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Mind the gaps! EU and the makings of robot autonomy

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Abstract: This paper explores the entanglement of visions, politics and innovation policy development with recent developments in robotics. We explore the orientations to purpose and direction with which innovations in robotics are encouraged. We explore the discrepancies between machines as reality and machines as fiction, in particular the vision of robot autonomy as fundamental to future developments with the particular aim to help solve Europe's societal problems. We argue that these complex entanglements are riddled with contradictions and 'gaps' to be minded, i.e., between industry and academic research, between technologists, ELS scholarship, policy and society at large and, last but not least, between machines of today and tomorrow. We argue that the political and policy landscape that encourages these innovation practices and cultivates imaginaries of robot autonomy is misguided (or mistaken) in its purpose-driven agenda which can only exacerbate existing contradictions. Rather, what is at stake is a level-headed politics of uncertainty to deliver a robotics agenda for a societal good that meets the criteria of responsible innovation.

1. Introduction: visions and politics

The European Robotics Technology Platform (EUROP) was founded by industry actors in 2005 with support from the European Commission.[1] At its formal launch, the commissioner for Information Society and Media, Viviane Reding, stated that:

> *…the Lisbon Strategy calls for a more competitive Europe, the only way to sustain our unique social model…We need to achieve higher economic growth through more innovation and higher productivity, whilst creating more jobs. We need also to address many societal challenges, the ageing population, the well being of our society, and the need for security…Robotics will contribute to these challenges (Reding 2005).*

Robotics development across Europe is increasingly coordinated by public-private conglomerates of policy, industrial and academic actors. The prime mover so far has been

1 The main initiator companies being EUnited Robotics, KUKA, ABB, Phillips, FhG IPA, and KTH.

industry because of its power to frame the premise of research and development policy in terms that orient toward industrial production. However, the industries do not act alone in shaping innovative and radical visions for the future of robotics. They rely on other communities to help create and push new agendas, including the academic research communities, policy makers, lawyers, the media and citizens more generally. Research and development activities in recent times have brought closer together actors who shape and strengthen a vision of how advancing robotics will contribute to ongoing efforts to promote and cultivate European competitiveness, innovation, higher productivity and growth. It has brought together actors who strongly promote visions of companion and assistive robots, capable of operating safely among humans in ordinary everyday environments.

EUROP prepared the strategic research agenda for European robotics, *Robotic Visions (EUROP, 2009)*, but in the year thereafter (2010) the network merged with the more academically-oriented European Robotics Research Network (EURON) to form what is now called euRobotics.[2] This new entity has since joined in a Public-Private Partnership (PPP) contract with the European Commission (Bischoff, et al, 2010)—a form of partnership which strategically supports innovation domains that*"are addressing major societal challenges by strengthening Europe's competitive position in a particular business sector"*. Consequently, a PPP-contract with the Commission significantly strengthens the policy support to expand on the opportunities that can bring robotics development into new and more advanced areas of deployment, fundamental to addressing Europe's problems.

Intelligent, learning and adaptable systems are at the top of the list of opportunities in robotics development. This is demonstrated by a wide-spread quest for scientific, industrial and legal pathways towards robot autonomy. A consortium of academic researchers, *Robot Companions for Citizens* (RCC), captures the gist of this quest as a scientific and technological challenge that has been matched with societal challenges and concerns. The RCC manifesto outlines the qualities of European societies: *"democracy, advanced economies, social inclusion and quality of life are ingredients of a welfare much of the rest of the world looks up to"* (RCC 2012). Then it states that European welfare is at risk due to negative demographics, man-made and natural disasters, economic downturn, trade imbalances, and a dwindling industrial base. The manifesto claims that there are discrepancies between the aspirations of Europeans and the realities with which they live. The gap is branded as *the challenge of sustainable welfare* (ibid) which then is faced with the shortcomings of today's machines in contributing solutions to the challenges faced by European societies. "W*e envision of a whole new class of machines to overcome the limitations of today's machines, new machines based on a whole new science*" (ibid). The shortcomings are further reduced to obstacles that form what the RCC calls the *robotics bottleneck* on the road to autonomous machines:

> *The first one is that current robots are unable to operate in real world conditions… no existing robot or autonomous system is capable of operating without sharp boundaries that delimit its role and protect it from harming humans, the environment or itself. The second is that for a traditionally engineered system, operating in complex real world conditions would result in high demands for energy, computation and storage (RCC 2012).*

One can argue that robotics development has always been intimately connected with visions of autonomous machines, in particular, any human-like intelligent appearances like those found in mythology, folklore and the science fiction genre (e.g. Hephaestus' golden assistants; the Golem; Asimov, 2004; Pixar Animation Studios, 2008). These visions have implications for how we understand human capabilities, human autonomy, intelligence and adaptation. As it stands however, the very notion of such machines remains a mechanical myth. Robotic

2 http://www.eurobotics-project.eu/about-eurobotics/euron-europ/europ-euron.html

devices can imitate humans and animals to some degree and we already appropriate a range of robotic tools and technologies as we do other types of machines and material artefacts more generally, i.e., for purposes that demonstrate human power to control them for some purchase in the world.

