A session: understanding any emerging technology takes time! It can also be tough going: no doubt, the designers will have been asking for initial samples of the technology - more than the RTD stream can deliver - without really knowing how much they are asking for, and that alone may set up a clash between the two streams. But it's all worth it: by now, the target specifications can be expanded, updated and revised from the basis of solid design input. And of course, the "spec sheet" can also be revised because in the meantime the researchers will of course have their own progress. Unexpected, "serendipitous" developments can be included too. The revised technology spec sheet (still largely visual!) is the input for the next design cycle. Now, fewer designs should be targeted, but with more emphasis on engineering and prototyping, and where possible with the actual first samples of the emerging technology.

How many design cycles are needed? Basically, as many as you can afford: at least two, and ideally three to four. In the LTM project, there were three full iterations, plus a fourth one devoted to technology showcasing. By themselves, these cycles can spin quite fast: professional designers are accustomed to creating new products in mere months. However, to allow for in-depth exploration of radically-new design directions and new meanings it is advisable to stretch out the design cycles to anywhere between 6-12 months. This will help matching the pace of the (necessarily slower) research and technology development - with the added benefit that the design work can be done part-time, and in parallel with other design assignments. So, a D-RTD project done this way would last between 1-4 years: short if the technology is close to maturity, but long if it is more ambitious in its development targets.

This iterative approach is the best way in which designers can give in-depth input to RTD processes (so, "design-driven"). Note that the design work is being done fully in the service of the emerging technology (so, "technology-anchored"), and should be seen as research-through-design, not purely as application-oriented work. Harnessing "the power of iteration" worked for the LTM project, and we expect it will work for technology as well. And as a final, practical tip: do not try to pin down all intellectual property rights (IPR) beforehand, but settle these on the go, on the basis of who-does-what. That too worked very well in the LTM environment.

How can professionals belonging to the same category share experiences developed in different industries and settings?



Marco Ajovalasit
Reader in Design
Human Centered Design Institute, Brunel University

Watch the video on Youtube at
http://bit.ly/LTM_Interview_AjovalasitM

How can designers get insights from challenges provided by material scientists' proposals?

László Herczeg
Design Director
Fuelfor

Watch the video on Youtube at
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How can material scientists get insights from challenges provided by designers' proposals?

Robert Abbel
Research Scientist in Printed Electronics
Holst Centre-TNO

Watch the video on Youtube at
http://bit.ly/LTM_Interview_AbbelR

4 The team

Enabling the Dialogue between Scientists and Designers

Åsa Öberg
Researcher
Innovation
Management

Politecnico di
Milano
and Mälardalen
University,
Sweden

As already discussed, the fields of design management and technology development are two different communities - both with their own language, culture, logic and assumptions. Designers strive to create scenarios of experiences for humans in contact with a product or service. Sketches, storyboards and narration exemplify their tools for describing a certain activity. Normally several scenarios are in play simultaneously to allow comparisons, trigger discussions and challenge existing mind-sets.

"Common space did not emerge from a smooth merger between the competences"

Only once a proposed experience aligns with the visions of the designers and their stakeholder will the means, or technology, to get there come into focus. Technological explorations of new products and services typically take a different viewpoint. With a new technology at hand, a range of possibilities is investigated before one scenario is selected to be the one to invest in. The difference between a designers approach and a more technology focused one is that in the latter case, a certain technology comes as a prerequisite.

When communities from competences as different as design and technology meet, some form of common ground is needed. In the LTM project, this common space did not emerge from a smooth merger between the different competences. Instead, an opposite approach could be identified: a clash of different minds rather than a merger helped the project to find ways to move on. This was followed by a fine-tuned and curious conduction by dedicated facilitators and finally, surrounded by a sense of comfort. These themes are here described as "the three C's".

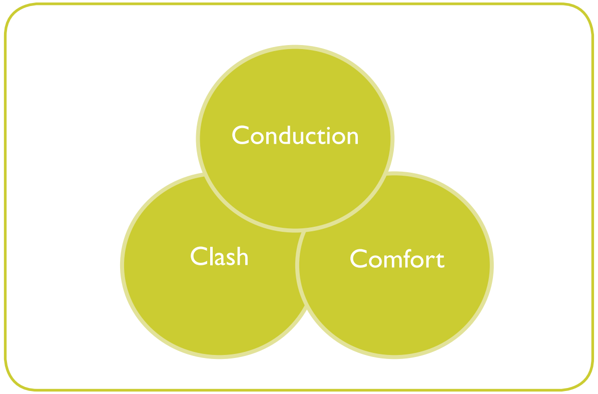
A meeting between significantly different communities does not have to be smooth. Rather, the opposite, a clash can be beneficial and helpful when a project aims to find commonality and a way forward. In the LTM project, significant time was dedicated to give room for the two different fields to express themselves. By allowing a lot of time for all participants to expose their thoughts and

* Politecnico di Milano is a scientific-technological university which trains engineers, architects and industrial designers since 1863. The University has always focused on the quality and innovation of its teaching and research, developing a fruitful relationship with business and productive world by means of experimental research and technological transfer. Mälardalen University has three development environments, one of them being the School of Innovation and Product Realisation, IPR. It covers the scientific competences within engineering, innovation and information design, necessary for developing new products, services and production systems in a technically leading, economically competitive and environmentally sustainable way.

views early in the project, a plethora of expressions came to light. This activity can be described as an act of "pre-emptying", of taking out existing preconceptions. By exposing their own visions, the participants got in touch with several interpretations of a subject, which gave room for new understanding. This cycle of "taking out own beliefs and taking in others" has been a positive asset driving the innovative thinking forward.

