PRISMA



Responsible innovation in practice: experiences from industry

This document reports on outcomes of the EU Funded Project PRISMA (Piloting Responsible Research and Innovation in Industry). PRISMA worked with 8 companies in order to help them to better integrate Responsible innovation in their innovation process and business practices. Several technological fields were included, namely synthetic biology, nanotechnology, driverless vehicles, and the internet of things. These pilots provide case studies of good practices in responsible research and innovation (RRI).





Partners

Delft University of Technology

National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

Karlsruhe Institute of Technology

Airi - Italian Association for Industrial Research

The University of Warwick



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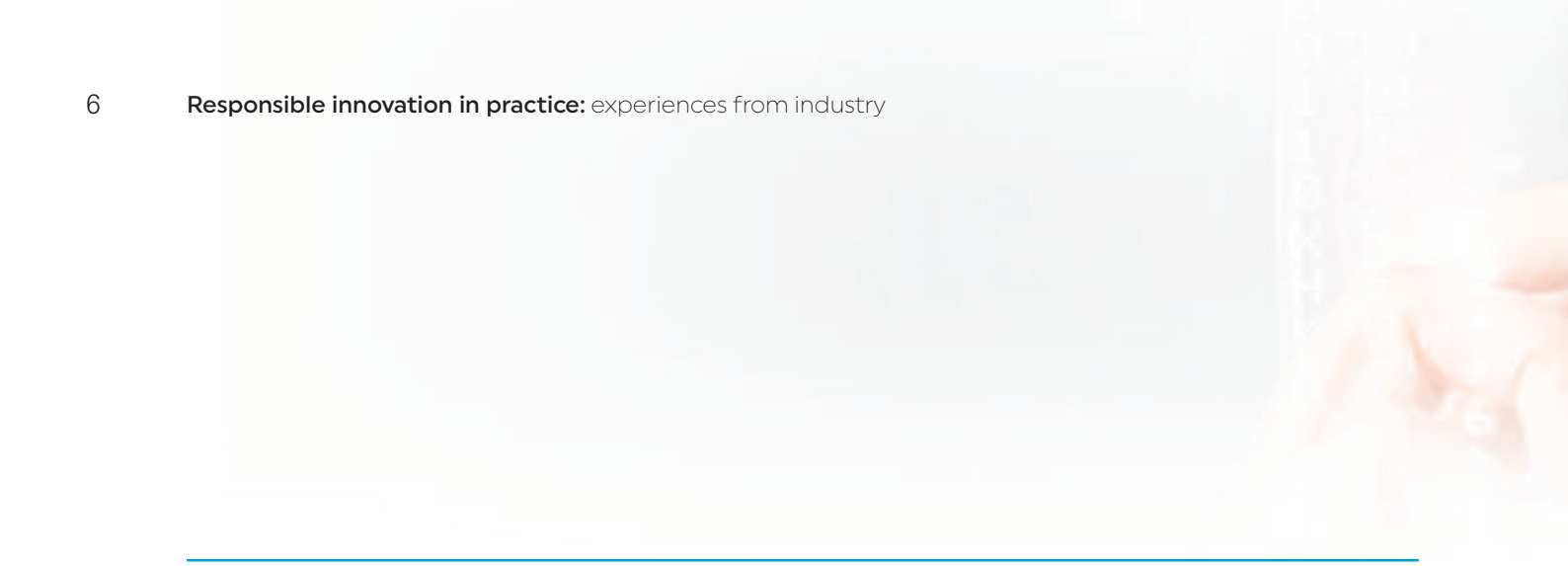
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Introduction and Reflections

The Work on the Project

The PRISMA project involved social science researchers and technologists from five different research organisations around the EU talking to eight technology projects about Responsible Research and Innovation (RRI). The goal was to draw specific lessons about how RRI can be implemented in practice more broadly. In this report we explain this work. The technology organisations involved ranged from small enterprises to large corporations to consortia of universities. The fields involved were automated cars, internet technology, drones, biotechnology, synthetic biology, and nanotechnology.

Pilot company	Type of company	Relation consortium partner – pilot	Technology field	Technology development stage	Country	Consortium partner
Colorobbia Consulting	Private	External support	Nano-technology	Emerging	Italy	AIRI
Laboratori Archa	Private	External support	Nano-technology	Emerging	Italy	AIRI
Evolva	Private	External support	Synthetic biology	Emerging	Switzerland	TU Deflt
Spectro	Private	External support	Internet of Things	Emerging /existing	The Netherlands	TU Delft
Aerialtronics	Private	External support	Drones	Emerging /existing	The Netherlands	TU Delft
Hub of All Things	PPP	Embedded ethicists	Internet of Things	Emerging	UK	University of Warwick
RDM	PPP	Embedded ethicists	Autonomous vehicles	Emerging	UK	University of Warwick
BISIGODOS	EU-financed project	Embedded ethicists	Bio-technology and chemistry	Emerging /existing	UK	University of Warwick

How might the ideas of responsible innovation be implemented? Two different methods were applied in PRISMA. The partners at the University of Delft and the Italian Association for Industrial Research (AIRI) — whose work is documented in chapters 2-6 — applied the approach of 'external support'. In this approach, the RRI is mainly applied by the company itself and external support is offered by one of the consortium partners. An advantage of this approach (compared to the embedded ethicist approach) might be that the company itself takes responsibility for its RRI policy; a disadvantage might be that the company lacks the resources (time, knowledge, expertise) to carry out the work. The partners at Warwick University — whose work is documented in chapters 7-9 — applied the approach of 'embedded ethicist'. Embedded ethicists aim at what has been described as "co-operative co-shaping" of technology. It can be understood as involving iterations of the following steps, as put forward by Gorp and S. van der Molen:

- Gathering of data about the project to help identify ethical issues.
- Reflecting on these issues and searching for relevant ideas in literature.
- Preparing the discussions on the ethical issues and decisions that would have to be made.
- Having a discussion with the […] team or some researchers and taking a decision.
- Reporting about the ethical issues and decisions made.[1]

This approach has the potential downside that it may be yet more demanding upon the technologist's time, and the potential advantage that it facilitates more dynamic and deeper reflection on the issues that are raised.

[1] Gorp, A. van, and S. van der Molen. 'Parallel, Embedded or Just Part of the Team: Ethicists Cooperating Within a European Security Research Project'. *Science and Engineering Ethics* 17, no. 1 (1 March 2011), pp. 34-5.



Issues cutting across pilots

Two issues arose consistently in the pilots and will be explored further in the subsequent chapters.

1. **The drivers and obstacles for RRI.**
   The question of the drivers and obstacles for RRI is perennial. The work of implementing ideas of responsible innovation brings to the fore the questions of why technologists would use time and resources in carrying out such activity. RRI can provide competitive advantage, improve reputation or corporate image. It can be built in to an organisation's philosophy. Organisations can improve their chances at being funded by meeting its requirements. In contrast, there can be limited resources for such activities, especially where they are complicated or time consuming, perhaps taking the form of an extended stakeholder dialogue. The practice of RRI also tends to be highly dependent upon professional relationships and can thereby be disrupted if there is organisational restructuring. As we will see, this occurred during PRISMA for two of the pilots, Evolva and Aerialtronics.

2. **Existing RRI practices under different names.**
   It matters that companies innovate in a responsible way; it matters much less whether or not they call their efforts in that direction 'RRI' or not. Indeed, the RRI brand is not universally recognised. Insofar as 'RRI' is the focus of research, it behoves the investigator to ensure that they do not miss important phenomena simply because it goes by another name. Across a number of the pilots were activities that might go under the heading of RRI, or indeed might serve as informative for those developing theories of RRI, but which were carried out by individual who were unfamiliar with RRI terminology. For instance, the adoption of voluntary certification on sustainability, social responsibility and ethics are part of the culture of Archa. Similarly, the HAT project has an idea of social enterprise as part of its *raison d'etre*.

Combining those two points together, we see that an effective way to work with firms (and individual researchers) in developing their RRI practice is to begin with their own practices and to identify ways in which they already meet some of its aspirations. The drivers in such cases must already be present and the obstacles to some degree overcome; the work of the facilitator then is to help to deepen and extend work that the technologist is already doing.

Particular normative issues

In this section we set out some of the normative issue that arise in the pilots

Sustainability

Sustainability is an important concern in technological development. One of the most influential definitions of sustainable development comes from the Brundlandt committee. It reads: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987). Apart from environmental care, it encompasses such values as intragenerational and intergenerational justice (see also social justice). There are nowadays a large number of tools available to assess the environmental impact of technologies and products and to set guidelines for the design of more environmentally sustainable products. This among others includes environmental impact assessment, life cycle assessment, principle for sustainable design, and circular economy approaches. For example, discussion on sustrainability in relation to Archa's work in the Nanocube project focused on respect for workers rights, supply of raw materials and environmental impact, and in Evolva concerns for sustainability focused on the role of a particular raw material in deforestation.

http://www.econation.co.nz/dfs-basics/
http://productsthatlast.nl/site/app/index2.html?#/home
http://www.buildingecology.com/sustainability/life-cycle-assessment/life-cycle-assessment-software
http://www.biochemproject.eu/download/toolbox/sustainability/01/120321%20BIOCHEM%20LCA_review.pdf
https://www.iso.org/iso-26000-social-responsibility.html

Theories of privacy

The use of personal information is at the heart of many new technologies, and consequently issue of privacy is ubiquitous. An examination of the value of privacy is therefore productive. Some theories of privacy focus on control of personal information as the defining feature of privacy (Warren & Brandeis 1890; Fried 1970). On the face of things, technologies such as encryption facilitate a significant advance in privacy, according to this conceptualisation. However, other theories cast their net more



broadly than control of information and include ideas such as a right against 'undue prominence' (Epstein 2000; Rachels 1975), or construe the basis of the value of privacy as grounded in a need for functioning autonomy or social relationships (Solove 2006). Projects considered below considering the issue of privacy include Aerialtronics, with the potential to directly invade privacy by filming places that would usually be unobserved, and Spectro, where potential dangers to privacy are much more indirect, but could result from collection or storage of data.

Data ownership

Even considering the narrower category of 'data ownership', there are some important conceptual issues concerning how we understand what 'control of one's data' means, and also some practical issues concerning cases in which the value of data control could in principle be traded off against other values (Westin 1967). Regarding the former: how is data is initially attributed to an individual (or a group of individuals) as being essentially theirs in the first place, how can substantive (rather than merely formal) 'control' that can be achieved? (Skilton and Ng 2016). Further, on what theoretical grounds are policies in this area decided? For instance, is the starting point the idea that people have a basic entitlement to control of information about themselves, or is it that we should aim at a system of information ownership and exchange that is beneficial to all? (Parent 1983). Regarding the latter: there may in principle be ways in which the degree of data-control could be in tension with the efficiency of the system, its commercial viability, or its attractiveness to users. RRI might examine in specific cases how far such tensions actually exist and how they might be resolved by appeal to theory and principle. These issues are raised in any project involving collection of data, such as Spectro and especially RDM. The HAT project considers an innovative approach to the question of data ownership in the case of online activity.

Transparency and open access

Open access is increasingly mandated by funding bodies, backed by the argument that where the public funds research, there should not be a further charge for accessing it. Complications arise concerning: (i) the appropriate forms of open access, including who funds the publication, (ii) the boundaries of public research where there are commercial partnerships; (iii) the ethics of making data public. The websites https://www.fosteropenscience.eu/ and http://www.pasteur4oa.eu/resources provide guidance. Beyond open access policies, there are security and efficiency arguments for progressing towards open source models of innovation. For example, transparency is explicitly

discussed with Colorobbia in relation to both production and application of nanomaterials, and actors in the R&I and product supply chain. Transparency is discussed in relation to Evolva by way of their attempts to achieve this via stakeholder engagement. For Spectro transparency was discussed in relation to their data gathering practices.

Public engagement

Public engagement is key to responsible research and innovation. The EU describes it as the "co-creating the future with citizens and civil society organisations, and … bringing on board the widest possible diversity of actors that would not normally interact with each other, on matters of science and technology."[2] Since important decisions on new technology are already made at the R&D and design stage, it is increasingly believed that public engagement should move upstream to the early phases of technological development. Different approaches to such early engagement are described in Doorn, Schuurbiers, van de Poel and Gorman (2013). There are many different relevant methods for public participation. An overview of various public participation methods and their pros and cons can for example be found in Rowe and Frewer (2000). For suggestions for public engagement in RRI, see also https://www.rri-tools.eu/public-engagement' and, for more on PRISMA's own approach http://www.rri-prisma.eu/toolkit/. Another useful guide can be found here: https://www.epa.gov/international-cooperation/public-participation-guide-introduction-public-participation. As mentioned above, transparency is discussed in relation to Evolva by way of their attempts to achieve this via stakeholder engagement, (which also exposed the company to criticism). Stakeholder engagement was recommended to both Aerialtronics and BISIGODOS as a way to build legitimacy for their innovations.