Working machines and material artefacts are missing the mythical edge that characterises visions of robot autonomy, an edge which points to contradictions in its makings. Increasing the autonomy of machines will complicate the conditions of controllability, decrease human control along with our understanding of such machines. At the same time the key idea is to build intelligent, learning and adaptable systems to better control the development of our societies along the trajectories of European values and societal priorities.

In the following three sections, we will further address the shaping of EU robotics networks, visions and strategies, the makings of robot autonomy as a topic for ongoing exploration, perplexity and debate, and the *minding of gaps* in these developments. As regards the first on this list, contributions from industry, the scientific research communities, law and policy, indicate how differently these actors imagine and position themselves within the networks that aim to advance robotics. There are ideological differences and issues of practical exploitation of purposes and goals, but they are also not equally powerful and influential when it comes to strategic planning and visionary work. For example, it is quite bluntly stated in the 2009 strategic research agenda prepared by EUROP that, *"industry will be the main driver behind these targeted stimulations because its needs for innovation and strong positioning in the worldwide robotics market are the greatest"* (EUROP 2009). In other words, European industry is vying for the strongest possible position in global markets. It seeks to bend the contributions of others toward those purposes, while others also assert themselves independently within what appears to be a highly political and policy-driven technoscape of robotics development.

As regards the second topic, the making of robot autonomy, we explore how such makings are differently envisioned and formulated, depending on whether the vision of autonomy comes from within industry, the scientific research communities or from legal scholarship. We explore as well how the different actors imagine and position themselves in relation to the project (and promise) of human-like performance. Visionaries and researchers have always portrayed varying degrees of optimism in this respect, as the following two statements indicate:

> *A type of human robot, a Humanoid is expected, to work together with human partners in our living environment, and it will share the same working space and will experience the same thinking and behaviour patterns as a human being* (http://www.humanoid.waseda.ac.jp/history.html).
>
> *This [human-like performance] is far beyond the current state of the art and will remain so for many years to come. Therefore, we propose to focus research efforts on a small set of strategic challenges required to make headway towards this vision* (FET, 2006, p.3).

Robots have for decades been cut off from most of society for reasons of safety and liability. Apart from a number of simple household and companion-type robots on the market, the physical space for robotic operations is often strictly delimited using physical barriers, e.g., in factories, or they are fitted with mechanisms for direct human control in specialised operations. But, if the ambition is now to overcome the necessity of such barriers, the arising challenge is that of inventing new kinds of control mechanisms, preferably ones that can be designated to the machine itself, *meta-ethics*, as it becomes more adaptable, flexible and capable of learning (see Asimov's three laws of robotics).

The third topic concerns the 'gaps' that are articulated, explored and dealt with to some extent in these developments. There are gaps between different techno-epistemic regimes that contribute to innovation in robotics. Their visions and orientations need bridging to strengthen the very project of building intelligent, learning and adaptive machines. They need bridging with visions and strategies to create sustainable wealth and welfare in Europe which is manifested already in innovation policy and societal priorities on the political agenda. There are gaps between machines as fact and machines as fiction which further complicates the relationship between different contributors to robotics development, but also relates to the efforts amongst legal scholars to articulate how or in what sense machines become legal entities. We describe how different regimes mind these gaps in constructing and imagining robot autonomy, and inscribing such a development in strategies for action whose purpose is to address societal problems.

We argue that what is at stake here are the politics of uncertainty and contradiction, rather than a straightforward project of minding gaps, in concerted efforts to situate robotic autonomy against current threats to Europe's welfare. On the one hand, we observe how visionaries and research leaders attempt to bridge the gap between different interests and orientations to robotics developments. They seek to strengthen the networks that contribute to robotics development and strengthen the scientific and technological research in order to bridge the gap between today's and tomorrow's machines. On the other hand we observe how purpose-driven the politics of innovation are in minding the gaps between European aspirations of growth, competitiveness and sustainable welfare, and the frequently mentioned societal problems of the day. We observe attempts to steer scientific and technological developments in the general direction of those purposes.

1.1 . A note on method

In this paper we take stock of the scholarly orientations each author brings to this case study and how they cut across the key arguments in complementary ways. In doing this, we utilise ethical and legal scholarship, vision assessment and socio-technical evaluation. We all examine a small set of documentary data, while exploring independently a number of other data sources which are particularly amenable to our individual approaches. For example, we explore the proposals for green/white papers on legal issues, mission statements and other output from roboethicists, social-anthropological studies of AI, HCI and robotics, and case study data from participatory design. As Ten Have explains, all such documents will always have to be considered some form of evidence. If they do not serve as the means to access original events, they are specimens of their own type, whereby the practices of documentation can be studied as ways of using documents (Ten Have, 2004). In this sense, documents are *social facts*. They are deliberately produced, distributed and shared in organised ways for one or another reason (e.g. Silverman, 2006, p.168; also Scott, 1990). They are produced and reproduced to assist in some activity and the investigator should thus be sensitive to the conditions of producing them, how they can `fix' certain aspects of current events and actions, and what the conditions are for making them available, for example, how information *travels* through time and space (Ten Have 2004).