Naturally, this unfettered release of perspectives was a test of patience and led to some tensions. The use of different terminology and communication styles can seem unclear to those not familiar with them. Still, in this project, taking time to listen and let people take in, or maybe even oppose what they hear, has been a key factor. After this initial "clash", interaction and dialogue came more easily and common ground started to appear. To conclude - the meeting of different competences most often creates tension, but if properly moderated, it enables deeper discussion. Therefore, let there be clashes. Let them come, leave space for them, and then slowly approach the questions that they trigger.

Allowing significant time for taking out the beliefs and ideas of each and every individual not only demands a big portion of time in a meeting. It also possesses the capacity to keep the whole group engaged and awake. Encouraging own personal thinking to be declared in a group of many (sometimes unknown) people can be a challenge for the participants but also for those moderating the session. In the LTM project, most plenary discussions were facilitated by curious and social people who liked to acknowledge others. This role is not to be associated with the one of a classic chairman who will "point to people" and "tell who to talk when", but to someone more akin to the conductor of an orchestra, inspiring others, giving examples, being generous, and offering own interpretations. The LTM project experienced several people taking turns in leading others in discussions and common reflections by going way beyond the typical role of a chairman. Furthermore, by improvising, changing time-schedules and even content of meetings as the



4.1 The Three C's of creating a common space in the project: The power of clash, the room for conduction and the creation of comfort.

unexpected developments sometimes required, these “conductors” signalled that not sticking to the structure was ok. In short, a second key asset of the LTM project and its methodology is the one of Conduction rather than rigidly structuring.

The role of the conductor actually starts well before the project itself, lending a special touch to the selection of individual participants. For instance, materials researchers were identified and involved not just based upon their strong merits as pure researchers, but also on their willingness to cross-collaborate and to welcome designerly approachers.

The factors of clash and creativity work well in an environment where people feel at ease to ask questions repeatedly, both within official meetings and also in less formal settings such as coffee breaks and in emails. This constant “asking” is eased when agendas are not too packed. In the LTM project, moments of strict time-schedules did not result in good ideas and reflections, but instead seemed to constrain people. Creating comfort among people in all possible ways (such as being present, being engaged, taking time to listen, caring for everyone, being generous, using humour) increased trust and deepened the discussions. Venue space also emerged as a success factor for meetings: typical meeting rooms or lecture halls are less unsuited as compared to more democratic environments.

In order to create common ground for the participants in the project, three factors have been crucial: Clash - a deliberate, but well-moderated action of letting different opinions meet and collide. Conduction - this situation of clash need to be balanced with an equal amount of creative direction, where everyone, both facilitators and participants, feel that they can creatively re-construct agendas if needed. Comfort - the energetic phases of clash and discussions come easily if the group manages to create a comfortable atmosphere, where curiosity rather than judgment drives everyone forward.

Question: How can you structure communication to get the best out of D-RTD projects?

James Burchill, PhD Candidate Human Centred Design

Marco Ajovalasit, Reader in Design

Human Centred Design Institute, Brunel University London*

In research projects, communication is integral to the project's success. It is not helpful to hear only after producing a document that some of the intended recipients do not understand it. Even worse is to see evidence of miscommunication in later work. To prevent this, and ensure efficient dialogue between project partners, it is necessary to create a common language. This requirement is especially urgent in D-RTD projects, where the consortia are more heterogeneous than in "pure" research projects. Confidence is the core of the common language. Finding a method of communication that suits both parties is key and by no means impossible. It can potentially save time and money while also increasing the creative output of the project. It should not aim to be completely infallible but both groups need to know that their work is in line with their partners.

The common language will be a living breathing entity, tendered to and maintained to best fit the situation. The language should be produced by representatives of both groups but managed by a neutral party rather than dominated by one of its two parents as it should be a reflection of the two and not drawn to favour one group's perception of how the language should function. The challenge for the languages' guiding body is to find how much of each groups knowledge needs to be shared and on what topics so the important decisions made by the groups are as informed as possible. It's pointless to worry about every decision and detail but those few which will define the project must be pinned down and developed to ensure the best outcome. This is why repeated Q&A sessions are advised as they expose key points where a common language must bridge a lack of understanding.

"Finding a method of communication that suits both parties is key and by no means impossible"

* Brunel University London is a campus-based university situated in Uxbridge, West London, and is home to nearly 15,000 students from over 100 countries worldwide. Founded in 1966, its distinctive mission is to combine teaching and research excellence with the practical and entrepreneurial approach pioneered by our namesake, Isambard Kingdom Brunel. The Human Centred Design Institute (HCDI) brings together a multi-disciplinary group of experts from different departments who develop the knowledge and skills required to design products, services and systems which are physically, perceptually, cognitively and emotionally intuitive.

Multiple Q&A session allow for quick iterations keeping the language alive and constantly improving by targeting the weak points the sessions expose. Using visual info, short lists and simple prototypes is a very effective way to communicate and allows for quick adaptation when the language needs changing. Avoiding long texts in this communication is important to limit the potential explosion of confusion that can result from different interpretations from even short, apparently obvious terms. For example during the LTM project designers had an entirely different interpretation of what 'material properties' meant than material researchers. The term was prolific within both groups' work, causing confusion when uniting their efforts. While these confusions cannot be completely avoided having them in short texts or part of a visual representation exposes the issue more rapidly, and allows for a quick reaction by the language managers.