Democratic consent

Most new technologies and technological decisions are usually not subject to direct democratic consent. Still, since technology may have a major impact on the lives of peoples and societies, it is often held that major technological decisions should be subject to some form of democratic consent. A minimal condition would seem to be that technologies meet existing legal rules and regulations. This includes substantial rules and requirements (for example with respect to safety, sustainability and privacy) but also procedural ones (like the requirements to make an environmental impact analysis for some technological projects). However, democratic consent is not limited to legal rules and requirements. One issue is that in particular formal legal rules and regulations tend to lag behind

[2] https://ec.europa.eu/programmes/horizon2020/en/h2020-section/public-engagement-responsible-research-and-innovation Accessed February, 7



technological development. This means that for important technological decisions one needs to organize either some more formal form of democratic decision-making (for example in parliament) or need to rely on more participatory forms of democratic decision-making (see also democratic participation). Another issue is that sometimes new technologies may not be allowed according to existing legal frameworks and regulations, but that does not necessarily imply that they are morally undesirable or cannot acquire democratic consent (see also creating stable governance structures). An example is self-driving cars: these are forbidden on the road in many jurisdictions but that does not necessarily imply that they are not a desirable development.

Democratic participation

Democratic participation is somewhat similar to public engagement and democratic consent, but is nevertheless expresses concerns not entirely covered by both. Whereas public engagement implies the involvement of the public and stakeholders in gives them not yet necessarily a voice in important (technical) decisions. And whereas democratic consent implies that important technical decisions should have democratic legitimacy, this legitimation can also be indirect through parliament or the law and does not necessarily imply a form of participation. Democratic participation then is particularly important where technologies have a significant impact on certain stakeholders and/or where it is hard to get democratic consent in other ways (for example because laws lag behind). Here are various ways in which democratic participation in RRI can be established. Examples are participatory design, open innovation and living labs.

Some tools and relevant websites:

http://participateindesign.org/approach/tools
http://www.design4wellbeing.info/
http://www.toolkit.100open.com/

Distribution of risk and harm

Alongside their benefits, transformative technologies can set back the interests of some individuals and can also impose risks of harm. The way in which such harms and risks of harm are to be distributed is of crucial concern. While a utility-maximising approach may seem tempting, there is reason to

consider factors that reach beyond this, such as the notion that those who benefit from a technology may rightly also share a greater proportion of its burdens, or that there are things that individuals can do that make them more morally liable to a share of the risk, or that there is an extra concern where setbacks are patterned along socio-economic groupings. Some take the position that we usefully aim at social practices of risk-taking that works to the advantage of each individual (Hansson 2013). Preventing risk of harm was discussed with Colorobbia, where beyond harm medical ethics questions such as criteria for informed consent, were also in play. Risk of harm was also a central focus of discussions with Aerialtronic, and was the basis for advice to pursue less intrusive uses for the product.

Transparency and open access

Open access is increasingly mandated by funding bodies, backed by the argument that where the public funds research, there should not be a further charge for accessing it. Complications arise concerning: (i) the appropriate forms of open access, including who funds the publication, (ii) the boundaries of public research where there are commercial partnerships; (iii) the ethics of making data public. The websites https://www.fosteropenscience.eu/ and http://www.pasteur4oa.eu/resources provide guidance. Beyond open access policies, there are security and efficiency arguments for progressing towards open source models of innovation.

Public private partnerships

A great deal of research in to new technologies is funded in part by public money. Correspondingly, three of the projects in PRISMA were run directly out of Warwick University with money from public research organisations and in partnership with commercial enterprises. The BISIGODOS project was an EU FP7 Framework project that included industrial partners across Europe working with algal oils; the Hub of All Things project on internet technology was developed under the aegis of money from UK funding councils including the AHRC; and RDM Group is part of several automated car -producing consortia that are funded through the public funding body Innovate UK.

Where the public purse has a direct financial interest in a technology development, there is an opportunity to structure the incentives and research culture of those working on a project in such a way that responsible innovation is directly encouraged. This can be achieved in several different ways,



including: (i) as *auxiliary projects* that seek to inspire or engage with existing research; (ii) as *overarching guidance* to all who place applications to a funding body; (iii) as *specific guidance* within specific calls. The project behind this report, PRISMA, is an example of an RRI *auxiliary project* that has a particularly practical leaning. Further examples include RRI Tools, RESAGORA, Responsible Industry, COMPASS, SMART-map and ORBIT, amongst others. Auxiliary projects about RRI have the advantage of intellectual independence. With their own centre of gravity they are not beholden to the practical aims of any particular technological development. Furthermore, RRI auxiliary projects facilitate the creation of generalisable theory. They allow the development of a body of ideas about responsibility in innovation that can be applied from one technology to another. However, RRI auxiliary projects have the disadvantage that they are limited in their practical ability to implement RRI directly, since they involve different timelines, networks, and priorities to those technology projects that they might seek to inspire or engage.

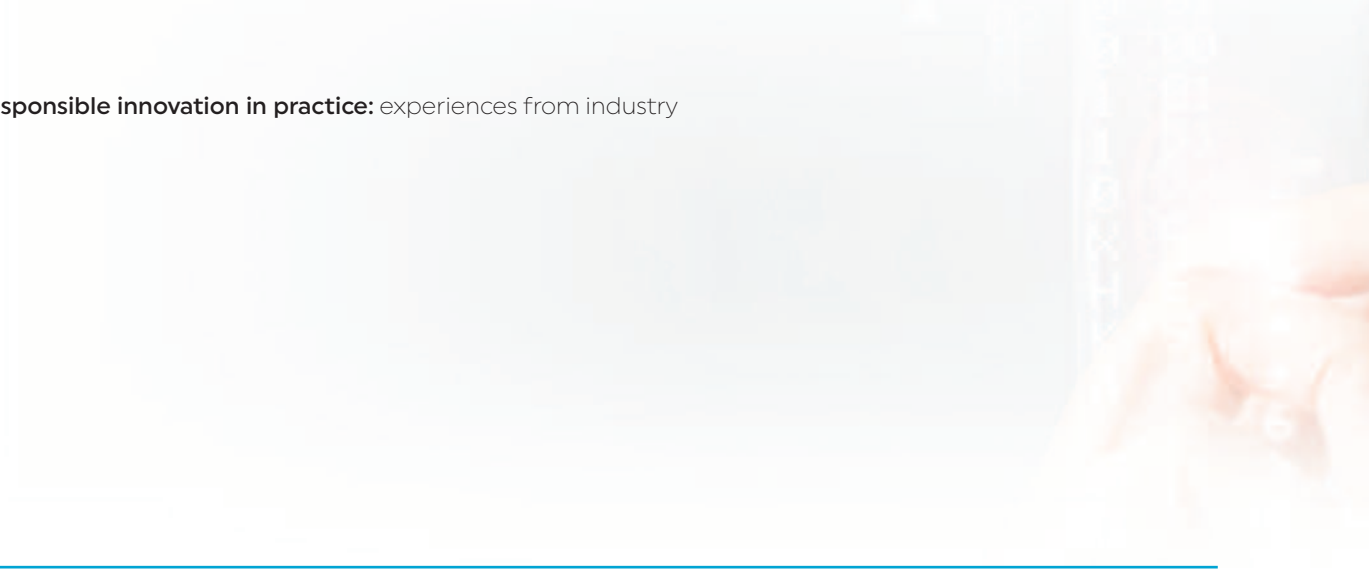
Instead, funders might seek to provide RRI *overarching guidance*. An example of this is the EPSRC's Framework for Responsible Innovation, which provides guidelines for all applications to that funding body. In comparison to auxiliary projects, RRI *overarching guidance* has a direct effect on the incentives and culture of innovators and can be expected to have more immediate practical effects. Nonetheless, general guidance of this form is open to the interpretation of reviewers of bids. If guidance is very general there is a risk that it will be unable to overturn any tendency to disregard or minimise RRI issues.

The third approach, RRI funding as *specific guidance*, is an idea put forward during our interviews industrial partners on the project. It involves specific elements of RRI being built in to calls for applications for funding. For example, bids on technology projects might be asked to consult with a certain kind of stakeholder or to use a specific RRI tool or form of technology assessment. Different versions of the call to which the PRISMA pilot on BISIGODOS was a response might have mandated for the creation of industrial and consumer products in consultation consumer groups, and displaying sustainability credentials throughout the projects with a speculative Social Life Cycle Assessment, revised in the interim and at the closure of the project. While this approach is more demanding upon the bodies that construct calls, it has the strong advantage that it will involve directly mandated and specific RRI activity.

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1. Colorobbia Consulting

"We consider pivotal to our R&D efforts an open and continuous dialogue with stakeholders, patients, in the first place, and regulators, health-care professionals, policy makers, media, the society at large. It is vital to improve functionalities, quality and reliability, acceptability, of the NanoMed technologies and products.

With PRISMA we learned the importance of focusing on the ethical and social impacts of NanoMed since the early phases of the development, to become responsive and trustworthy toward needs and requests from users and society. This experience has convinced us of the strategic value of RRI for NanoMed and our organization."

Giovanni Baldi
Director, Ce.Ri.Col - Colorobbia Consulting Research Centre



The company and the technology

Gruppo Colorobbia is specialised in the production and distribution of raw materials, semi-finished products and chemicals for the ceramics and glass industry.



Colorobbia Consulting S.r.l. is the technology service company of Gruppo Colorobbia, with activities on research, chemical and chemical-physical analysis, compliance with environmental and safety regulations, IT and process plant engineering.

The company is active in research and development, prototyping and production of nano-based products to be used in the industrial fields of pharmaceuticals, nanomedicine, coatings and environmental protection, as well as to provide services in term of research, chemical and chemical-physical analysis, compliance with environmental and safety regulations in force, IT and process plant engineering.

The core values of the company include: quality and excellence in R&I; attention to environmental health and safety (EHS) issues in R&D and production processes; respect of ethical standards in R&I; development of innovative solutions to tackle societal challenges. These values guide the overall business model of the company.

The NANOMED project, a large research project based on in-house resources from the company and funding by different cooperative projects, aims to create a technology platform providing an integrated and modular system, for the diagnosis and treatment (theranostic) of cancer and nervous system diseases. It is a nanotechnology based system using a combination of targeted and controlled drug delivery, hyperthermia and radiofrequency and laser imaging methods.



The time to market of these products is expected in a medium to long term time frame.

The technology platform will lead to different products, including a contrast agent, a formulation (drug), a cell therapy system and a portable and integrated medical device to produce the cell therapy system.

For all products, the key research challenge is to realize a personalized and point of care therapy, for a highly effective, accessible and affordable treatment for severe diseases.

Key ethical and social issues of NanoMed include: safety and use/biodistribution of nanomaterials (NM) into the human body, regulatory challenges for NM, including specific issues for NM in ATMP (Advanced Therapy Medicinal Product), open access/information along the value chain for NM, users and stakeholders perspectives/acceptability/ethical aspects, related to nanomaterial and to personalized, point of care therapies and nanomedicine, socio-economic impacts of the new treatments.

Working with Colorobbia Consulting

Activity included a series of meetings in person and by telephone with staff of the company, organization of a multi-stakeholder dialogue designed to address the specific ethical and social issues identified by PRISMA,[3] a public workshop to discuss on the application of RRI in NanoMed,[4] and engagement of the pilots in activities organized by the PRISMA project. The main contact person has been the R&D Manager and a business manager of Colorobbia Consulting and the NanoMed project. Meetings and interaction has been conducted also with people working in R&D and quality, as well as external partners of the NanoMed project.

The company has actively cooperated in all PRISMA pilot activities: has allowed PRISMA partners to get access to extensive information and to get in contact and engage relevant stakeholders of the NanoMed project; has cooperated in the participatory events organized within PRISMA; has provided information to select and measure RRI-Key Performance Indicators for the NanoMed project; has taken part in the the PRISMA pilot kick-off workshop in Brussels (April 2017), and the stakeholder dialogues in Berlin (Nov. 2017) and Milan (Oct 2018); has co-operated in filming a video interview, has discussed, reviewed and agreed on actions to continue pursuing RRI during the next product development phases (roadmap for RRI implementation in NanoMed).

[3] The agenda of the PRISMA and NanoMed multi-stakeholder workshop is available here: https://www.airi.it/wp-content/uploads/2018/11/Programma_workshop_Prisma_Nanomed.pdf

[4] The workshop "Responsible Innovation in Nanotech applications for healthcare and wellbeing" was held on September 13th, 2018 in Rome, within the NanoInnovation 2018 Conference, with the aim to promote the RRI activities of the two PRISMA pilots dealing with nanotechnologies.