We see knowledge about autonomous robots in the EU as constituted through different practices, i.e. as acted out in different networks such as law, ethics, politics and the robotics community itself (academe and industry). Noticing the different modalities involved in all these networks, we especially focus on the ways in which knowledge circulates and is translated *between* networks of practice. Significantly, whereas most practitioners will, in some sense or other, focus on the creation of 'autonomous robots', it is by no means given that the concept of autonomy (or robotics for that matter) means the same within different actor networks. Still, while these practices keep operating according to epistemic and normative mores, they also reflect upon the practices of others taking place. Through such reflections we observe the pervasiveness of the western techno-cultural imaginary. We identify mythical elements in the midst of techno-scientific practice, sustaining the creation and transmission of knowledge (ethics - law - politics - robotics, etc.). In other words, the techno-scientific implements the hardest of artefacts along with the instrumental values of competitiveness and growth, however, fuelled by make-believe and fascination.

2. The shaping of robotics networks

Founding the technology platform EUROP in 2005, enabled a certain socio-technical imaginary of advancing robotics that opened for the involvement of other robotics developers across Europe (Jasanoff and Kim 2009, Levidow et al. 2012). Among key actions were attempts to forge a common language and a vision that could be used to direct and coordinate pan-European and cross-sectoral activities within the robotics domain with the aim to deliver new and innovative products to market. The drafting of the 2009 strategic research agenda was made possible through a coordinated action project (CARE) under the 6th framework programme, consisting of 125 partners from different parts of the European robotics industry.[3] Through a specific road mapping methodology based on working groups, consensus meetings and expert consultations, the CARE project delivered a broad agenda, including visions and key strategies for the whole research and development community. This agenda identifies core market sectors of strength for European robotics: *industrial*, *domestic service*, *professional service*, *security* and *space robotics*. Within these sectors, product visions are further developed by focusing on certain market pulls (industry) as well as the more radical technology push (academy). Overall however, this robotics vision is oriented towards the advancement of industrial production, centred on concrete applications across societal sectors, e.g. *robotic workers, robotic co-workers, logistic robots, robots for surveillance and intervention, robots for exploration and inspection*, and *edutainment robots* (EUROP, 2009: p. 13).

One can say that EUROP belongs to the industry sectors, although, the platform has largely been sustained through EU research grants that have supported the ongoing work of mobilising academic research communities for industrial purposes, and mobilising as well the available ethical, legal and sociology (ELS) expertise to 'clear away social and ethical obstacles'. Indeed, one of the key recommendations in the 2009 EUROP roadmap was to “avoid ethical, legal and societal issues become barriers” to the further expansion of European robotics (2009: p. 37). Part and parcel of a strategic approach to this issue was that industry must engage with policy makers, and that public awareness should be further developed. The main issue concerns robotics for everyday environments. If the barriers that separate robots, society and the environment are to be broken down, a number of issues relating to the uncertainty and unpredictability of robots can be expected to arise, not the least with reference to liability issues.

Two key outputs of ELS activities so far with funding from Supported Coordination Action under the 7th Framework Programme:

3 CARE is important due to its strategic role. In addition the EU funds robotics projects in a number of areas, such as security, health and ageing, social robotics, aeronautics and industrial robotics, as well as more basic research into necessary enabling technologies. When entering ”robotics” into the CORDIS project web-page (http://cordis.europa.eu/fp7/ict/projects/home_en.html), the page comes up with 157 projects in FP7 alone.

1. Proposal for a Green Paper on legislating robotic technologies (Leroux, et al, 2012)
2. Guidelines on Regulating Robotics (Palmerini, et al, 201.4) [proposal for a white paper]

Prior to these contributions seeing light, a workshop on ELS issues was arranged by euRobotics to lay out a plan of direct engagement with the legislative process: “*The […] workshop on the ELS issues in robotics will present the current version of the Green Paper (i.e. a forerunner of the White Paper, a consultation document with a preliminary set of ideas, strategies and guidelines to face the identified issues) on robotics and law...*” (euRobotics Forum, 2012: workshop description). What is unusual about this approach is that it is not normally the business of an EU-funded research project, in this case coordinated by an industry platform, to produce concrete proposals for EU legislation.[4] The introduction to the Green Paper acknowledges this anomaly in a disclaimer stating that *“This document is not a green paper stricto sensu. It constitutes a proposal for a green paper since it is not an official EC document”* (Leroux, et al, 2012). In spite of the disclaimer however, the Green Paper is seen to foreshadow the “*[w]hite Paper on Regulating Robotics, containing guidelines and suggestions for the European Commission in the field of regulating emerging robotic technologies*”.[5] Taken together these contributions are expected to establish a solid framework of '*robolaw*' in Europe.

While the Green Paper mobilised lawyers, the two main authors are industry representatives from the CEA List Robotics Lab and Alenia Aermacchi (Finmeccanica). In other words, the overall framing of the document remained in the hands of industry, but the general aim of the Green Paper is stated as promoting a *“dialog between the law community and the robotics community”* (Leroux, et al, 2012: p.2). Some of the key concerns raised in the document were further worked out through presentations at the Robolaw kick-off event at the euRobotics 2012 Conference.[6] For example, one presentation attended to the taxonomy of robotic technologies and remarked that these technologies *will be described in their features and potential scenarios of employment directly by the researchers who are developing them.* Thus, the focus is aimed at both existing and emerging/envisioned technologies, whereby scenario methodology is deployed to provide reasonable access to the latter. But, the main idea is that the actors who develop robotic devices are the ones who also provide descriptions of the functions of both actual features and scenarios. The resulting taxonomy will then provide the catalogue of technologies to be studied by legal, philosophical and ethical experts.