Beyond the type of document deciding what methods and props are used to communicate sets the tone of the language. An exceptionally strong method of communication especially in the early part D-RTD projects is the use of analogy and metaphors to communicate the potential of the materials by comparing it to existing products. Comparison with real, tangible items talks to designers and materials researchers by using their own experience but also supports the production of prototypes and gives ideas for future applications. LTM used this method until the concepts were established, after which the language thrived through a visual and practical format. The use of physical representations of both groups work has enabled a great discussion, either in the form of samples and demonstrations from the researchers or appealing and engaging prototypes from the designers. It brought confidence to the discussion, because having something to work with showed both groups how their counterparts were thinking and what outcome they wanted for the material. These strategies worked because they efficiently used the existing resources of the groups involved, ensuring the language that arose was adaptable and relevant.

How can material scientists and designers leverage one each other?

James Burchill
PhD Candidate Human Centred Design
Brunel University London

Watch the video on Youtube at
http://bit.ly/LTM_Interview_BurchillJ

How can two significantly different communities smoothly «meet»?

Åsa Öberg
Researcher Innovation Management
Politecnico di Milano

Watch the video on Youtube at
http://bit.ly/LTM_Interview_ÖbergÅ

How can designers share their knowledge and approaches in order to explore new application fields?

Eric Bierman
Design & Development Director
“Vanberlo”

Watch the video on Youtube at
http://bit.ly/LTM_Interview_BiermanE

5 Discovering new application fields

Unveiling the hidden potential of emerging technologies.

Claudio Dell'Era, Assistant Professor Design Strategy

Stefano Magistretti, PhD Candidate Innovation Management

Politecnico di Milano

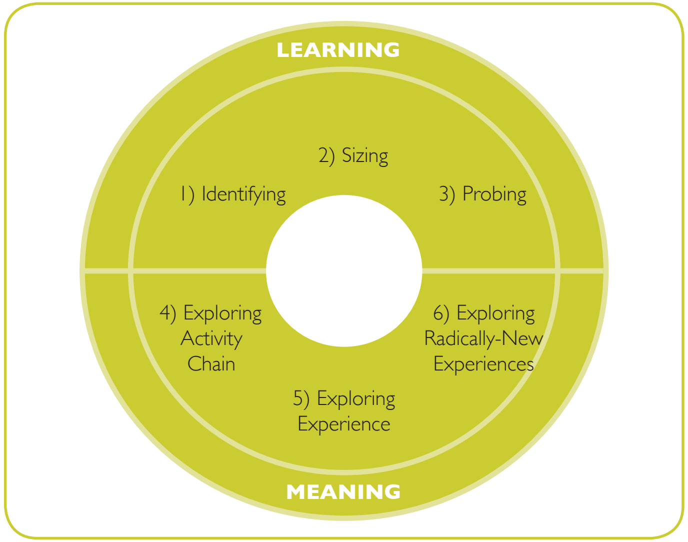

From understanding the challenges of innovating technologies and how teams of designers and material scientists can do this, we move now to understand how to discover new application fields, unveiling the hidden potential of emerging technologies. Because, when a new technology is being developed, it has infinite possible directions. How to steer technology towards application fields where its value can be captured at its best?

If technology development is left to the spontaneous dynamics of scientific research, it will likely take an implicit direction: addressing an existing need, in order to solve it better. In other words, without any guidance, technology development would aim to improve an existing application (this in an activity that is unconscious even in the researchers' mind). This occurs because often the technology has been created specifically for this purpose: to address an existing problem that old technologies solve improperly, and replace these old technologies. Unfortunately, this spontaneous development is often not the most valuable. Indeed, technologies can often enable new more valuable applications that are not simply substitutes for old solutions.

"The initial exploration aims at understanding more in depth the potential of a technology"

But, how to find these more valuable applications? In the LTM project the process in Figure 5.1 was applied iteratively.

In this process, the LEARNING phase aims at understanding more about the nature and potential of the technology. The initial exploration is not aimed at finding solutions for a specific application field, but - at understanding the potential of a technology more in depth before committing to a specific direction. The MEANING phase, is aimed instead at unveiling a hidden meaning in the emerging technology. This is done by identifying properties that are secondary in existing application fields - but that can be disruptive in novel domains.



5.1 The D-RTD process can be conceived as a circle. The first half of it is dedicated to the LEARNING phase (3 sub-phases: identifying the technological uniqueness; sizing the technological boundaries; learning by probing). The second half of it is dedicated to the MEANING phase (3 sub-phases: Exploring the Activity Chain; Exploring the Experience; Exploring Radically New Application Fields).

The explorative LEARNING phase is guided by three managerial practices:

1) Identifying the technological uniqueness: In the first stage of the D-RTD process it is important to abstractly interpret the basic features provided by the emerging technology, splitting them into subgroups based on their nature (e.g. physical, mechanical, aesthetic, etc.). As previously mentioned, building a team composed by material scientists and designers can allow analysis of the same technology from different angles.

2) Sizing the technological boundaries: Involving designers and placing them side by side with material scientists means looking at an issue with a different perspective in order to render technological requirements capable of satisfying latent needs and changing existing paradigms. Designers, thanks to their conceptual thinking, tend to look at a technological issue with a less critical perspective as their knowledge about it is limited. Designers are voluntarily or involuntarily inclined to question those who physically develop the technology and challenge them further.