Advice

There are some particular social and ethical issues that have received focus in the course of the pilot and for which specific advice has been developed through discussion with the company and interaction with stakeholders. These include:

Product key (social) values

Reflection with the company and dialogue with stakeholders helped to identify the most relevant values to pursue for NanoMed products. It turned out that Colorobbia should work to address these values in product design, in order to provide scientific evidence of them and as well identify suitable ways to communicate these values to all actors along the supply chain, including end-users. These values include (vision):

- Product efficacy
- Safety of the product, in particular regarding safe use of nanomaterials along the value chain
- Excellence in R&D
- Ethics (respect of patients' rights) and patient-centric procedures for both clinical trials and cure (principles of precaution, beneficence, dignity, informed consent, data protection and data ownership)
- Transparency about the ways of production and use of nanomaterials, toward all actors along the R&I value chain and the product supply chain
- Affordability, accessibility of the treatment: ensuring the final system, delivering the personalized therapy at the point of care, will be affordable for health-care professionals (e.g. local hospital structures) and patients

Addressing quality, reliability, safety and efficacy of the R&I process and NanoMed products by state-of the art practices and standards

How quality and safety aspects related to the use of nanomaterials in advanced therapies should be addressed during the development process and all along the life cycle, considering the novelty of the application (and related uncertainties).

Quality procedures are in place all along the R&D and production process of NanoMed, including characterization, synthesis, testing , safety, and reliability phases. In particular, NanoMed ensured



early certification of the R&D labs, based on Good Manufacturing Practice for Medicinal products. A safe by design approach is implemented within NanoMed since the beginning of the project. Since the early stages of R&D, nanomaterials are selected (adapted and in case re-designed) to ensure they have a very low risk profile.

Fundamental and applied research is on-going to compare and validate results with state of the art scientific knowledge, and as well as with benchmark products, in order to carefully understand the mechanisms of action of the treatment, understand long term effects and improve reliability.

Cooperation and co-creation of the R&I products with regulatory bodies, authorities (cell therapy) and with patients (e.g. for clinical trials)

Cellular therapies, in particular in combination with the use of nanomaterials and the development of point of care devices (as in the case of NanoMed), are at the forefront of the existing regulatory frameworks. Problems of definitions and classifications, overlaps, lack of consistent guidance are some of the challenges in the application of regulation. How could these aspects be faced within the NanoMed Project?

- Regular monitoring of normative developments and early cooperation with EU and national authorities active on medicinal products, ATMP and nanomaterials is already part of the NanoMed activities
- A dialogue on ethical and social impacts with actors along the value chain of the R&I project, including researchers, suppliers, hospitals, authorities, patients' associations, ethical committees, has been started (also thanks to the PRISMA project), and will need to continue in the future
- Dialogue with stakeholders, will help in particular to plan and design protocols to ensure respect of patients' rights, including appropriate procedure for data management and informed consent with regard to data collected during clinical trials and therapy.

Assessment and dialogue on business models/costs/benefits with investors and the healthcare system

The assessment of socio-economic impacts of medicinal products is a step usually performed once the product is close to the market phase, considering the final application, and the actual market. In

the case of personalized and point of care therapies, this is complicated by the novelty of the approach, including issues related to the potential impact on the existing healthcare system and the type of business models suitable for these new therapies. Developing (responsible) business models, ensuring affordable and equitable access to the treatment (also taking into account the potential life-saving character of these new therapies) is an open and challenging issue.

- NanoMed should plan specific activities for early analysis of cost-benefit impacts of the new therapies, and screening of potential novel (responsible) business models
- This could be informed by dialogue and cooperation with risk managers and potential public and private investors, including the health-care system (e.g. local authorities and hospitals)

Create a communication and dialogue strategy toward professional, patients and society

How could a patient centric approach be implemented in NanoMed, taking into account patients' rights and needs?

- Design an informed consent protocol together with health-care professionals, patients' associations, and ethical committees, considering the peculiar aspects of personalised medicine and nanomaterials. Include information on uncertainties related to the new therapies
- Create informative events targeted to health-care professionals and patients to raise awareness on opportunities and challenges of personalized therapies, in particular the use of nanomaterials and ATMPs
- Identify appropriate communication means and channels to inform the wider public on NanoMed technologies and products. Ensure an easily accessible and understandable communication of benefits and risks of the product. Consider engagement of scientific journalists and media experts to realize the communication strategy
- Engage a multi-disciplinary panel of independent experts and end-users in order to assist the project regarding strategic choices on ethical, legal and social aspects (e.g. risk-benefit evaluation) taking into account also technical developments (e.g. safety of nanomaterials) and socio-economical aspects

The aspects underlined above will be structured and elaborated in a roadmap to integrate RRI into the



NanoMed products, covering all the period until the commercialization and use of the product. The agreement with the company on the final roadmap will the conclusive step of the pilot.

Final remarks

The cooperation with Colorobbia on RRI implementation has been quite fruitful, also thanks to the experience and attitude on social responsibility of the company.

The NanoMed project is complex and ambitious and there is little chance of success without a broader alignment with the needs and perspectives of the final users, in particular the healthcare system, health professionals and the patients.

A set of detailed actions that could promote RRI uptake within the NanoMed project emerged during the pilot, some already planned in the R&I strategy of the company, others that will be considered in future developments of NanoMed.

The experience with PRISMA supported the company in better understanding (anticipating) potential ethical, legal and social risks (and benefits), and finding ways to address uncertainties in existing and

future developments in norms and standards, and exploring ways to ensure societal acceptability of the final products of NanoMed.

RRI is expected to create value for R&D and innovation activities, improve corporate image and reputation, and help to gain a competitive advantage.
Defining practical RRI actions for NanoMed has been a long process, requiring an in-depth self-reflection process involving the management and researchers participating in the project, and interaction with stakeholders. RRI integration requires the company to open up (part of) their processes, and foster cooperation with different stakeholders, at different levels in the company and as well in different phases of R&D development.

A formal (or informal) strategy for RRI should be developed to put RRI in practice, and the challenge is to align it with the company practices and business strategy.

Resources (human and financial) are needed to implement RRI actions, and the PRISMA analysis of the NanoMed project clearly shows that the more RRI is embedded in existing process, the more this could be resource demanding.

2. Laboratori Archa

"Thanks to our participation in PRISMA, we better understood the relevance of societal values to improve the R&D process, and the need to cooperate with authorities, certification bodies, distributors, end-user and consumers, to align NanoCube products to their needs, expectations and requirements. We have also been convinced on the importance of a transparent communication toward all stakeholders, to address uncertainties and concerns related to the use of nanomaterials. With this lesson in mind we plan to integrate some of RRI aspects emerged in PRISMA into social responsibility and quality certification procedures of Archa."

Francesca Braca
Project Manager, Laboratori Archa



The company and the technology

Laboratori Archa S.r.L (Archa) is a small-to-medium size enterprise (SME), with the mission to provide assistance, technological innovation and know-how to companies to enable them to produce while respecting human health and the environment, preventing risk and complying with moral and ethical principles.

The support spans over all the stages of the innovation process: outlining/definition of the idea, the research and development phases, prototyping, start-up and industrialization.

Archa and its start-up for the industrialization of products, Techa Srl, are involved in PRISMA pilot through the research project NanoCube.

The NanoCube project, coordinated by Archa and Techa (Tuscany region funds POR FESR 2014-2020) develops innovative technologies aimed at producing nanocapsules and nanosystems providing

controlled release of bioactive agents for cosmetic and biomedical applications. Partners include research organizations, cosmetic producers, hospitals, a company developing the production equipment and a private research centre.

The products expected by the project include:

- A dermocosmetic (detergency) product, providing innovative and more effective ways of using a natural active substance for antimicrobial action. The system has manifold advantages: reduce the risks for workers and users in handling and using the active substance, reduce the use of active substances compared to conventional treatments, improve the efficiency of the final product.
  The system might be further developed into a class I medical device with anti-inflammatory action. Thanks to its properties, the device could act as a replacement for conventional antibiotics used for derma applications and thus in the long term reduce the need for antibiotics.
  For both the two products the expected time to market is in the short to medium term.

- A bioactive 3D nanostructured patch for chronic lesions care, using a complex nanostructure surface to improve adherence with skin and nano-capsules for the controlled releases of active substances. The product is expected to improve efficacy of the healing and tissue regeneration processes in case of chronic derma lesions and in the long term to reduce costs correlated to lesion care. The expected time to market is in the medium term.

For all products, a key research challenge is to make use only of natural ingredients, including the nano-capsules, and processing steps without the use of chemical (synthetic) solvents.

Key ethical and social issues are addressed along the R&D pathway. They include: precautionary approach in the risk management of nanomaterials, research ethics (research activities on humans, replacing and reducing animal testing), addressing specific ethical values in product development (in line with demanding ethical certifications for natural and organic cosmetics), address issues of risk perception, and user acceptability in relation with nanotechnologies.

Integration of innovative technologies, such as nanotechnologies, in the sector of natural, organic cosmetics is one of the key challenges of NanoCube.



Working with Laboratori Archa

Activity included a series of meetings in person and by telephone with the staff of the company, organization of a multi-stakeholder dialogue event designed to address the specific ethical and social issues identified by PRISMA[5], a public workshop to discuss on the application of RRI in NanoCube[6], and engagement of the pilot in the main activities organized by the PRISMA project. The main contact person has been the Project Manager of NanoCube at Archa, though meetings and interaction have been conducted also with people working in Management, R&D, quality, CSR, as well as external partners of the NanoCube project.
The company has actively cooperated in all PRISMA pilot activities. It has allowed PRISMA partners to get access to extensive information and to get in contact and engage relevant stakeholders of the NanoCube project. It has cooperated in the participatory events organized during PRISMA. It has provided information to select and measure RRI-KPI for the NanoCube project and taken part in the workshop in Brussels in in April 2017 and the Milan stakeholder dialogue in October 2018; has co-operated in filming a video interview and discussed, reviewed and agreed on actions to continue pursuing RRI during the next product development phases (roadmap for RRI implementation in NanoCube).

Advice

There are some particular social and ethical issues that have received particular attention in the course of the pilot and for which specific advice has been developed through discussion with the company and interaction with stakeholders.

Product key (social) values

Reflection with the company and dialogue with stakeholders helped to identify the most relevant values to pursue for NanoCube products. It turned out that Archa and the partners of the NanoCube project should work to address these values in product design, and to provide scientific evidence through testing activities and to identify suitable ways to communicate these values to all actors along the supply chain, and end-users and consumers.

[5] The agenda of the PRISMA and Nanocube multi-stakeholder workshop is available here: https://www.airi.it/wp-content/uploads/2018/11/Prisma_DialogueInitiative_Archa_Agenda_Fp.pdf

[6] The workshop "Responsible Innovation in Nanotech applications for healthcare and wellbeing" was held on September 13th, 2018 in Rome, within the NanoInnovation 2018 Conference, with the aim to promote the RRI activities of the two PRISMA pilots dealing with nanotechnologies.





These values include:

- Product efficacy: the added value, beyond existing product benchmarks, provided by the new technology (controlled releases of natural active substances, use of nanostructured surfaces
- Safety of the product, and nanomaterials in particular: ensuring safe use of nanomaterials all along the product life cycle
- Natural ingredients: product based on the use of natural substances and not using any chemical solvent
- Improvement of quality and shelf life (dermo-cosmetic product)
- Highly efficient lesion care, with no side effects (medical device)
- Efficient and safe production system for nanocapsules
- Accessible/affordable cost of the final product
- Compliance with sustainability and business ethics principles, including in particular respect for workers' rights, ethics in supplying of raw materials, reduced environmental impact in processing and production

Precaution, safety and quality in production

How should safety of nanomaterials be addressed during the development process and all along the life cycle, considering the existing debate (and related uncertainties) in methodologies for testing, classification and future regulatory developments of nanomaterials?

A safe by design approach has been considered in NanoCube and it should be further sustained. This includes a precautionary approach in selection, design and functionalisation of ingredients of the product; consideration of the state of the art practices and standards (beyond normative requirements) for the characterization, measurement and safety testing of nanomaterials.

The computational pre-screening techniques and in-vitro approaches already considered by NanoCube have been identified as valuable to this end. Further insights are needed to ensure a full assessment of potential exposure to nanomaterials during the production of nano-capsules, and regarding the end of life of the product.

Standards and guidance developed by OECD on nanomaterials, use of control banding approaches for safety of NM in occupational settings, expert advice, continuous update on regulatory

developments are among the tools identified to this end.