This arrangement between engineering and ELS scholarship substantiates our argument that industry is in fact dominating robotics development. It points to an emerging area of uncertainty on how the articulations will be managed between the activities of engineers and the activities of lawyers and other ELS experts,[7] and it complicates the involvement of academic research communities engaged in robotics. EUROP has been the main platform and site of robotics innovation. However, as in other ICT and innovation-intensive areas, (see EC 1993, ERT 1998, ISTAG 2001, 2004, Aho 2006), robotics as an innovation domain sits on the intersections of different societal and expert sectors, to the extent that the manufacture of robotic devices cannot be disentangled from scientific/academic research, the making of legal

4 It is of course well-known that industry strongly influences EU policies on a number of levels. The remarkable thing is the direct approach of actually proposing legislative pre-documents.

5 www.robolaw.eu/RoboLaw_files/documents/robolaw_brochure_20120322.pdf

6 www.robolaw.eu/RoboLaw_files/documents/RoboLaw_KOM_Odense%205March2012.pdf

7 Furthermore, meetings will be organized in direct connection with civil society. The circulating White Paper is projected as the result of interactions between experts in law, ethics, philosophy and robotic engineering, as well as a “two-ways communication” with members of the public who can both “contribute to the debate” and whose awareness of these issues will thereby be raised.

frameworks, the creation of standards, public imaginaries and political visions of how to create/renew/rescue Europe. Politics and the development of innovation policy are increasingly infused with technological and industrial visions and, as we strongly suspect, it goes the other way around as well. Scientific and technological visions of the future are increasingly pulled by policy makers and politicians armed with a societal agenda.

Reding's speech at the launching of EUPOP in 2005 went into some technical detail on robotics development and so was clearly informed by specialists working for the Information Society Technologies (IST) Programme of the European Commission, i.e., its advisory group ISTAG. This group is largely made up of representatives from ICT-based industries and academic research, and so not an administrative body, but an expert consultancy which has advised the Commission for many years on where to put the investments into the IST programmes. Among other things, ISTAG proposed the launching of Ambient Intelligence in 2002 as a strategic research agenda to push European consumer electronics and materials science forward (Gunnarsdóttir and Arribas-Ayllon, discussion paper). It also proposed the creation of the Future and Emerging Technologies (FET) flagship initiative in 2009, on top of the existing FET open and FET proactive programmes which were already receiving very large sums of money (since FP6) to support research into the opportunities afforded by technology convergence with ICTs in the pivotal role (European Commission, 2009). ISTAG even suggested robot companions as one innovation domain that could achieve FET flagship status, so it is not surprising that one of the contenders became the Robot Companions for Citizens (RCC) consortium.

According to the European Commission, FET flagships are *"ambitious large-scale, science-driven, research initiatives that aim to achieve a visionary goal"* and *"provide a strong and broad basis for future technological innovation and economic exploitation in a variety of areas, as well as novel benefits for society"* (Cordis website). The RCC consortium, led by the Scuola Superiore di Sant'Anna in Italy (Prof. Paolo Dario), was one of six pilot projects funded by the Commission in the run-up to the launch of the flagship programme, of which two finally emerged as winners.[8] The consortium came mainly out of the academically-oriented EURON, consisting of 73 partners almost exclusively from academic institutions. Its leader was well situated at the head of academic robotics research through long-time involvement and leadership in EURON and being advisor to the commission on innovation policy as member of ISTAG and the co-chair of the 2009 ISTAG report.

As stated in the RCC manifesto and final proposal, the visionary goal was to master the necessary key-enabling technologies in order to begin designing and building sentient companion robots with the aim to tackle and solve Europe's societal challenges. We can say that not all members of this consortium were equally enthusiastic about this goal but,[9] while the final proposal clearly recognised the requirement that a FET flagship ought to be out-of-the-ordinary visionary, the actual vision they put forward says more about the wider socio-technical, political and policy landscape in which the RCC consortium emerges. It is a clear expression of the kind of research agendas that have become prominent in recent times (Nordmann and Schwartz 2009), in which the promissory and imaginative capacities of

8 The Pilots were organised as Coordination Action (CA) projects. Main partners of the RCC CA were: Scuola Superiore di Studi Universitarie di Perfezionamento Sant'Anna (SSSA, Italy), Technische Universiteit Muenchen (TUM, Germany), Fondazione Istituto Italiano di Tecnologia (IIT, Italy), Universitat Pompeu Fabra (UPF, Spain), Karlsruher Institut fuer Technologie (KIT, Germany), Ecole Polytechnique Federale de Lausanne (EPFL, Switzerland), Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA, France), Koninklijke Nederlandse Akademie Van Wetenschappen-Knaw (KNAW, Netherlands), The University of Sheffield (USFD, United Kingdom) and University of Patras (UPAT, Greece).