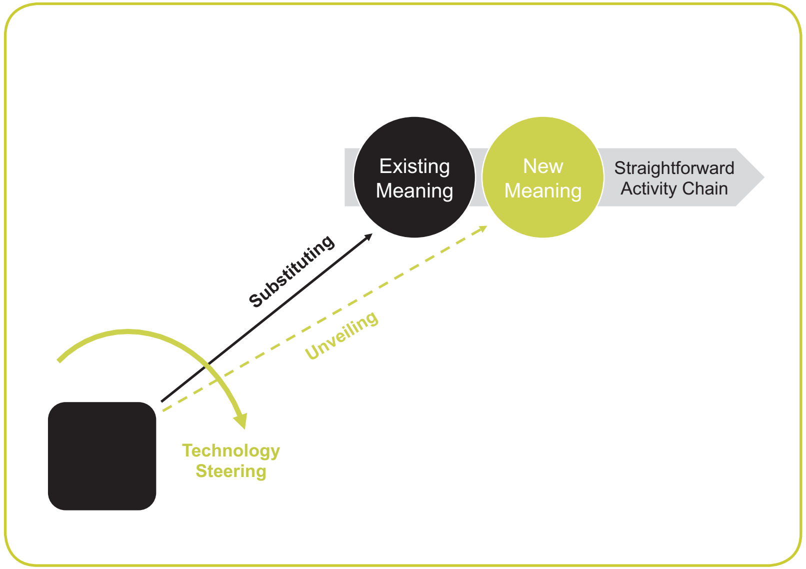
3) Probing: The D-RTD methodology in the LTM project worked with fast iterative cycles based on fast-prototyping that allows to rapidly probe, conceptualize and assess different applications. User cases, mock-ups with analogous materials and simulated functionality have been used to quickly test both the technical feasibility and the user perception.

From the learning phase the process moves in the meaning one where three additional practices contribute to the creation of the entire process.

4) Exploring the Activity Chain: The Activity Chain is defined as the end-to-end sequence of related phases an end-user should go through in order to fulfil a specific need (e.g. the purchase of a piece of furniture belongs to a broader activity chain where the end-user will consider the layout of his/her house, the space where the piece of furniture will be positioned, etc.).

The straightforward application leverages on the new technology substituting the previous one and maintaining untouched the existing meaning. The application of the piezo technology in pickups can represent a significant example: since the 60s they allow to acquire "music" and transforming it in an electronic signal as the electromagnetic technology did since many decades; tiny microphones equipped with piezo technology were sensible to frequencies of sounds and vibrations transforming variations of pressure to electronic stimuli.

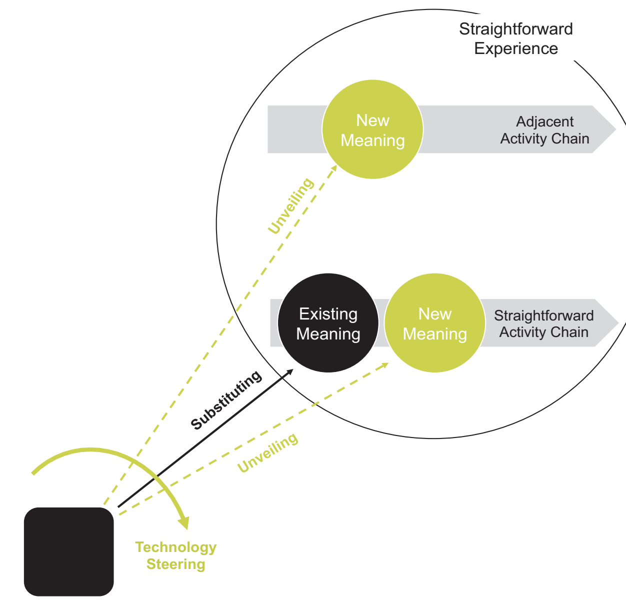
Each application covers only a small portion of the Activity Chain. Exploring upstream and downstream phases, it is possible to unveil new meanings. For instance the application "acquiring sound waves" belongs to the Activity Chain "producing music": the piezo technology could be adopted in the tweeter speakers belonging to the "audio diffusion" phase.



5.2 The MEANING phase of the D-RTD proces contains three sub-phases. The first one focuses on identifying and exploring the so called Activity Chain.

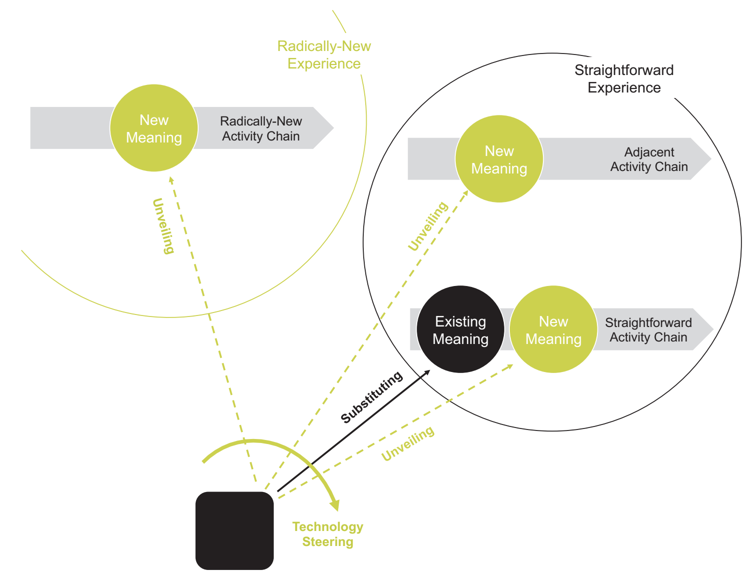
5) Exploring the Experience: The Experience is defined as the context where several Activity Chains co-exist in order to fulfil several needs perceived by the end-user (e.g. during the dinner Experience the end-user interacts with several Activity Chains such as cooking and eating food, entertaining family members and guests, etc.).