Interaction and cooperation with authorities to anticipate potential risks and identify suitable ways to minimize them has been also suggested as a key action, in particular in the case of the medical devices (due to the more demanding requests of the regulation).

(Ethical) acceptability and societal desirability of products

How could acceptability of the final product be ensured considering public risk perception of nanotechnologies (in particular cosmetics)? How are the concerns of distributors and certification bodies in using new technologies linked to uncertainties in terms of risks, public concern and regulatory development? And how best to address the scepticism of users and customers of green and natural cosmetics regarding the use of new technologies?

A communication strategy needs to be developed, with a focus on the use of nanomaterials. Product claims should be supported by scientific evidence (testing activities). Specific criteria to take into account for communication along the supply chain and to consumers include:

- Distinguishing between use of ingredients (including nanomaterials) based on natural substances (molecules non modified with respect to the natural molecules) and synthetic substances
- Highlighting improvements in durability and efficacy of the product, achieved thanks to the use of nanotechnologies. In particular underlining any improvement in terms of shelf life (avoiding/reducing the use of conservatives in the cosmetic)
- Providing indication on the safe use of nanomaterials during production, use and disposal (complementing normative requests to include nanomaterials in product labelling)
- Ensuring transparent and sound communication, based on scientific evidence, of information on product characteristics, including use of nanotechnologies.

In order to ensure acceptability of the final products, the communication strategy should be enriched by regular dialogue (co-creation) on the product development with stakeholders, in particular, developers, producers, certification bodies, distributors of the cosmetic products. This dialogue, started



during the PRISMA project, should continue all along the product development phases.

Process and Product certification.

How is RRI embedded in the innovation governance of the company and in the project? What RRI aspects emerging from the project could integrate existing certifications at process and product levels, and become part of the usual approach to innovation management of the company?

Adoption of voluntary certifications on sustainability, social responsibility and ethics is part of the culture of Archa, as well as in that of the other companies involved in NanoCube (producers). For Archa and Techa, this includes adoption of OHSAS 18001 (Occupational Health and Safety Assessment), SA8000 (Social Accountability), UNI EN ISO 14001 (environmental management), UNI EN ISO 9001 (quality management). The cosmetic products of NanoCube are expected to fulfil requirements of the COSMOS certification (certification for organic and natural cosmetics products in Europe), and as well of certifications concerning biological farming for production of raw materials. These certifications provide an added value to address the specific ethical and social issues identified for NanoCube and to pursue an RRI approach.

At the process level, the advice has been to integrate safety procedures for nanomaterials developed within NanoCube in the usual risk management and quality procedures used by the company (in line with the above mentioned certifications). This might include indication for researchers to implement safe by design approaches, procedures for safe handling of nanomaterials in the workplace, indication for end of life management of nano-related products. Control banding tools for safety of nanomaterials (such as the ones in the PRISMA RRI toolkit) might be considered to this end.

The attention to gender balance in any of the R&I activities of the company, as shown by almost equal participation of women and men to projects and consideration of gender aspects in project design and execution, could be further emphasised in project communication.

Adoption of additional certification mechanisms could be considered to further highlight and consolidate the approach toward RRI of the company. An example of standards useful to this purpose are the Guidelines for management and processes development for responsible innovation (UNI/PdR



27:2017). At the product level, the explicit consideration of aspects related to nanomaterials (e.g. application of the precautionary principle in selection of formulations; implementation of best practices for safety, etc.) within existing certification mechanisms could be pursued.

The aspects underlined above are going to be structured and elaborated in a roadmap to integrate RRI into the NanoCube products after the end of PRISMA, and covering all the period until the commercialization and use of the product. The agreement with the company of the final roadmap will be the conclusive step of the pilot.

Final remarks

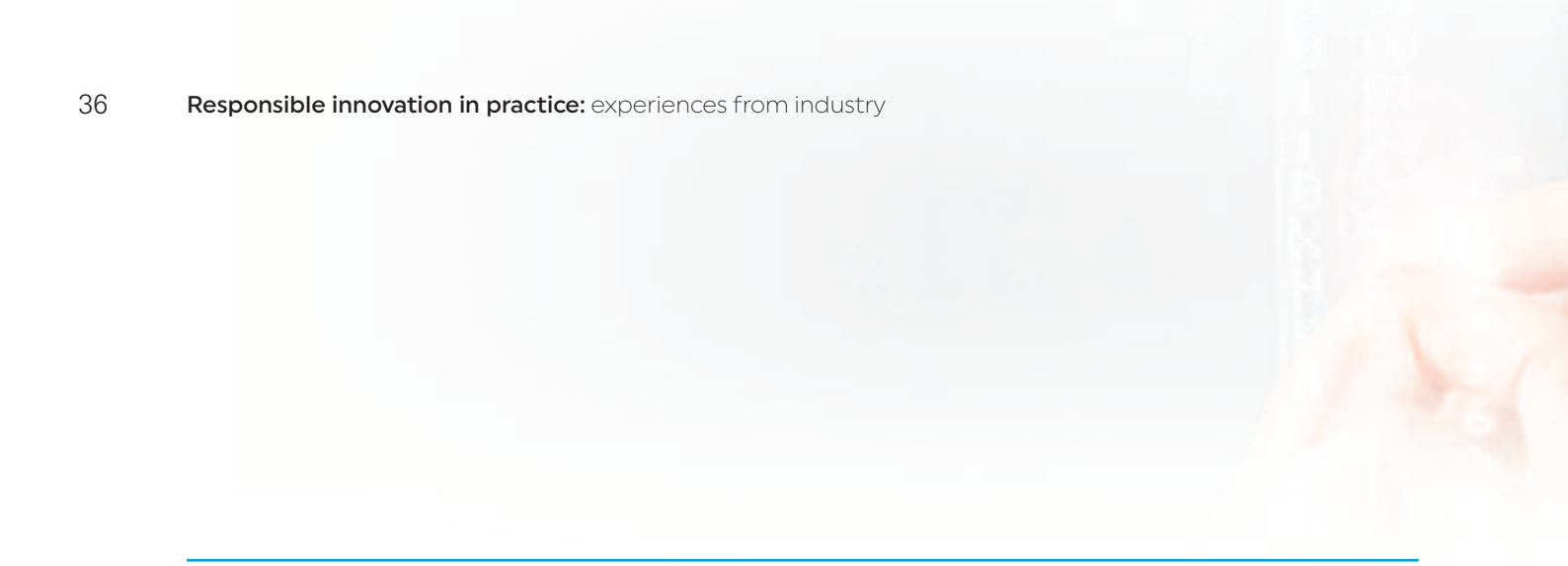
The cooperation with Archa on RRI implementation has been quite fruitful, also thanks to the experience and attitude on social responsibility of the company. Some of the RRI tools and approaches emerged by the work of PRISMA might in the future be integrated in usual practices of the company on several R&D projects.

The experience with PRISMA supported the company in a better understanding of potential impacts (both risks and benefits) of the NanoCube project. In particular RRI approaches helped to anticipate both Environment, Health and Safety and Ethical, Legal and Social Aspects of nanotechnologies with specific advantages at product level. This included improvements of safety and communication in the use of nanomaterials, fulfilment of certification requirements for natural and organic cosmetics products, alignment with distributors requirements for "premium" products, and better understanding of consumers' expectations.

However, the PRISMA pilot shows that assessment and implementation of RRI actions, for example the organization of stakeholder dialogues, are resource demanding.
There is a need for a specific expertise on RRI, and thus for people trained in coordinating and conducting RRI actions. It should also be considered that in cooperative projects, some of the partners might lack experience, or willingness, in cooperating and taking part in RRI actions.



Therefore, in most of the cases adequate resources should be made available to put in practice RRI. Considering specific tasks and resources (personnel, financial) for RRI since the early stage of a R&I project is an essential aspect for successful RRI implementation. Depending on the specific situation, this might include getting support from external experts, as it was in the PRISMA project.



3. Evolva



"I now feel that RRI just might possibly serve as a sort of inoculation (think of the flu shot metaphor) against future backlashes, and will help us better inoculate our partners and customers, although it won't guarantee that no backlashes will ever occur."

Stephan Herrera
VP, Strategy & Public Affairs, Evolva

The company and the technology

Evolva was created in 2004, as one of the first biotech firms to incorporate synthetic biology into its R&D platform. Evolva leverages modern biotechnology, including synthetic biology, to produce what are called yeast "strains," which are then brewed like beer in the traditional fermentation process. The purified end product contains no recombinant material. These end-products are molecularly identical to those traditionally extracted from plants, animals and petrochemicals.

In this way, Evolva seeks to replace ingredients that have 'issues'. Quoting the Evolva website about those issues: "The plant or animal that makes the ingredient is too rare, too hard to grow or does not make enough of it. Hence, the ingredient is not available at the right quality or price that allows most of us to benefit from it in a sustainable manner". [3]

Evolva's products include active ingredients such as Resveratrol, Nookatone and Valencene. Resveratrol, which is found in trace amounts in grapes, berries, nuts and other plants, is an example of a high-demand ingredient with a problematic sourcing history. Resveratrol is formulated into a number of products to promote healthy aging benefits.

Evolva has experienced resistance from some environmental organisations in the past with some of their innovations such as fermentation-produced vanillin. The company is committed to Responsible Innovation, however, so far this has not prevented resistance from some societal actors.

[3] https://www.evolva.com/wp-content/uploads/2016/03/Evolva-AR15-Preprint-30Mar2016-EN.pdf> accessed 19/12/18



Stephan Herrera
VP, Strategy & Public Affairs, Evolva



Working with Evolva

The following issues can be identified that are seen as problematic by those critical of Evolva:

Safety:

Genetically modified organisms are a potential threat to biological diversity if they escape to the environment. The regulatory process and framework for these products are not strict enough according to opponents.

Existing value chains/benefit sharing:

Long lasting tradition and knowledge of existing farming practices may in the long term become redundant if biotech and fermentation-derived products replace those from small, independent farms in developing countries. Producing products using a gene that can be found in a plant that has been traditionally harvested in geographies known for their fragile communities might in some cases require the biotech producer to provide some form of access and benefit sharing per the UN Convention on Biological Diversity and the Nagoya Protocol.

Sustainability:

Fermentation products are not environmentally sustainable because they require a carbohydrate feedstock. The most common feedstock used for the yeasts in South/North America and European fermentation production is sugar, the production of which may lead to deforestation.

Labelling/marketing:

Synthetic biology and many other forms modern biotechnology are considered to be "extreme genetic engineering" and hence their products should not be allowed to be labelled as “natural” even if these products are chemically identical to the product that was extracted from animals or plants, and contain no trace of the genetically modified yeast used in production.

Evolva's current response to these issues is as follows:

Safety:

Evolva states that its R&D is fully compliant with the UN Convention on Biological Diversity. From the website: "All our ingredients are produced in contained 'closed-loop' manufacturing facilities that are regularly inspected by regulatory authorities. The genes that we use are either sourced from various species, in compliance with the CBD, or constructed de novo based on online databases or other sequence data."

Evolva is a Swiss-US company. Both countries have comprehensive regulations governing research into and commercial uses of biotechnology. Per the website: "Evolva supports the public review and expert technical/legal assessment of such regulations, and when necessary, the strengthening of laws to ensure that they continue to be fit for purpose."

Existing Value Chains/benefit sharing:

Evolva states on the website that it is committed to "the fair and equitable sharing of benefits arising from genetic resources.".[4] Furthermore the company had at one point in time donated small sums of money to support the conservation of biodiversity and basic science education in developing countries.

Evolva claims to not target existing traditional value chains. When the company was developing vanillin, they aimed to provide an alternative to the vanillin which has for generations been produced from petrochemicals and paper pulp. They did not intend to compete with farmers of natural Vanilla. Due to cost and other issues, the vast majority of mass-market product producers use vanillin, not vanilla.

Sustainability:

Evolva invested in an analysis of the key LCA metrics involved in fermentation-derived vanillin. Most of the metrics supported the company's sustainability aspirations. However, there are many variables involved in the production of a first-generation fermentation ingredient (geography, yeast strain optimization, etc.) that will change in the near-term as the process is optimized. Sustainability remains, therefore, aspirational until the yeast strain and production process are perfected over time.

All of that considered, however, the environmental organisations concerned about the sustainability impact of Evolva's products, would not be convinced by a LCA. They would question its assumptions

[4] https://www.evolva.com/biological-diversity-and-the-environment/> accessed 19/12/18



or find issues that have not been sufficiently covered by the LCA. Also, most food and beverage producers focus on price and taste. They rarely pay suppliers a premium for ingredients that come with LCA data. There is rarely a green premium.