9 From our direct involvement with consortium members.

technologists draw upon and blend in with societal visions. It is increasingly more difficult to determine whether policy and politics pull or push, while the enabling capacity of *the discovery engine,* is brought to bear on both nature's secrets and the envisaged needs of citizens. However, under these *conditions of possibility* the academically-driven consortium left very little room for input from industry and its mediating function to deliver actual products to markets. The industry is recognised in the proposal as important and necessary, but treated almost as an add-on—important but not particularly interesting or relevant. Thus, the main identifier and basis for collective action of the RCC, was the fascination with exploring and building objects that move, act, think and feel without a clear pathway to accountability—delivering products to market and societal goods that meet the criteria of responsible innovation.

The RCC initiative did not achieve FET flagship status but the consortium still exists as part of Europe's robotics networks, where industry remains in a leading role. What we learn from these developments is how complex the networks have become, involving not only one or another form of robotics expertise but also ELS scholars and policy developers. Ongoing developments in robotics, including efforts to regulate the making and remaking of political and policy visions, takes place within relatively established circuits of knowledge production and in well-organised networks. But as different networks are brought into closer collaborations and competition, one can also see their differences come into view.

3. The makings of autonomy

In this section we focus on how industry, science and law have engaged with the makings of autonomy: how they perceive the general challenge of robotics autonomy and how they construct their respective visions, goals and strategies in accordance with specific parameters and norms, enablers and constraints.

3.1. *Industry: strengthening growth and competitiveness by opening new markets*.

In the robotics roadmap, autonomy is singled out as an application requirement—a detailed specification of the properties that robots will need to have in the near future:

> *Autonomy is the system's ability to independently perform a task, a process or system adjustment. The level of autonomy can be assessed by defining the necessary degree of human intervention. Modern robots are mostly pre-programmed. Limited autonomy is present in some domains. In the future robot systems will perform increasingly complex (sequences of) tasks in decreasingly well-structured and known environments. Less human instruction or supervision will be needed over time* (EUROP 2009, 22).

Although robot autonomy is not the same as human autonomy (Haselager 2005), it has something of the same virtual characteristics, a sort of regulative principle or meta-property to steer actions and strategies. It is not a technical specification of machines; rather, it denotes the expansion and improvement of robot capabilities, to act independently from human intervention and in new environments and situations. The will to autonomy expresses a wish within the industries—a *will* to expand toward new markets and application areas, notably those of assistive robots in a number of domains (care, home, work, disaster areas, etc.). If robots are to enter these areas of life and work they have to be able to operate on their own; hence a gradual liberation from humans '*in the loop*'.

This will is grounded in industry's need for competitiveness and growth. As such, industry is likely to adapt to any major trends and changes in markets and new technologies, which over the last 20-30 years has been strongly driven toward more automation. For industry, then, increased autonomy is necessary because it contributes to growth and competitiveness when automation can be extended into new application areas. The EUROP road map is replete with prescriptions for how developments *will* happen, for instance *"robots and humans will cooperate and share space with each other"* (EUROP 2009, 8). Autonomy for robots is thus conceived of in technologically deterministic terms which is common throughout the history of technological development (Ellul 1980, Winner 1986, Feenberg 1999, Pinch and Bijker 1987). However, this determinism resides more in the industry strategy itself in the ways in which it commands of developments of machines and markets, than in the ways in which robots work or can be expected to work.

The theme of determinism and autonomy for technological entities comes with a twist. Developments seem to be pre-determined but the goal is after all to create machines that are capable of adaptability[10] and learning. If this program is successful, robots should be able to exhibit greater degrees of non-deterministic behaviour. As stated in George Bekey's introduction to *Autonomous Robots* (2008) *"[t]here appears to be a contradiction between autonomy, which implies that a robot is capable of taking care of itself, and control, which appears to imply some sort of human intervention"* (p. 3). The contradiction has practical implications. The more autonomy one grants to robots, and the more one introduces them to unpredictable and complex environments, the more difficult it becomes to control them. Whereas classical robots operate in closed-off, insulated and protected environments, the breaking down of the barriers between machinery and society opens up for much greater unpredictability. *"As these systems become more complex, they are likely to exhibit more and more unexpected behaviours"* (Bekey 2008, 1). The industry vision may be seen therefore, to be at odds with its own will to control and predict.[11] It is clear that the intention is not to relinquish control but rather to displace or reconfigure the control hierarchies in different, more dispersed ways. Although robots should integrate with users and society in new ways, it remains necessary to ensure that *"the safety of humans and their general superior position in the control hierarchy is ensured"* (ibid., 9). The question then becomes how the requirements for increased autonomy are to be squared with requirements for control, which are likely to be strained as autonomy increases. On a more general level it also becomes a question of how the control hierarchy is to be structured. As we will describe in the next section there is no specific strategy for how to deal with this contradiction. Rather, gradual and incremental improvements on already existing technologies seem to be the way forward, although, there is no guarantee that industry will be headed in the desired direction, i.e. to expand the use of robots to new environments and at the same time retain control.

3.2. *Academic research: Robot Companions revealing underlying principles of Nature*.