The Experience defines a contextual space where many Activity Chains can co-exist. Starting from the Straightforward Activity Chain, many other Adjacent ones can be identified in order to explore potential new meanings. For instance the LED technology were initially adopted in lighting products in order to substitute incandescent and halogen lamps. The Straightforward Activity Chain "interior lighting" contribute to the "home living" experience where many Activity Chains co-exist. Many other applications contribute to this experience such as TVs, hi-fi systems, pieces of furniture, etc. Nowadays, several consumer electronics companies have developed LED and OLED TVs in order to improve the immersive property of the screen.



5.3 From the focus of the Activity Chain the MEANING phase continues in Exploring the Experience, where several different types of Activity Chains can coexist. They all contribute to the same user experience.

6) Exploring Radically-New Experiences: The exploration of the opportunities identified by the analysis of the Activity Chains and the Straightforward Experience can stimulate the envisioning of Radically-New Experiences. In the LTM project the experimentation around several healthcare applications and the rich dialogue between designers and material researchers steered the technology development from healthcare experiences (e.g. rehabilitation, emergency safety) to wellbeing (e.g. kids education, nutrition) and entertainment (e.g. listening music) ones.



5.4 Lastly, the MEANING phase in an D-RTD process leaves the known field of experience and explores completely different applications fields, reinterpreting the emerging technology.

The selection of the most promising application fields is based on the following five criteria:

Value for users (Will people love it?): This is based on the appeal that the product has on final users. It is a subjective value, that is not standardized and that varies according to the environment and market conditions.

Profitability / Market size (Is it relevant for business?): This represents the potential value the innovation could create for the business.

Differentiation (Will it make a difference to competition/current path?): This represents the capability to generate competitive advantage.

Appropriability (Can we “own” the meaning? I.e. the brand, technologies, distribution, etc.): This is the ability of the company to retain the profits generated by its research activities, barring imitation by competitors. It is an incentive to bear the costs for the D-RTD activities, which by nature are subject to high risk and uncertainty in the results.

Feasibility (Are there any interesting product/service idea already?): This represents the last criterion suggested for the analysis of our innovation. In the majority of companies, it happens that innovative ideas clash with the available budget and with the state of the art of the technologies. This implies the need to make compromises in the development of the actual product.

Question: How can the exploration of new application fields provide insights in understanding the potential of emerging technologies?

Christian Tubito, Project Manager Innovation & Research

Material ConneXion*

Innovative materials, as with many other emerging technologies, usually need time to become fully realized and to achieve their potential in the market. Still, it is possible to predict the potential of a prefiguring technology. In the LTM project the process of explorative activities has been inspired by a five step process developed by Material ConneXion Italia, as detailed of steps 1 and 2 presented in the previous chapter.

a) Mapping the known: The first activity is to map the main and well-know characteristics of the "budding material technology", taking into account all different dimensions (technological, senso-rial-aesthetical, business and user ones) starting from the intrinsic potentials of the material and trying to envision those which can be affected and in which way. It is important that all dimensions are always taken into account in each of the following steps. In this step it is useful to define at a glance the obvious fields of application of the new technology, to consider its limitations and constraints, and to highlight ambiguous and unclear elements.

b) Analysis of similar technologies/materials: As largely recognized in the culture of design, studying similar technologies gives the chance to learn about specific emerging technologies. The same approach also works for materials. As a kind of "potential benchmarking" this step aims to give the opportunity to highlight interesting applications or detect those aspects the emerging technology should improve in order to be more "competitive". Studying similar technologies gives the chance to elicit new requirements for the emerging one starting from existing materials. Furthermore, using existing material samples, it is possible to help the analysis and to support the dialogue within a working team with heterogeneous competences. Through hands-on sessions with similar technology samples, it is possible to steer multidisciplinary teams to figure out potential new applications, to understand limits or added values, and to explore physical properties, senso-aesthetic qualities, and cultural associations. It is also possible to revise and validate the initial characteristics that emerged in step A. Thanks to the use of physical samples it is also possible to elicit the potential about physical and mechanical qualities of the emerging material.

> "...starting from the intrinsic potentials of the material and trying to envision those which can be affected"

* Material ConneXion is the world's leader in communicating material innovation, inspiring the designs of tomorrow through the materials of today. Material ConneXion is the trusted advisor to Fortune 500 companies, forward-thinking agencies, and governmental bodies seeking a creative, competitive and sustainable edge. With an international network of specialists, the company possesses a vast cross-industry perspective on materials, design, new product development, and sustainability. Material ConneXion maintains the world's largest subscription-based materials library with samples of more than 7,500 innovative materials and processes across all disciplines of design – an indispensable asset to a wide audience of users.

c) Specification of expectations: In the exploration activity, it is necessary to define the expectations regarding the new technology through a merging and balancing of the different points of view. Expectations should be able to open the new technology to new applications while facing feasibility issues. The relevant overall design features and the related pertinent functional properties need to be selected and/or defined and/or clarified.

d) Analysis of potentials: It is necessary to conduct an analysis of possible pertinent new contexts of application, considering the detected potential with a broader approach, that is, analysing industries rather then specific solutions. Interviewing experts in given fields can be helpful in order to collect consistent and useful elements and determinants. In this step, the R&D team should carry out an explorative translation of the feasible requirements and characteristics of the emerging technology into design characteristics.

e) Organisation of the potentials: Several tools, commonly applied in design processes, should be used to better visualize but mainly to organise the potentials. A sort of matrix table should be created in which design features, technical characteristics, possible new requirements, and new potentials are listed and combined with possible applications in order to evaluate the interest of their prospective fields of application. It is also necessary to map where interventions within the generative process of the emerging technology could occur in order to achieve possible new suitable "requirements". This process helps to condense useful insights and to structure the exploration. As a final outcome, a list of relevant elements of interest should be created and evaluated in order to create platforms (areas/ideas with common element for which the emerging technology could give the same technological/applicative answer).