Labelling/marketing:

The company never described its products as 'natural'. But, it did describe its processing technology as 'natural' because fermentation is indeed natural. Evolva explained that the decision of how to label the ingredient is 100% in the realm of national regulatory bodies, not the companies that make the ingredient or produce a product that uses this ingredient.

However, in hindsight, Stephan Herrera from Evolva says that it was a complete waste of time trying to explain the difference between process and product. He also regrets wasting time and effort trying to explain that fermentation is a 'natural' process. This message was apparently too complicated to be communicated effectively. Critics exploited all of these gaps by framing the issue as one in which Evolva was seeking to deliberately replace vanilla made by poor farmers in Madagascar.

Herrera has called the public engagement effort around vanillin as something akin to walking into the perfect storm. Moreover, it was not productive to public engagement efforts to try and debate, counter, or define what qualifies as a 'natural' process or a 'natural' ingredient when most national regulatory bodies do not even have a uniform definition for 'natural'.

Transparency and public engagement:

Evolva invests in maintaining relationships with stakeholders. They invite critical perspectives from the beginning of their innovation trajectories and meet with nonprofits that follow biotech and emerging technologies with a sustainability narrative, such as Forum for the Future, Woodrow Wilson Centre and NGOs such as World Wildlife Fund.

However, its interactions with some NGOs proved very complicated with three particular groups in the US. Evolva did not want to mention them by name as they remain vehemently opposed to Evolva's use of synthetic biology, regardless of Evolva's efforts to be transparent and to seek collaboration. The lack of success in practicing RRI has led the company to become skeptical of the concept. There is concern that being transparent and actively pursuing public engagement with its critics made the company more vulnerable to criticism.



Advice

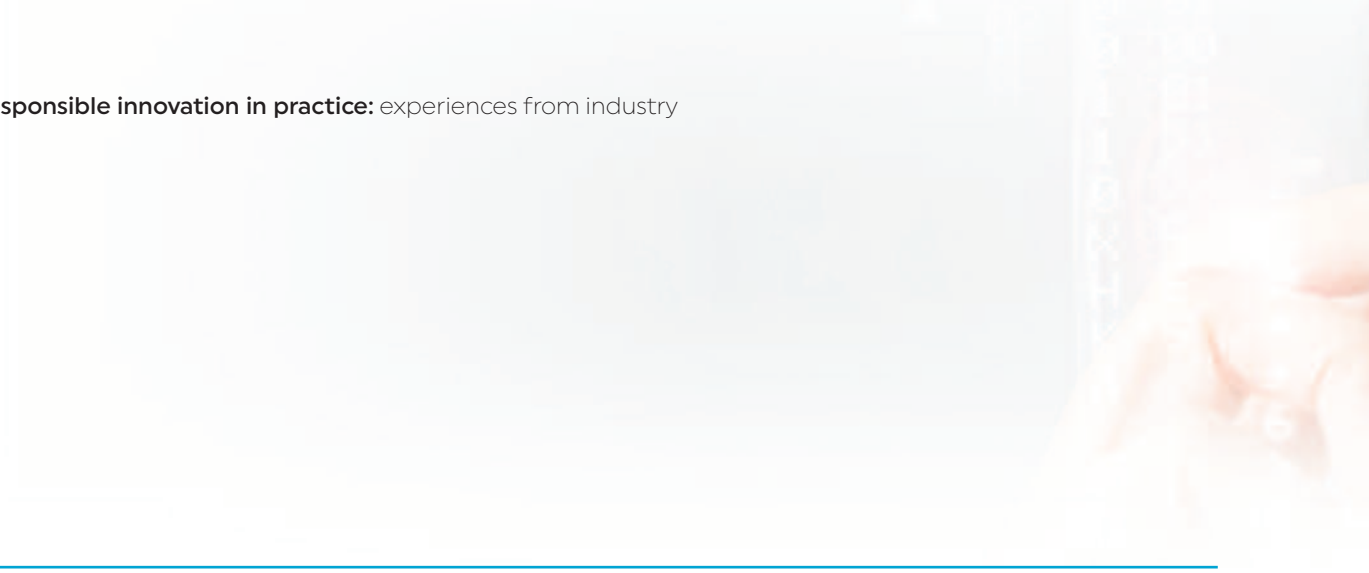
Four main issues emerge from the above analysis that deserve thorough consideration for Evolva to continue its RRI strategy.

1. How to select which ingredient to replace through various forms of biotechnology like synthetic biology and fermentation production?
2. How to establish whether the alternative is indeed more sustainable than the existing ingredient?
3. How to determine what fair and equitable benefit sharing implies?
4. how to collaborate with other actors to develop these frameworks and assessments in a societally robust way?

Some suggestions for concrete actions that could contribute to resolving these issues:

- Develop a robust framework for selecting the ingredient which deserves to be replaced by a synthetic alternative
- Co-operate in schemes for sustainability criteria for the specific ingredient
- Support sustainable practices for feedstock supply for the engineered yeast
- Create opportunities for vulnerable farmers in new value chains

If the above mentioned issues are answered in a collaborative practice with a wide range of constructive actors, Evolva could move from a defensive kind of RRI to a more pro-active, confident kind of RRI. Defensive RRI is geared towards damage control and risk-management. Confident kind of RRI is geared towards the development of a robust rationale underlying and motivating all steps in the innovation chain. Such a rationale will allow for a more confident engagement with critical NGOs and concerned consumers. The Agarwood case that Evolva is currently developing could serve as a showcase for such an approach.



4. Spectro



"What was particularly illuminating for me was that by collecting more data about cleaning we also as company may get new responsibilities which may led to new moral dilemmas. This has led us to adapt new policies for what data we share with our clients"

Laurens Metternich
CEO Spectro

About the company

Spectro is a Dutch manufacturer of cleaning agents for professional use. It a family-owned company with about fifty employees. The company has existed since 1986 and is located in Oss, in the South of the Netherlands. The company has a small R&D department with currently 4 people, mainly with expertise in chemistry. The company won the Family Fundament Award for the Best Dutch Family Business in 2014.

The company has an active Corporate Social Responsibility (CSR) policy, with a focus in particular on sustainability. The mission of the company is 'to decrease the total environmental impact of its products as well as decrease the cost of cleaning', and the company has the ambition to become a European player in the area of sustainable cleaning agents. The strategy of the company is aimed at developing high-quality innovative cleaning solutions that increase sustainability and lower the costs of cleaning.


ecodos
Kitchen Cleaner
ecodos
ecodos
Disinfectant
3
STOP



The company and the technology

The company develops highly concentrated ecological cleaning agents that are combined with smart dosing systems. A main example is the brand Ecodos that has been developed since 2007. The Ecodos system takes care of the exact dosage of cleaning agents, so that overdosing becomes impossible. The rationale behind this is that life cycle analyses show that a large part of the environmental impact of cleaning detergents is in the use phase. Reducing detergent use, thus, has a positive environmental impact. Moreover, it reduces costs of cleaning. The Ecodos Easy system also has a small solar panel so that it can function independently from the electricity grid. The system stores data about its use.

A main technological development for Spectro is the Internet of Things (IoT). This will allow making cleaning devices connected and the collection and exchange of data. Some larger multinational companies are already developing and advertising new cleaning applications that use IoT. Spectro is embarking on this development and is developing a number of applications using IoT. Such applications will allow better maintenance and servicing (e.g. refilling in time). They also allow the collection of data about cleaning which can contribute to better or more efficient cleaning.

Working with Spectro

In close cooperation with Spectro, a number of responsible innovation activities were undertaken (see box 1).

Box 1: RRI activities

- Literature study about hygiene issues in hospitals and the potential for better cleaning solutions
- An inventory of the main stakeholders and values
- The development of a number of value scenarios
- Identification of value conflicts and potential ways to deal with them
- Help Spectro develop a RRI strategy

One of the potential markets that was explored for new clever dosing systems using IoT is that of cleaning in hospitals. This market is interesting for Spectro because the company is still a smaller player in that market but would like to expand. It was found – through a literature study – that healthcare-associated infections (HAI) are a main concern in hospitals. It is estimated that in the EU 4 million people acquire an HAI annually, and approximately 37,000 premature deaths occur due to HAI. In an additional 110,000 cases, HAI contributed to the death of patients according to estimates. This is said to result in 16.4 million extra days of hospitalization in the EU, and an estimated cost of €5.5 billion annually in the EU. It is further estimated that 20 to 30% of these infections could have been prevented.

Three routes are important for preventing HAI; 1) patient-to-patient contamination, 2) contaminated hands of healthcare personnel, and 3) environmental contamination. Spectro could in particular contribute to reducing the third route. There is no agreement in the literature about the relative importance of this route and the best (technological) solutions for it. Nevertheless, there is clearly a potential for the type of smart cleaning solutions combined with IoT that Spectro aims to offer. It can be concluded then that there is an opportunity here for Spectro to develop new products that offer a clear added social value combined with a potentially interesting business case for the company.

However, a stakeholder mapping showed that there are a number of barriers to the introduction of such new technologies. It was found that a large number of stakeholders is involved, in particular in the case of hospital applications (see box 2). Getting these stakeholders aligned is a major challenge. One particular problem is that the departments (or external companies) doing the actual cleaning do not seem to conceive the current situation as problematic nor do they seem to see any potential for the use of IoT in cleaning.

Box 2: Main stakeholders for hospital applications

- Distributor of cleaning products
- Cleaning department hospital
- Cleaning personnel
- Healthcare personnel
- Patients (and relatives)
- Purchase unit of hospital
- Logistics department hospital
- Direction hospital
- Expert infection prevention of hospital
- Health Inspection
- Ministry of Health



Another more general obstacle is that cleaning contracts are often the result of tendering and that in such procedures the emphasis is often currently primarily on the costs of cleaning (rather than the resulting hygiene). A first step in overcoming such barriers might be to set up a pilot with one hospital; but even that might require efforts that extend the capabilities of a small company and could probably be better initiated at the branch level.

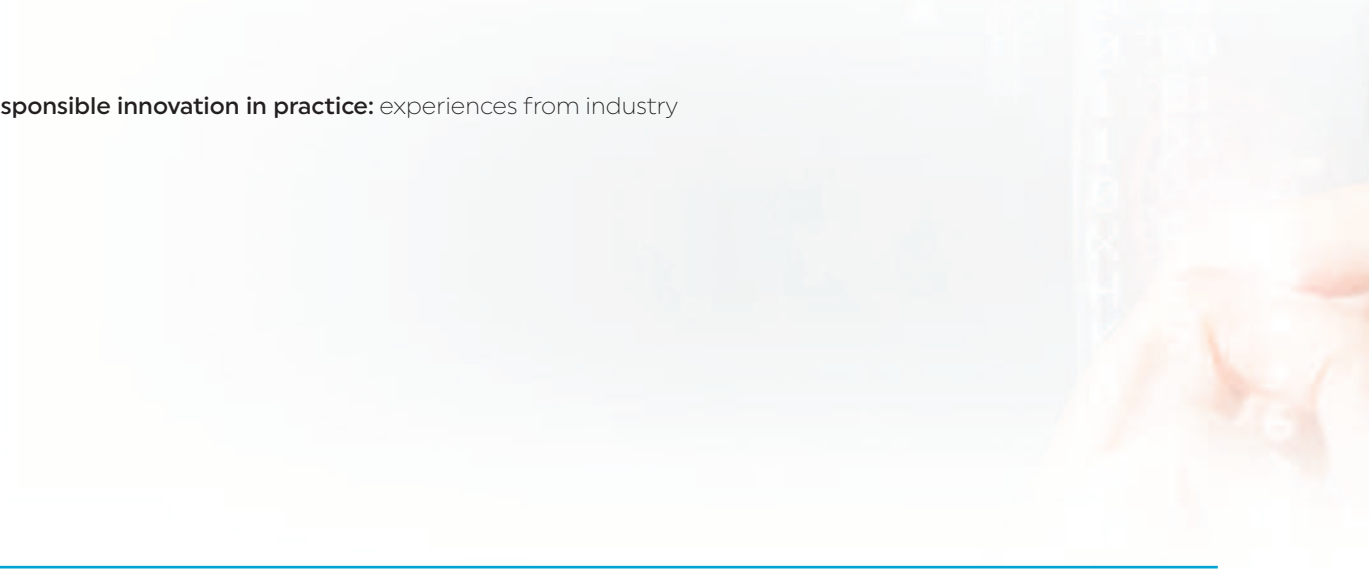
It was further found that responsibly developing such new cleaning technology requires attention to a range of values in addition to the values of sustainability, quality and innovativeness that are already central in Spectro operations. These values are: public hygiene, privacy, security, transparency (of data collection), autonomy (of cleaning personnel), and reliability and trust. These values were further explored by developing a number of value scenarios. These are short hypothetical stories about (unexpected) use that help to reveal relevant values and potential value conflicts.