The idea of Robotic Companions was introduced in various form over some years in EU policy documents (ISTAG 2004; Dario et al. 2004, ERCIM 2006, EC 2009, ISTAG 2009). One can assume therefore that the concept had been nurtured for a while within EU policy circles which then enabled the emergence of the RCC proposal as *a transformative new science* based on an understanding of *the most complex machinery* known to man: animals

10 Adaptation is thus another application requirement mentioned by the document.

11 Standardisation is thus another "application requirement" which may be seen to (partly) counter the drive towards flexibility and adaptability. Standards emerge as central cross-cutting themes across both science, technology and legislation. Other "stabilizing" factors are, as we shall return to, the development of legal frameworks to stabilize conditions for autonomous robots.

and living beings. The scientific vision and challenge underpinning the RCC proposal was:

> *"to unveil the secrets of the embodied perception, cognition, and emotion of natural sentient systems that make them capable of acting, interacting and adapting effectively to their physical and social environment and of being cognizant and sentient of this relationship to the world"* (Dario et al. 2011, 50).[12]

These secrets were comprised of three fundamental design principles underlying the evolution of bodies and brains: *simplexity*, *sentience* and *morphological computation*. Together with *Multifunctional Nanomaterials*, *Energy* and *Society* a set of scientific principles constituted the fundamental pillars of the proposal (RCC 2012, 2012b). Taken together, they would support the *"bridge between science, engineering and application"* (*ibid.*). Although we cannot go into great depth, we shall provide some more background on these principles:

The *Simplexity* pillar aimed to describe and understand solutions hit upon by organisms dealing with complex problems. A central idea is that organisms, from the micro-scale over invertebrates to vertebrates, have depended on a limited set of cognitive and adaptive mechanisms for their survival and evolution. These mechanisms, the RCC claimed, have been preserved by evolution, and can be studied and turned into principles of engineering and design for robots. Constructing the equivalent of living systems' brains and nervous systems, simplexity would bring robotics beyond '*simplified model adaptation*' towards the '*computational models the nervous system uses*'.

Morphological computation. While simplexity is applied in problem-solving, it also closely coupled with the notion of an embodied cognition. The RCC proposal sought to overcome long-standing separation of embodiment and cognition, mind vs body, in robotics and artificial intelligence. Central here is the creation and use of new materials capable of low energy use, information processing and computation in order to achieve new physical properties for improved interaction with their environment and better integration among different physical parts. The key is taking into account direct links between embodiment and information, between embodiment and the wider environment in which a system is embedded. Overall, this promotes a view of robots as "*complex dynamic systems*" (RCC 2012b, 31). According to the proposal, previous separation between the controller and the controlled, central to both AI and robotics, can not be upheld. Embodied cognition signifies a shift "*from control to orchestration*" (*ibid.*).

According to the RCC proposal, achieving *simplexity* and *morphological computation* combined with major achievements in nano-materials and energy resourcing, will converge in the design of robots in ways what will bring into being their *sentience*. Achieving *sentience* in machines is the essential feature of the scientific integration promised by the project, i.e., "*the ability to integrate across perception, affect, cognition and action in order to construct one coherent scene and context in which action can be interpreted, planned, generated and communicated*" (ibid., 32). Through such integration a new type of architecture for robotics systems is conceived, overcoming the AI and other bottlenecks through the engineering of

12 Clearly, this story could start further back. For instance, research programs in rehabilitation robotics have a long history in Europe, and can, at least in the cases of France, Germany, the UK and Scandinavia be traced back to the 1970s (Dallaway et al. 1995). Inside the EU structures these initiatives started to come together in the early 1990s, i.e. with the establishment of the internal market. Dallaway et al. describe how the TIDE project "was set up as a precompetitive technology research and development initiative specifically aimed at stimulating the creation of a single market in rehabilitation technology in Europe". Robot Companions for Citizens can thus be seen to be building on such traditions of care robotics, but also as significantly expanded in scope and vision. Main factors for this expansion has been the merger of robotics with Artificial Intelligence and ICTs, in Europe implemented through the program of Ambient Intelligence.

more simple and energy-efficient mechanisms, built with smarter and more efficient materials. Rather than relying on classical top-down control architectures (see for instance Bekey 2008), sentient robots will be apt at higher degrees of socially intelligent interaction, even incorporating feelings and affection (RCC 2011). In this sense, sentience provides (at least) a double response to the paradox of autonomy. On the one hand sentience is intended for more contextually intelligent and freely operating robots. On the other hand, their propensity to feel and act more like living beings will make them more reliable, “*by virtue of being sentient they will be dependable machines we can trust*” (RCC 2011, 48).

This biomimetic approach made for a dual strategy. The understanding of mechanisms and design principles developed by living systems over the course of evolution should feed into the engineering designs of artificial systems. Through better understanding of artificial systems, RCC researchers would also be capable of reverse engineering to improve our understanding of living systems.[13] This, it was argued, was not a simplistic linear approach, but rather one meant to oscillate between the natural and the artificial, and also incorporating input from the societal/user considered. The result would be a continuous process of techno-social-scientific discovery, i.e. a '*discovery engine*' (RCC 2012b, 37). The experimental back-and-forth would be a set of experimental platforms, delivering prototype robot applications: *health companion*, *wearable companion*, *explore companion*, *work companion* and *universal companion*. These experimental platforms would be the concrete sites in which simplexity and morphological computation could be explored and implemented to ultimately achieve sentience.