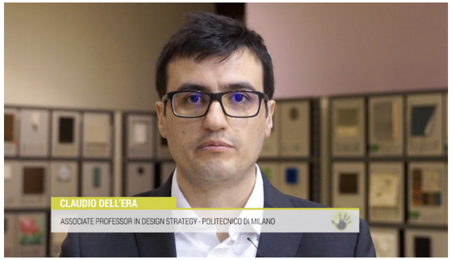
These steps help perform an exploration activity for an emerging material solution. The exploration activity should be concluded with envisioning and simulation activities in order to generate concrete insights. Using tools and methods from different cultures (design: e.g. brainstorming; business: e.g. marketing analysis; engineering: e.g. technological feasibility) it should be possible to envision new potential contexts of use and new interactions and model-users, and to elicit new requirements and characteristics achievable by the budding material solution.

How can the exploration of new application fields provide insights for understanding the potentialities of emerging technologies?

Christian Tubito
Project Manager Innovation & Research
Material ConneXion Italy

Watch the video on Youtube at
http://bit.ly/LTM_Interview_TubitoC

How can companies explore the opportunities provided by emerging technologies?



Claudio Dell'Era
Associate Professor in Design Strategy
Politecnico di Milano

Watch the video on Youtube at
http://bit.ly/LTM_Interview_DellEraC

How can emerging technologies be explored in order to identify potential application fields?

Roberto Giannantonio
Living Lab Manager
Dhitech

Watch the video on Youtube at
http://bit.ly/LTM_Interview_GiannantonioR

How can corporations identify new development directions that leverage emerging technologies?

Francesco Zurlo
Full Professor in Strategic Design
Politecnico di Milano

Watch the video on Youtube at
http://bit.ly/LTM_Interview_ZurloF

6 Policy implications

Reflecting on potential suggestions for policy makers

Erik
Tempelman
Associate
Professor
Industrial
Design
Engineering
Delft University
of Technology

Menno
van Rijn
Managing Partner
Bax & Willems

Many existing public policy initiatives aim to improve the technology-to-market cycle. Design-driven RTD adds to this toolbox: it can help business explore technological innovations faster, and develop them into meaningful products and services.

This "D-RTD" adds value through a multidisciplinary focus on engineering, marketing and business, with a powerful iterative design approach tailored to the inherent uncertainties of the technology-to-market cycle. D-RTD breaks with the traditional technology-driven linear development cycle, and helps business and society extract more value from scientific and technological progress.

In terms of recommendations, the LTM consortium advises policymakers to continue to experiment with the use of design as an explicitly valued and required element in RTD projects. Design is explicitly not to be "added on", but should be incorporated as an integral element. Also, even during early iterations, concrete design activity and prototyping is recommended, and this work should be seen as research, and valued as such.

We recommend to not expect designers to commercialise the outcomes outright. Most designers work at professional service firms, which have a different business model, and different strengths. For fast commercialization and uptake, OEMs are still the preferred partners. However, the involvement of such partners tends to steer the applications in predefined directions, limiting design freedom and possibly missing out opportunities for the technology. As a solution, the loose involvement of OEMs (e.g. as done in the LTM project, through the lead user panel) can work well, and create new alliances that drive the technology forward. Indeed, the lesson learnt from the project is that such involvement is key.

Furthermore, one should not expect designers and researchers that have not worked together before to be productive straight away. Developing the collaboration needs time - typically one year, and several face-to-face meetings or workshops. Existing partnerships can of course move faster. This also implies a long-term recommendation for higher education: arranging for research- and design students to experience in working with each other would remove the need for any introductory period during a later D-RTD project.

"The experiences ... with design-driven material innovation can be generalized and extended"

Beyond the LTM methodologies, we recommend to continue exploring new types of designer-researcher interaction, e.g. smaller collaborations, transversal groups of designers working with various RTD projects, or vice-versa, just one designer with a group of RTD players, etc. Furthermore, specific tools for such interaction will need to be developed, with business software being a clear candidate.

Finally, a recommendation can be given for taking support actions. Project LTM for instance benefited from the InnoMatNet project that started just before, with an exchange between projects that helped generate attention for the project. The contact with the Engineering & Upscaling Cluster was similarly valuable - indeed, in Project LTM, where no OEMs were involved as direct partners, this cluster made a key addition to the mix. It is recommended to study closely which strengths are built into proposed consortium (not even the best proposals can have everything, and stay within a tight budget, too), and align the support actions, or even simply choices for project office and project technical advice, accordingly.