Advice

The company's CEO has indicated that participation in the PRISMA project was particularly useful for him because it made him think about issues he would not normally think of. He was particularly persuaded by one of the value scenarios and concluded that he should avoid the ethical dilemma of either withholding certain information or betraying the trust of a customer.

Spectro now aims at more actively sharing data with its customers so that they can take responsibility for the frequency and quality of cleaning. The CEO also found out that many of his customers are not aware of the data being collected and of the potential value of this data. He now sees it as the company's responsibility to make its customers more aware.

Increased collection and sharing of data may also potentially raise privacy issues. The data that are currently collected are most likely not personal data in the sense of the GDPR (General Data Protection Regulation) of the EU because they cannot be traced back to individuals. Nevertheless, it would be wise for Spectro to develop a policy about privacy collection and sharing that explicitly addresses privacy issues, in particular because future technological innovations may involve the collection of data that can be traced to persons.



5. Aerialtronics



"We aim to make a positive change, unify with different stakeholders, companies and government authorities in order to include our and their interests and responsibilities"

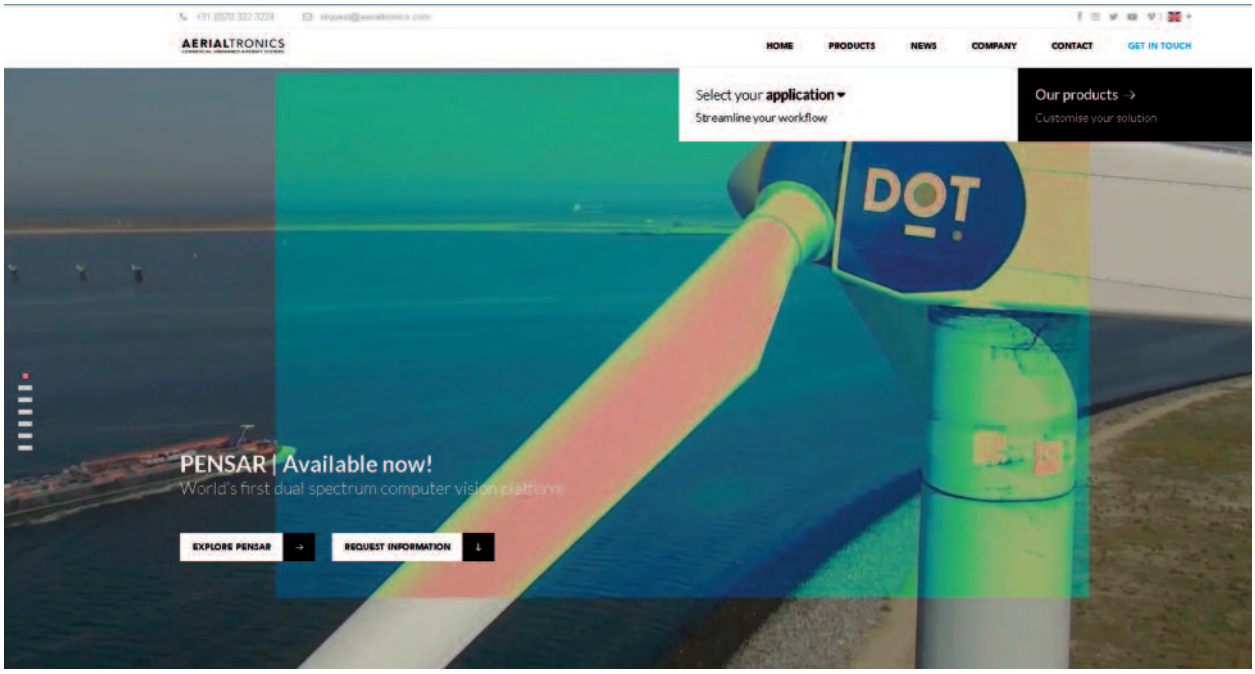
Timothy van Langeveld
Legal Counsel - Policy & Regulatory Affairs Lead, Aerialtronics

The company and the technology

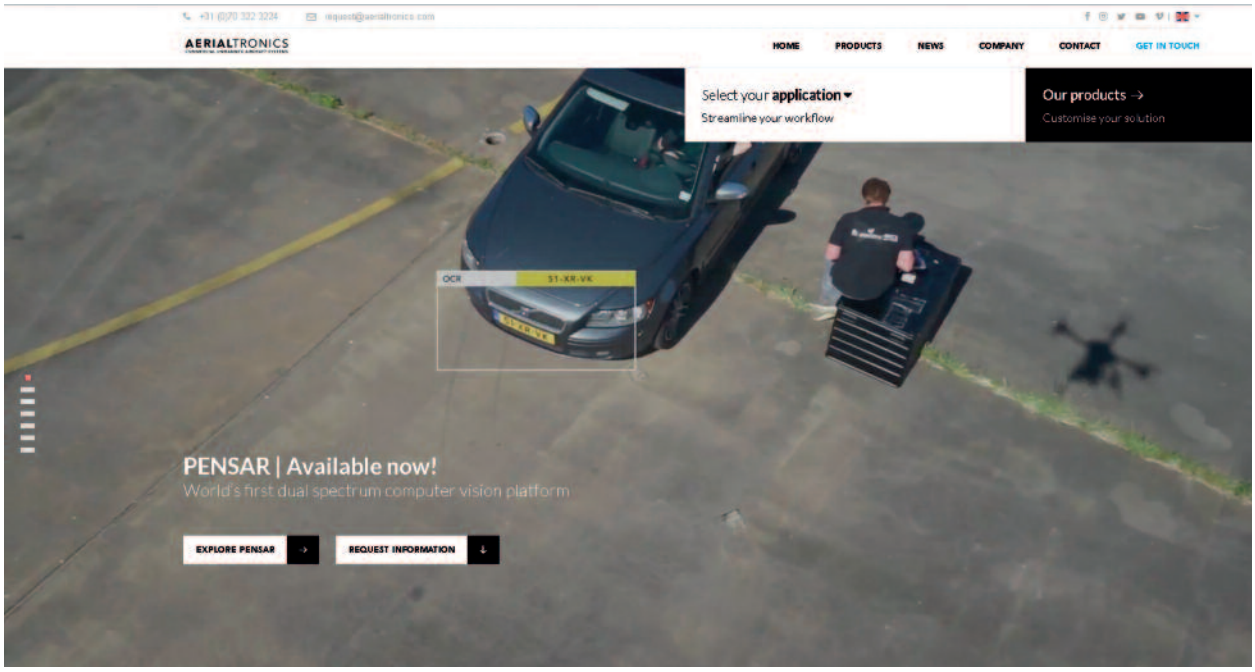
Technologies to develop autonomous Unmanned Aerial Vehicles (UAVs) are central in the case of Aerialtronics. UAVs also known as drones are large vehicles that can operate either autonomously or in a swarm. Central to the development of these autonomous UAVs is the development of technologies that allow these vehicles to operate safely in an urbanized environment. Currently, existing legislation prevents these activities and as such the commercial value of the technology. In this pilot we work with Aerialtronics, an SME based in Katwijk, the Netherlands. The company focuses on specific technologies that allow the drone to operate more independently from an operator and aims to sell the drones for professional and commercial tasks, such as monitoring and small maintenance tasks carried out for instance by police, fire departments or industrial inspection and maintenance companies. In the Autumn of 2017, the company is acquired by Drone Volt, a French manufacturer of commercial drones. With the acquisition of the knowledge base of Aerialtronics, Drone Volt can further develop the drone technology and include specific technologies, specifically in the field of security. Aerialtronics has developed professional drones that are equipped with technology to monitor and survey by drawing on artificial intelligence and big data analytics. The main technology is the Altura Zenith surveillance system which can be extended by data capture modules (audio, video, physical parameters, etc.) and software for the processing and analysis of the data collected.

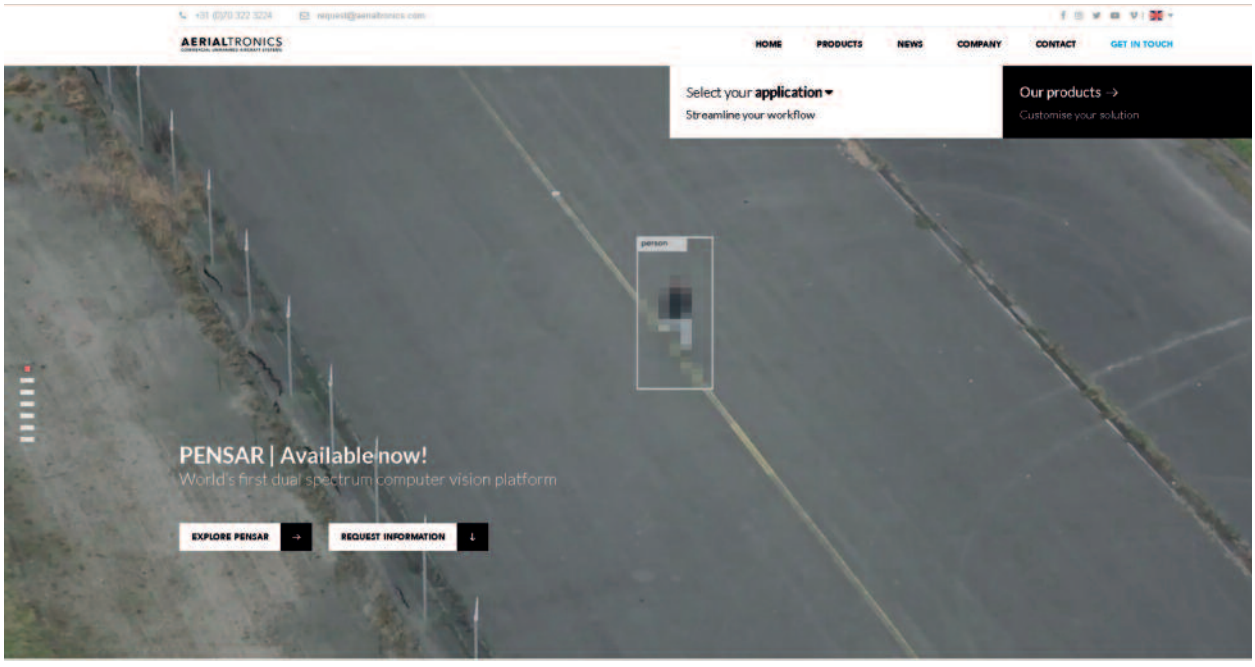
The technology

The technology we focus on in this project is the Pensar. The Pensar is a dual spectrum computer vision platform that is mounted to a drone and operates with the Altura Zenith. The Pensar can capture images and data and analyse it real-time by making use of reading text or thermal vision. This helps the operator of the drone, for instance to recognize characteristics, read license plates of cars or serial numbers of equipment immediately in the course of performing monitoring tasks.



The operator can also get more insights with daylight and thermal vision overlaid on one screen in real-time. This makes the drone a piece of equipment that can perform specific tasks very well with a high level of detail and a potential intrusion in the private lives of people, especially when operating in urban areas. Due to this, the Pensar is equipped with a special privacy masking tool. This tool automatically and instantly blurs the details of sensitive data such as the privacy of bystanders.


AERIALTRONICS
HOME
PRODUCTS
NEWS
COMPANY
CONTACT
GET IN TOUCH
Select your application
Streamline your workflow
Our products →
Customise your solution
PENSAR | Available now!
World's first dual spectrum computer vision platform
EXPLORE PENSAR
REQUEST INFORMATION


AERIALTRONICS
HOME
PRODUCTS
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GET IN TOUCH
Select your application
Streamline your workflow
Our products →
Customise your solution
PENSAR | Available now!
World's first dual spectrum computer vision platform
EXPLORE PENSAR
REQUEST INFORMATION

Working with Aerialtronics

The activity with Aerialtronics is to a certain extent infrequent and we changed the focus during the course of the workplan. The infrequent collaboration is partly due to the takeover of Aerialtronics by Drone Volt, at the end of 2017 and because Aerialtronics has focused more on the Pensar technology and less on drone technology as such. Initially we started the project with reviewing the implementation of a technology for sensing the direct environment of a drone and prevent it from colliding into other objects. The sensors, based on onboard ultrasonic technology, give feedback to the drone operator and is a first step to make the drone more autonomous and interact it with regards to its environment. The technology is called the Sense and Avoid system and is a modular functionality for the Altura Zenith Unmanned Aircraft System. This innovative sense and avoid solution improves safety during the inspection of telecommunication towers, utility poles and oil rigs, particularly in windy conditions. The helps the pilot to keep a safe distance from obstacles and increases the safety of their inspection. The system is a precise measurement system that was developed in 2016 and is currently sold to clients. The first generation of the system informs the pilot about the location and distance and can autonomously intervene between the operator and the drone when the drone comes too close to certain objects.