It may be instructive to compare these experimental platforms with the EUROP application scenarios from 2009. Certain overlaps may be found (i.e. robotic co-workers), however, the overall picture is one in which the RCC platforms extend far beyond both the EUROP robotic visions. They are closer to ISTAG on social robotics and/or AI. This positioning is not merely expressed in terms of the unifying scientific vision by RCC advocates, but also in terms of social ambition, of creating more sociably apt, i.e. *sentient*, robots. The robot companion is supposed to be '*more than an assistant*' (Dario 2011) and so becomes a yet-to-be realized societal project in which humans and machine interact in new ways. The scientific principles of simplexity and morphological computation from which sentence emerges, are also telling in this respect, since they are meant to displace traditional control architectures and strict barriers with more socially situated and interactive robots. Within industrial robotics, autonomy for robots is mainly a project devoted to the expansion, growth and competitiveness of industries. In the RCC vision however, the notion of autonomy is matched with a unified scientific vision and its direct relation with engineering and creation—situating mind *as* body, and the body in evolution and nature, in ways that can be technologically reproduced. Autonomy emerges more as all the fantastic things that can be done in areas ranging from basic research (i.e. neurology, psychology, materials science, etc.) through to care for the elderly or explorations of disaster areas. All members of the RCC consortium did probably not share the vision of genuinely sentient robots but the common denominator, one can say, was a fascination with making things that move, think, feel and act. Indeed, there are numerous uncertainties about the vision of sentient robots, all of which are well-known to observers of robotics and AI.

13 And, in so doing, the RCC project embodied what may perhaps be termed the foundational gap of robotics, especially when seen as a way of experimental philosohy aimed at understanding life through its artificial recreation: ”Aiming to reenact Creation, at least in part, to produce life or some of its aspects artificially, philosophers and engineers have hoped to understand the connection between spirit and body, mind and matter, the subjective and objective experiences of life” (Riskin 2007, 1). It is noteworthy that this motivation sets the RCC apart from the industrial regime to which it is also responding.

For example, doubts remain about general idea of simplexity. It is said to reproduce computational models used by the nervous system, yet introduces the notion that a *task can be phrased as an abstract coherent model that takes place in a geometric space*. It also introduces minimalism in search for *the least complex solution to a given class of tasks*, and that natural systems follow principles to optimise their capabilities and *policies*. We may thus ask if living systems really use computational models to function, represent tasks within geometrical space, and thereby aim to optimise their capabilities? Do they necessarily choose the simplest possible solutions? Or, are these perhaps anthropomorphisms introduced by the researchers themselves?

As concerns morphological computation, the turn towards embodied cognition is also not all that new. As described by Lucy Suchman, Rodney Brooks introduced the notion of situated robotics in the 1980s. Criticisms have been raised about this paradigm, for instance from phenomenological and hermeneutics perspectives (Dreyfus, 1972; Dreyfus and Dreyfus, 1986; Suchman, 2007; Robertson, 2002). Suchman, quoting Alison Adams, argues that Brooks and others recognised the problem of embodiment, but they still did not deal with it in its complexity: Brooks reproduces a "*bodied individual in a physical environment, rather than a socially situated individual*" (Suchman 2006, 231).

Taken together, this means that *sentience* also enters into the tension between autonomy and control. In the new control hierarchy, *orchestration* is supposed to emerge more bottom-up and situated in embodied intelligence. However, taking embodied intelligence seriously (as implied by 'soft AI') seems to imply that very specific meanings and functions cannot be given to principles such as simplexity, but that it rather depends on specific social and ecological constraints, which are not replicated in engineering principles, hence, the idea that sentience emerges once all the other design challenges are overcome. However, all such constraints (or limits) lead to a loss of the scientific rigour that was prescribed by the RCC proposal, and run the risk of having to fall back on well known approached to AI and mechatronics i.e. the piece-meal approaches the RCC consortium intended to overcome.

3.3. *Legal : confirming and exploring the promise of autonomous robots*

One way of compensating for loss of technical predictability and control is through the introduction of legal (and ethical) frameworks. The problem was clearly stated in the Roboethics Roadmap, issued by the EURON network: "*…the increasing autonomy of the robots could give rise to unpredictable and non predictable behaviours*" (Veruggio 2006). The emergence of robots as new entities that are able to make autonomous decisions is seen as a challenge of the legal system that will change the legal order and perhaps even result in a paradigmatic shift in legal thinking (De Cock Buning et al., 2012). This paradigmatic shift in legal thinking is most typically provoked by the question of legal personhood for artificial intelligences. This question has already been posed since the rise of computer science, and has its roots in Alan Turing's question and test on whether machines can think and can be called intelligent (Turing, 1950). In the legal field, the question of *Legal Personhood for Artificial Intelligences* was first posed by Solum in a seminal article with the same title (Solum, 1992) and sparked a whole subsequent legal debate. In the texts of the legal partners in the European networks of robotics, legal scholars are called upon to confront the question of legal personhood for robots, since experts are suggesting that artificially intelligent robots may well become comparable to humans in their faculties of decision. Such developments press upon legal thought the urge to pose questions about the concept of legal personhood in different legal fields and how these are challenged. Which are the necessary properties of a civil law contract partner? (Alan and Widdison, 1996). What is the basis for the fact that in constitutional law humans are legal subjects from birth? (Boyle, 2011, p.6) What kind of a concept of personhood is involved in the criminal law on guilt? (Hildebrandt, 2011; Beck, 2009). An important first emphasis in dealing with such questions is that the concepts of "subject", "subjectivity", "person" and "personhood" referred to here are not philosophical concepts, but strictly legal concepts (Stradella et al., 2012). These concepts should not too readily be taken in an ontological sense that substantiates them. Instead the concept of person in law is purely a technique that provides a point of imputation of rights and obligations.[14]