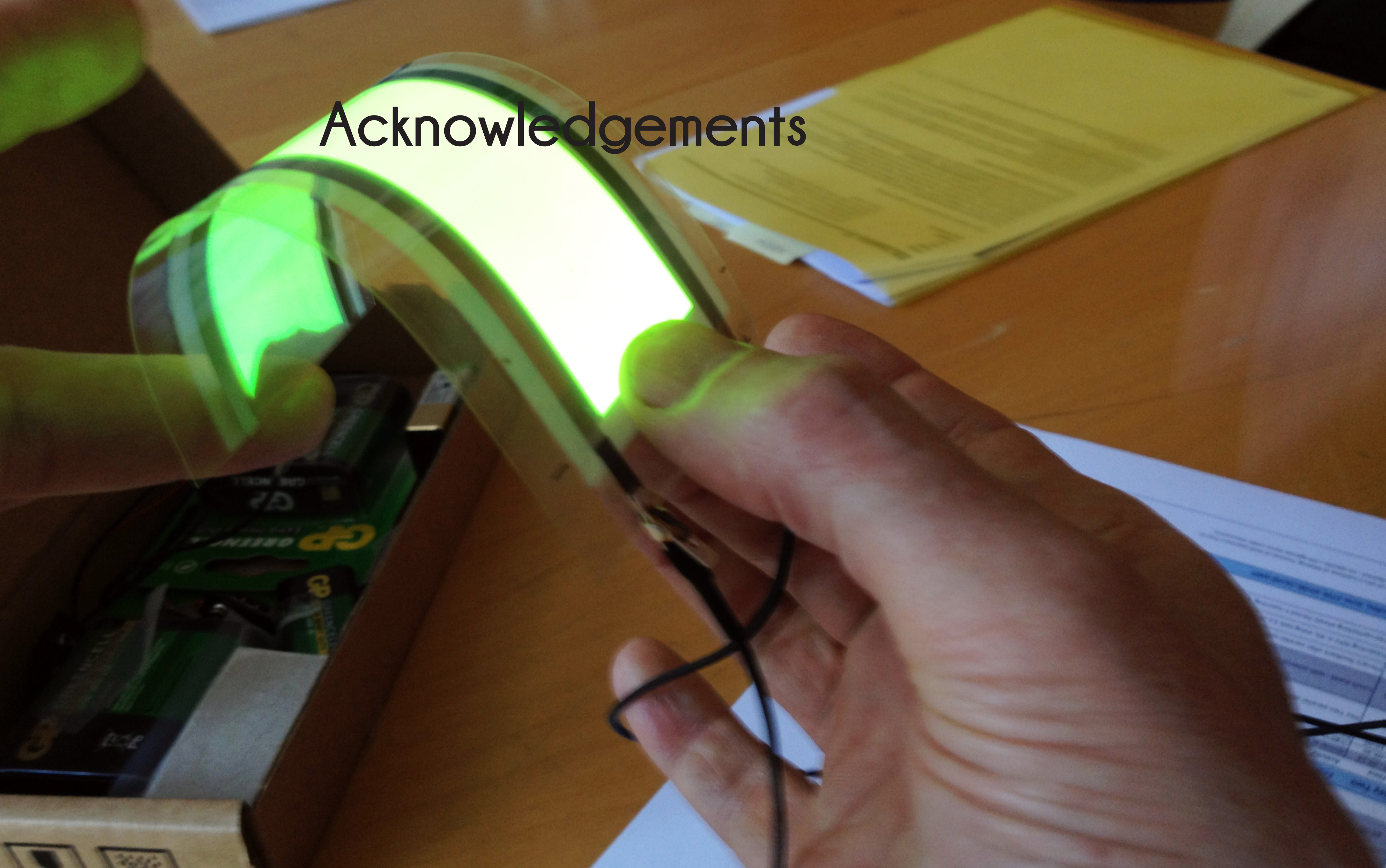
How can Policy Makers exploit the results achieved by the LTM project being the pioneering application of the Design-driven Research and Technology Development (D-RTD) approach?

Erik Tempelman

Associate Professor in Industrial Design Engineering
Delft University of Technology

Watch the video on Youtube at
http://bit.ly/LTM_Interview_TempelmanE_Part2

Acknowledgements



··· LTM project co-workers ···

TU Delft: Jeroen van der Aa, Bahar Barati, Daniella Deutz, Pim Groen, Sara Horvat, Kaspar Jansen, Elvin Karana, Andreas Köhler, Martin Lehmann, Wim Poelman, Marieke Sonneveld, Erik Tempelman, Angeline Westbroek. **Studio Edelkoort:** Sophie Carlier, Sophie Lattes, Anaelle Madec, Gert van der Keuken. **Diffus:** Michel Guglielmi, Hanne-Louise Johannesen. **Fuelfor:** Orion Campos, Bernat Cuni, László Herczeg, Peter Kukorelli, Mar Llines, Esteban Martin Gimenez, Lekshmy Parameswaran, Ramin Shambayat. **Fjord/Accenture:** Izaskun Bilbao, Andy Goodman, Lena Hammes, Antti Kuivamatti, Javier Loureiro, Manuel González Noriega, Carla Piazza, Marco Righetto, Alvaro Romero, Elodie Rousselot, Mayus Sierra. **Pilotfish:** Jeroen Bijsmans, Romy Martin, Marc Nagel, Umur Sener. **Lamb Industries:** James Eaton, James Lamb, Jessica Fox, Doug Stokes. **Minima Design:** Nigel Blair, Tom Etheridge, Andrew McCulloch. **VanBerlo:** Rosèl van den Berg, Eric Biermann, Bertineke Visser, Jonathan van Wijngaarden. **Grado Zero Espace:** Giada Dammacco, Filippo Pagliai, Dario Presti. **Aito Interactive:** Pauli Laitinen, Jockum Lönnberg, Tiago Monte, Billy Pitiot, Jukka Riihiaho, Jari Toropainen, René de Vries. **Material ConneXion Italy:** Micol Costi, Venere Ferraro, Emilio Genovesi, Rodrigo Rodriquez, Veronica Sarbach, Christian Tubito. **Holst Centre:** Robert Abbel, Hylke Akkerman, Pim Groen, Eric Rubingh, Jie Shen, Erik Veninga, Suzanne de Winter. **Bax & Willems:** James Deighton, Itziar Hernando, Menno van Rijn, Francesc Rul'lan, Anneke Stolk. **Brunel University:** Marco Ajovalasit, James "Burch" Burchill, Fabrizio Ceschin, Paolo Coppo, Chris Frampton, Andrea Mazzocut, Massimo Micocci, Farnaz Nickpour. **University College London:** Martin Conreen, Zoe Laughlin, Mark Miodownik, Sarah Wilkes. **Mälardalens Högskola:** Åsa Öberg. **Politecnico di Milano:** Claudio Dell'Era, Stefano Magistretti, and Roberto Verganti.