While this semi-autonomous system is relevant, not only for practical purposes, such as windy conditions, it is also an interesting system to investigate how the operator of drones and legislation, including the wider stakeholder environment, responds to it. The idea is that future generations of this technology will have higher levels of intervention and should allow the drone to take its own decisions regarding the tasks it needs to perform. Aerialtronics is discussing with legal officers to see how it may help the implementation of autonomous drones in the future.

However, we decided to focus on the PENSAR technology, because it is being sold and has a potential high intrusion on people's private life.

We started the process of working with Aerialtronics by having talks with various people in the organization to discuss sensitive technology that can be addressed in the PRISMA project. At first we focused on the sense and avoid technology and shifted during the spring of 2018 to the PENSAR technology, which fit well under the goal of PRISMA: 'responsible research and innovation'. In the discussions with Aerialtronics we reviewed the ethical aspects of the new PENSAR technology and



discussed with potential clients, local governments and universities and the wider stakeholder environment about the technology development of the PENSAR and the repercussion for bystanders.

Advice

At this moment, we conducted a number of interviews with company representatives, experts in both university and government and stakeholder organization. The advice we have is to follow two strategies in parallel.

1. Building legitimacy

The first strategy is to build confidence in the technology. Having drones that collect big data and operate more autonomously maybe be perceived as unwanted by users and bystanders. However, the technology can help authorities and inspection companies in the monitoring, surveying and maintenance activities. The question to be answered in this strategy aims at how can we be build trust and test the vison cameras in public spaces, and how do we inform bystanders and authorities about the issues of this equipment?

We advised working closely with civil aviation roads authorities, and considering how other road-users can be given informed expectations about their behaviour. One organisation useful to this task is the national CAA. They have workgroups that discuss the implementation of new legislation concerning the autonomous and Unmanned Aerial Vehicles (UAVs). The focus should not only be on this organisation because we advise the company to build a sense of urgency, that for society there is a lot to gain if the legislation for autonomous drones is passed. The safety of large groups of users, the monitoring of crowd management, people at events or traffic at streets can be increased and the authorities can take immediate measures to safeguard the actions of people. By building a sense of urgency, the authorities can better make a trade-off of the pros and cons of the technology.

2. Identify a lead user.

Building legitimacy should go hand-in-hand with building a life case for implementing the PENSAR

vision platform for a lead user. We advise the lead user to be a government organisation, such as the police or the local municipality when it concerns crowd management. The inclusion of stakeholders can be tested then when the lead user is a known and trusted organisation that uses the technologies to help the people and safeguard them when they attend an event. Our advice is also not to use the technology immediately for traffic control or to use it for sanctioning or controlling people's behaviour. When it is used in the case of the latter, the stakeholders will be fuelled with arguments that the technology is breaking into the personal lives of people and is misused.

In summary, our advice is:

- the influence of the technology on people is pertinent and should be developed and implemented further with care.

- the first applications for the technology in public spaces should be aimed at helping the people that they monitor with the technology. This is to build confidence and trust and to show the benefits of it to the wider public and stakeholder environment.

6. Hub of All things



"... once we started working with the PRISMA community we found we're not alone, we realized there's a whole school of people who are doing similar approach as we do, we're also learning from the community on different ways and in best practices of implementing ethical research and innovation. "

Xiao Ma
HAT Data Exchange Ltd. Founder
and Warwick University Senior Fellow

The company and the technology

The product is the 'Hub of All Things' (HAT); this entails the HAT microserver, which is a new technology that confers intellectual property rights of personal data to individuals through their ownership of a database, wrapped with containerised microservices. The HAT can be described as:

- A legal artefact: a person is data controller/processor & subject;
- A technological artefact: a person can invoke private analytics and algorithms on their data to share;
- An economic artefact: a person can exchange data in bundle combinations & data is unencumbered;
- Market artefact - scaffolding into existing markets as a private data account, premium user account for applications/websites to pull data to/ from;

The HAT ecosystem is the first-ever personal data exchange ecosystem that enables individuals and organisations to exchange data directly between individuals and organisations without third party involvement. While there are many personal data lockers and repositories, the HAT is uniquely an artefact that is actually owned by the individual, and has a schema that 'flattens' and 'liberates' vertical structures of data so that new mashups and new ways of putting together data for new services could be created to serve individual lives. Individuals can acquire their own data from internet-connected objects or services, and this acquired data is then transformed by the HAT to enable individuals to contextualise their own data, making it meaningful and useful for decision-making. With that data, individuals can grant websites and applications rights to the data in their microserver that allow them to obtain more personalised services and recommendations. It seeks to solve the widely-perceived inadequacies of the online economy by implementing global operating standards for personal data exchange. The HAT is therefore a personal data platform for firms to offer individuals services for their data in a scalable way, yet allowing individuals to control the data rights given to firms. Importantly, the HAT and its transformed data is owned by the individual.

For firms, the HAT opens opportunities for exchanges and use of personal data in a way that is privacy preserving, real time and on demand. Firms can (1) build smart devices that individuals can control and acquire the data on the device onto their HAT; (2) build smart applications for individuals to make use of their data; or (3) help individuals exchange their data for better buying decisions, personalisation



and recommendation (4) not need to hoard data as firms can request for data in real time and on demand whenever needed and only while the user is using the service.

The enterprise grows out of a series of university-based research projects. The HAT project as a whole has received several grants from the RCUK/EPSRC/digital economy fund. Its researchers are actively seeking further funding. It has also crowdfunded £158,000. The team of researchers has involved 6 UK universities, 7 professors and 20 researchers. Alongside the UK Government funded research projects, there are two central private organisations:

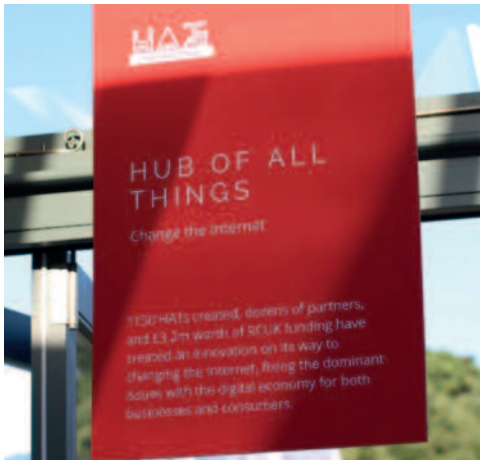
1. The HAT Community Foundation (HCF) Ltd. A not for profit company registered in England. Governed by its membership on behalf of the whole HAT community.

2. HAT Data Exchange Ltd (Hatdex). A private limited company with share capital, with a mission as a social enterprise. (See http://hubofallthings.com/downloads/hat-briefing-5-the-hat-foundation/ for details on the organisation of the HAT community. See also http://hatcommunity.org/hatdex-economic-and-revenue-model/ for a brief account of this.)

The research project was initiated in 2013 and ended in 2015, but research continues with more than £10m funding using HATs for tourism, health, education and finance research, coordinated by HATLAB (https://hat-lab.org). The HAT Community Foundation and HATDeX were founded in 2015 and publicly launched in 2016. The company's product itself is at live testing stage with 1600 HAT owners (HATS available through iOS, web and Android).

Working with Hub of All Things

The vision for this pilot project was continued involvement in the role of embedded ethicists. This was divided in to two phases. The first was an extended scoping exercise, consisting of a series of meetings on topics that have arisen in earlier discussions, with the goal both of iteratively narrowing down the specific points at which the PRISMA researchers in the Interdisciplinary Ethics Research Group at Warwick (IERG) could make productive interventions and also bring out unrecognised issues. The second phase focused on delivery of specific Responsible Research & Innovation advice, which we set out overleaf.



Activity has included authoring a work plan, a regular series of meetings in person and by telephone with members of the company including Xiao Ma, Jonathan Holtby, and Irene Ng; involvement of the company at the PRISMA workshop in Brussels in April 2017; involvement of the company at a forthcoming event organised by us for the UK intelligence services; a workshop in February 2017 on data ownership with HAT and Warwick Interdisciplinary Ethics Research Group; the attendance of the embedded ethicist at the HAT research seminar in Cambridge; and acquisition of a beta version of the product for testing by IERG.

In carrying out this activity IERG are continuing to work with the members of the HAT Community Foundation on privacy issues in particular and are working in particular on (i) the value of privacy that HAT supports, and (ii) the contexts in which trades of data for services are non-exploitative. Two particular ongoing issues in this regard are:

- The extent to which facilitation of people's rights to their personal data is dependent on the manner of regulation of the data trading platform as much as it is dependent on the technical capability to trade data itself.

- How HAT is beneficial to both individuals and companies, and the extent to which there may be trade-offs in this regard built in to the architecture of the technology, for example where the exploitative aspect of trades of data in exchange for services might be replicated in a HAT-governed market.

Advice

The efforts of the HAT community to take the lead at the public and intellectual level in the areas of the theory of data ownership and data privacy are laudable. This is manifested in several places including in the publication of papers and online articles on the topic by HAT developers, the MadHatters newsletter, and the organisation of the Wolfson-HAT seminar series. The work in this direction is a model for other technology developers in bringing normative issues in at an early stage of technology development. Our general advice is that HAT continue and deepen such work, and in doing so offer a yet richer body of answers to the questions that the idea of a personal data exchange raises. More specifically we propose:

1. **Further investigation of the ways in which HAT activity falls in to RRI categories.**

   The RRI brand has some cache with funding bodies, and the translation of HAT's activities into RRI terms might have the advantage of making its work more attractive to funding bodies who formally recognise RRI and from whom HAT seeks funding. Furthermore, RRI has some functional value that may supplement the existing efforts of the HAT as a social enterprise. For instance, HAT might seek certification as a B Corp.

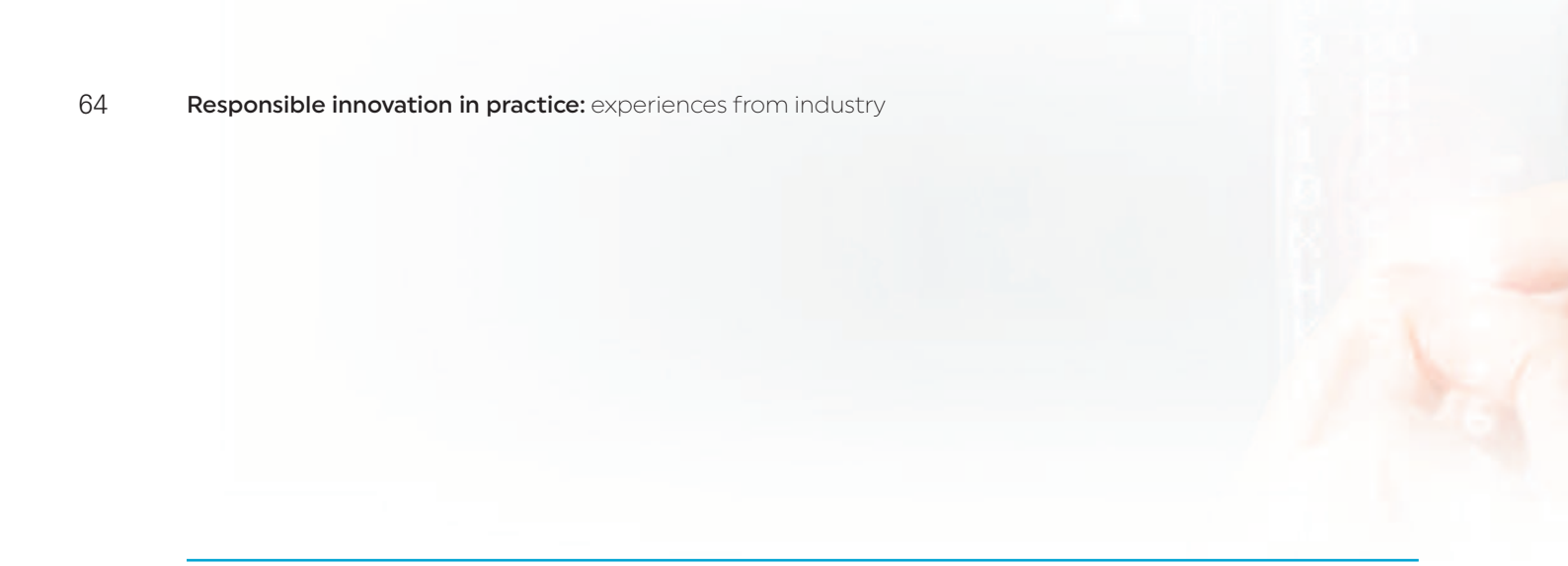
2. **Exploration of possible tensions between HAT's role as improving data security and HAT's role as improving data privacy or control.**

   The personal data exchange is sometimes advocated on the grounds that it is personal, and sometimes advocated on the grounds that it provides for exchange. The extent to which these two goals overlap or conflict is central to understanding the HAT's social appeal. On one hand, the HAT provides for a complicated architecture in which each individual's information is kept in a separate database. This seeks to provide not only practical security of data, but also legal ownership and control, since there is legal precedent for the ownership of databases if not data itself. On the other hand, HAT allows people to extract the value from their own data, thereby escaping the apparently exploitative nature of the online economy. However, it may be the case that the easier it is for data to be exchanged, the less it will be ensiloed within the HAT's secure architecture, being instead held and mediated by third parties. We propose further understanding of this possible trade-off and the desirability of different points upon it.