··· Student contributors ···

TU Delft: Guillaume Berre, Kevin de Boom, Katalin Doczi, Manon Fernandez, Stefan Heijboer, Sara Horvat, Iris Jönstheuvel, Jill Lin, Frederick van Loock, Neola Mascarenhas, Claudia Poma, Andrea Portioli, Robin dos Santos Gomez, Vincent Stuber, Andre Taris, Georgios Tselikos, Tim Vermeulen, Jing Yao. **Brunel University:** Rob Adam, Ryan Breeze, Otto Kauhanen, Roberto Mafrici, Julian Minuzzi, Jack Rich, Daniel Sztana. **University College London:** Hirsh Pithadia. **Politecnico di Milano:** Stefano Corlianò, Gregorio Ginestri, Michele Loperfido, Gloria Marzari, Pierpaolo Pisanelli. **IT-University of Copenhagen:** Nina Mørch Pedersen.

··· Affiliated contacts, companies and organizations ···

Advanced Materials Cluster of Catalonia: Pau Virtudes, Asics: Rene Zandbergen, BNO: Rob Huisman, CATAS: Andrea Giavon, CETEMMSA, Coloplast: Malene Thorup, ComfTech: Alessandro Sarffatti and Alessia Moltani, Cumulus: Justyna Maciak, Dhitech: Roberto Giannantonio, Danish Design Centre:

Nille Juul Sørensen, Design Council UK: Chris Howroyd, DuPont: Kerry Adams, DuPont Teijin Films: Valentijn van Morgen, FARO: Emiliano Bacco and Simone Pirovano, Flex Tronics International: Stefano Pozzi, FLOS: Francesco Rodriquez, Andrea Gregis and Daniela Moreno, German Design Council: Andrej Kupetz, Granta Design: James Goddin, Group-bticino: Andrea Colombo, Nicola Ardo and Paride Satta, Hungarian Design Council: Miklos Bendzsel, INDO: Pau Artus ¨ Innovhub Milan: Iliara Bonetti ¨ Legrand ¨ Logitech International: Christophe Constantin ¨ Luxottica Group: Giulia Smonker, Magnetti Marelli: Giovanni Bianchini and Giuseppe Curcio, MaterFAD: Aline Charransol and Valerie Bergeron, Morgan Piezo Ceramics: Bryan Mander, Natural Machines: Adriana Bertolin and Xavier Olive, Natuzzi Group: Domenico Ricchiuti and Livio Mottola, Nemes: Lorenzo Gabellini, NHS UK: Dr. Terry Parlett ¨ NightBalance: Thijs van Oorschot ¨ PAL Robotics: Luca Marchionni ¨ Francesco Ferro and Joan Oliver ¨ Philips: Elise Talgorn ¨ Philips Research: Hans van Sprang, Prysmian Group: Flavio Casiraghi and Davide Sarchi, Royal Auping: Simon van Es, Samsung Design Milano: Marzio Riboldi and Giulia Redi, Solvay: Alessio Marrani and Ivan Falco, Sumitomo Chemical Europe: Jumma Nomura, SusChem: Klays Sommer, Syntens Innovatiecentrum: Piet van Staalduinen, Triennale di Milano: Andrea Cantellato, Veneto Nanotech: Piero Schiavuta, Vibram Creative Lab: Simona Montemari and Francesco Perrotti, Whirlpool: Marco Bonneau and Ferdinando Valenti (and several others)

··· LTM workshop hosting ···

TU Delft: workshops 1, 5 and 12, Brunel University: workshops 2 and 8, Pilotfish: workshop 3, Material ConneXion Italy: workshop 4, Bax & Willems: workshop 6, Aito-Touch: workshop 7, Holst Centre/VanBerlo: workshop 9, Politecnico di Milano: workshop 10, Fjord/Accenture: workshop 11

··· LTM project committees ···

DMIC: Mark Miodownik (chairman), James "Burch" Burchill (secretary), Roberto Verganti (member)
Liaison Committee: Pim Groen (chairman), Menno van Rijn (secretary), Emilio Genovesi (member)

··· LTM work package leaders ···

Marco Ajovalasit, Brunel University: WP1, Pim Groen, TU Delft NovAM/Holst Centre: WP2, Umur Sener and Jeroen Bijsmans, Pilotfish: WP3, Jari Toropainen, Aito-Touch: WP4, Eric Biermann, VanBerlo: WP5, Christian Tubito, Material ConneXion Italy: WP6, Erik Tempelman, TU Delft IDE: WP7 & project coordination, Claudio Dell'Era, Politecnico di Milano: WP8

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EU Project Officers: Dr. Lula Rosso, Dr. Rene Martins, EU Project Technical Advisor: Dr. Guy Baret
EU Engineering & Upscaling Cluster: Dr. Gerhard Goldbeck, Euronews channel: Denis Loctier

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For further information, please visit:
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