3. Emphasis on the democratisation of the marketplace.

It appears that a great deal of the effective power of the HAT in providing people with control of their data occurs in the specifics of the governance of the marketplace in personal data that it proposes. It is in principle possible for HATs to be ubiquitous but for data only to be tradable in marketplaces that freely allow third party trades and thereby seem exploitative in just the same way that the current online economy seems exploitative. Indeed the current HAT cannot provide 'first point of access' personal data silos; it provides auxiliary silos for combining existing data sets that are stored and controlled elsewhere, such as on Google or Facebook servers. This suggests that a central part of the HAT's offering in giving people control of their data is in writing and enforcement of the codes of practice that govern the bodies who can connect to HATs, rather than in the existence of HATs themselves. The organisation already has gone to some lengths to consult stakeholders and democratise this process; our advice is that since the distinctive offering of HAT depends upon this process, efforts at democratisation of the marketplace should remain central.



7. RDM

"... there are all sorts of ways that down the road, the system will have to trade the operation objectives against a business case, and that's another reason for having experts in the field, and another part of the learning we've had with the PRISMA project...how you can decide what is a sensible level of remuneration, what is a simple level of trading other people's opinion or data against an end solution? "

Simon Brewerton
Chief Technical Officer, RDM



The company and the technology

Autonomous or 'self-driving' vehicles promise many safety, environmental and congestion-reducing benefits for future transport. In recent years the first steps have been made towards producing and marketing autonomous vehicles. In this pilot we work with the RDM Group, an SME based in Coventry, UK, that produces small low-speed self-driving pods. These are envisioned as being deployed for the 'last mile' of a journey, such as between a railway station and the final destination. They also might be used in shopping malls, university campuses, airports, or for parcel delivery.

The company RDM is part of several consortia that receive funding from Innovate UK, a body that distributes government funds for research. Amongst the project members are also Jaguar Land Rover and Milton Keynes Council. Furthermore, RDM has been involved in UK research council funded projects on automated cars managed by Warwick Manufacturing Group, Warwick University, including the projects INTACT, SWARM, and SMARTER.

Working with RDM

Activity included a regular series of meetings in person and by telephone with members of the company and research group, as well as personnel from WMG, RDM, and Milton Keynes Council. The company has taken part in PRISMA workshops in Brussels in April 2017 and February 2018, has co-operated in filming a video interview; and has allowed members of the PRISMA team at Warwick to experience the pods and the simulator.

It has become clear that the most central issues for our productive focus are information privacy, commercial use of private data, and urban planning; at IERG we have developed our dialogue with the above-mentioned partners in these directions.

The process of working with RDM started with a long period in which the company and WMG staff identified issues for the company that were most usefully addressed with PRISMA. Although they are not labelled as such, there are a number of ongoing practices within RDM that fit comfortably under the heading of 'responsible research and innovation'. Our goal in working with RDM has been to identify, augment and add value to these existing practices in our own role as 'embedded ethicists'. Ongoing RRI-like practices include:



- working with local governments and universities and thereby indirectly engaging with stakeholders through the democratic and research activities of those institutions;

- taking the lead in establishing standards for the new technology with the ISO.

With regard to the first of those aspects, we might emphasise that there is a sense in which RRI activity is 'baked-in' to RDM's work, since the development of the technology is inherently responsive to the needs of government funders and local government. Milton Keynes' interest in the vehicles begins with the fact that its population is likely to increase, and densification is politically difficult; there will be development of communities around the outskirts with new schools and a planned transport pathway. There is a broad goal of helping the city to move towards a less car-based system; on the other hand, the local population is (at least for now) committed to cars. The approach of the local authority in Milton Keynes is pragmatic and experimental: provide people with different transport choices, encourage them to use new forms of public transportation and see whether they in fact do so.

Advice

There are three particular social and ethical issues that have received focus in the course of the pilot.

1. Research Ethics and Testing Procedures

How should the trials of automated vehicles on public roads should be conducted, and how can other road-users be given informed expectations about their behaviour?

We have advised that the key value at stake is the **involvement of a diversity of stakeholders.** Stakeholders include a wide range of actors: those who are involved in financing, designing, manufacturing, selling and marketing the product; users who would benefit from the product; businesses that would benefit from the product; individuals or businesses who are sceptical about the product or who believe they may lose out were it implemented. These groups may overlap. Stakeholders also include industry organisations, NGOs, and local government representatives. The more diverse the actors involved in the development of the product from the outset, the more likely it is that bottleneck issues will be addressed before the technology is too expensive to change. For



example, trial participants may be sought from different populations with a deliberate goal of including those who may not naturally sign up to the process, such as the elderly. More broadly, trials should be understood to be a part of a general process in which different elements of the social group that will use the technology are ultimately consulted.

2. Data collection and usage.

How can the technology be designed in a way that responsibly takes account of privacy and data-use in the future while maintaining its own and its clients' commercial freedom? RDM's operating model involves raising revenue by brokering the data provided by users and the offers made by retailers to pod passengers. This raises the issue of informed consent to the use of this data and the related issue of the various possible uses of data beyond the actual or reasonable expectations of the individual. For instance, businesses may solicit preferable routes on the basis of statistically likely interest on the part of travellers. The RDM technology is being designed from the outset on the model of 'service in exchange for data'. The RDM project is also innovative in facilitating commercial purchases of data it collects.

Our advice in this area is that **the technology should be developed with a clear eye on the recent debates surrounding the existing economic model of information exchange.** This will enable the technology not just to avoid the kind of controversy surrounding Facebook in its dealings with Cambridge Analytica, but moreover to show leadership in forming fair kinds of data exchange. This


RDM
AUTONOMOUS
pod
001
RDM
AUTONOMOUS
CAUTION!

begins with systems aimed at establishing informed consent and personal control of data, a process that is now more regulated under the General Data Protection Regulation, so that trading of data to third parties is limited, and that individuals are able easily to extract and remove the information held about them. Since new technologies are often held to higher standards it will be of benefit to the deployment to seek to be leaders in this area by providing separation between users' data in storage thereby increasing cybersecurity; and by implementing protocols that provide for the use of anonymization techniques as extensively as possible.

3. Public spaces, urban planning, and commerce.

How do we understand the limitations imposed by spaces in which this technology is to be deployed? The system might be conceived of on the model of public transport or on the model of a taxi service – or something in between. Such an understanding makes a difference to the permissions and restrictions that the public will be willing to place upon the system. The way the vehicle interacts with commercial retail is a salient instance of this issue. It is conceivable, for example, that retailers could vie for customers by paying for a preferred route that brings passengers to their premises. Furthermore, the possible social benefits that the technology could provide (e.g., through agreements with charities supporting blind people, aid for those living in sheltered housing for elderly, traffic calming schemes, park & ride systems) might similarly alter its status in this regard by playing a role in civic development.

Advice

- **the civic role of the technology is strong and should be developed further**
- **the commercial element is innovative but requires strong backing from democratic institutions in order to be carried out in the public sphere (through arguments relating to congestion, pollution, and safety)**

8. BISIGODOS

"... And it really is informing how we think about designing our projects for different calls, trying to incorporate some form of RRI into most of our grant proposals that we're putting into the future. So I think what I'm learning is a greater appreciation of what RRI is, and how best to implement it in the future."

Stuart Coles
Assistant Professor
Warwick Manufacturing Group



The Project and the technology

The EU project BISIGODOS aimed to identify ways to use algae as a feedstock in order to produce valuable chemicals, amino acids and high added-value bio-resins that would normally be produced using petrochemicals. The algae biomass can be fed directly with CO2 from industrial emissions (cement, steel factory, thermal power plants, etc.) as a raw material that is cost-effective and renewable. The process is assisted by solar radiation, nutrients and sea water microalgae. The consortium brought together expertise and resources within the areas of: microalgae and photo-bioreactors production and optimization, manufacture of amino acids for food products, production of conductive polymer coatings, bio-resin development for water-based inks, bio-surfactants production and bio-PU adhesives manufacturing, and end-users in the food, flexible packaging, hair care, metal industry and paints products. The project's website is at www.bisigodos.eu.

Working with BISIGODOS

The BISIGODOS project itself was completed in April 2017. The work carried out with Warwick involved continuing to examine RRI issues with the researchers and businesses including discussion of their next steps and what lessons can be learned more broadly. The work provided an opportunity to assess its overall arc and what might be learned from its outcomes, especially bearing in mind possible future projects.

The project was structured in such a way that industry consortium members would provide specifications of products to be created from the algae. Thus, the project's public deliverable D1.2 puts the requirements list in the following way:

> *Some of the material property requirements provided by the end users are the following (numerical requirements are not shown due to confidentiality requirements)*
>
> **Table 3. Material Property Requirements.**
>
> | Property of algae-based polyols | |
> |---|---|
> | Physical form | Acid number |
> | Functionality | Viscosity |
> | APHA Colour | Moisture |
> | Density | Odour |
> | Heavy metals | Appearance |

It became clear from discussion with those involved in the project that this arrangement put a significant degree of control in the hands of the industry consortium members, to the extent that late term alterations in requirements would lead to development that may not be ideal in sustainability terms. The technology is at a relatively early stage and there is value in allowing experimentation with different forms that it may take. Nonetheless, it seems that in this case the high degree of confidentiality of the material property requirements and the attendant absence of external stakeholder involvement perpetuated an arrangement in which considerations of immediate commercial strategy





3a. Hair care applications (CRODA)



3b. Inks for painting packaging applications (SUNCHEM)



3c. ANTICORROSIVE PIGMENT COATING APPLICATIONS (BECKERS)



3d. PU adhesives for flexible packaging (CUSA)



3e. Ameno acids for food and consmetic applications (GBR.AT)

received a great deal of weight. More specifically, an issue for RRI purposes is the use of a bleaching process to create transparent rather than green packaging products. The structure of the consortium — which itself was a response to a funding call (for further discussion of this point see the section on public private partnerships in chapter 1 of this report) — in this way led to the development of a technology that paid less due than it might have to the value of sustainability.

Advice

There are two central lines of advice arising from our involvement with the researchers.

1. Seek to find ways from the outset for projects in general and technology assessment practices in particular to be deliberately stakeholder-engaged

It is typical for those working under the rubric of RRI to propose greater stakeholder engagement. The BISIGODOS project provides no exception. Greater efforts might be made (in ways that pay due attention to issues of commercial sensitivity) in the material requirements process to consult the following, amongst others:

- consumer groups
- other industry actors
- policy makers.



There may be challenges in achieving such engagement regarding resources, expertise, framing effects and capture, and commercial sensitivities. However, it is clear from the recent broader developments in RRI that there are various avenues that will partially or fully meet such challenges.

2. Broaden the range of technology assessments

The Life Cycle Assessment and value assessments carried out on BISIGODOS were:

A. confidential
B. made at the very end of the project
C. carried out with the more standard attributive methodology
D. run separately for each of the products being produced.

Insofar as RRI is being addressed, the assessments could be improved in each of these regards. Public assessments would facilitate the above-described stakeholder process. So-called 'anticipatory' assessments of technology at the start of a project may be speculative but can help its subsequent direction and can make explicit the reasoning of researchers to stakeholders. While Attributional Life Cycle Assessment is the standard, there is an increasingly sophisticated set of assessment methods that seeks to take into account economic or social value and indeed to draw out the values that are implicit in those carrying out the research. Finally, the Life Cycle and Value Assessments were carried out on the assumption that each product separately (surfactants, coatings, and so on) would be produced; it would be worthwhile also to see such assessments on the wider assumption that algal oils replaced petrochemical feedstocks in the economy more broadly.

PRISMA



www.rri-prisma.eu

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