Some European Constitutions recognize the personality principle as the basis for the attribution of fundamental human rights.[15] In other Constitutions the concept of human dignity, which is also enshrined in article 1 of the European Charter of Fundamental Rights, forms the basis for this attribution.[16] In naturalistic theories, legal personhood is held to be a natural feature that pertains exclusively to humans as natural persons. Other non-human entities cannot be attributed any rights or personhoods. Certain cases however, can be distinguished in which legal personhood has been rather treated as a legal status that is also attributed to other entities. The most obvious case is the legal recognition of the legal person, a form of limited personhood for corporations as an association of humans. This concept allows several different natural persons to act as a single entity that has certain rights, protections, privileges, responsibilities and liabilities. As such it is thus not directly applicable to individual entities like robots.[17] With Solum, the question could be raised whether artificial intelligences need to also be attributed human rights. Koops et al. conclude that the attribution of culpability to robots in criminal law or the attribution of (post)human rights in constitutional law does not yet make any sense. They follow Solum in claiming that such an attribution would require a degree of consciousness and intentionality that AIs do not possess.[18] In the end however, such an attribution has to be an empirical question that will also have to take into account that robotic entities will challenge these human-centred concepts of consciousness and intentionality (Koops et al., 2010).

Since the attribution of full legal personhood seems out of reach, we can ask whether robots can be attributed a limited degree of legal personhood that is sufficient for engaging in civil law transactions like entering into a valid contract.[19] Even this is already presented as "*a big step to take*" considering that "*the impact on society would be radical, since [robots] would become an active, participating object in (commercial) society* (De Cock Buning et al., 2012). Nevertheless, it is not clear on basis of which criteria legal personhood is acquired here, not even by humans. In national legislations, law simply attributes legal personhood to *natural persons* and *legal persons*.[20] In the instruments of international law such provisions do not even exist. An important question is whether such full legal capacity is required for robots at all or whether legal alternatives should be considered. The robot could be qualified as an

14 The legal subject should not be confused with the primary autonomous subject of (Cartesian) philosophy. The earlier scholastic concept of subiectum iuris actually made reference to an objective sphere as that which is the subject of the legal debate, the controversy. Later this notion became supplanted according to a certain ideology in legal doctrine by the 'subjective' subject of will and autonomy (Thomas, 1998, pp. 97-98). Dewey has also argued for distinguishing this specific legal concept of person from the concept of the person in everyday speech, psychology or moral philosophy (Dewey, 1926). He states that "even if there is be such an ulterior subject per se, it is of no concern of law, since courts can do their work without respect to its nature, much less having to settle it" (p. 660).

15 See article 2 of the Italian Constitution.

16 See article 1 of the German Constitution.

17 In this context we could mention a proposal for a special legal category of electronic personhood for robots – the electronic person Ldt. - has been put forward for bundling legal responsibilities of various parties and with a financial basis and public registration (Leroux et al., 2012, pp. 60-62).

18 (Solum, 1992, pp. 1262-1276)

19 See on this issue (Allan & Widdison, 1996).

20 See for instance articles 2:5 and 3:32 of the Dutch Civil Code.

instrument or extension of the will of its user, so that all acts can be attributed to the latter. The robot can be qualified as being mandated as an agent employed by its user for concluding certain transactions, in which case the user is also solely responsible for the actions (chapter 3 of the Principles of European Contract Law). Another possibility is the qualification of the robot as a minor or as a mentally impaired person who has limited contractual capacity.[21] In this case the robot would be able to engage in some kinds of simple transactions, but is excluded from other more important transactions (Leroux et al., 2012; De Cock Buning et al., 2012; Stradella et al., 2012).[22]

4. Minding gaps

The EUROP 2009 roadmap frames the aims and objectives of strategising robotics development in terms of gaps to be filled and challenges to be met. As a research agenda for the robotics industries, the roadmap is a powerful exercise in assertiveness and *industrial will*, but it pushes the road-mapping metaphor to its limits. Scientific and technological challenges – the detours, alternative pathways and breakthroughs to which they may lead – cannot all be known in advance. Consequently, some *gaps* and *challenges* are unknown and profound uncertainties, such as the ones surrounding the making of robot autonomy. More generally, uncertainties and unknowns indicate ongoing tensions between ideology and practice, between vision and reality, academic research and industrial production, policy development and the societal and market relevance of the envisaged breakthroughs within the field.

For example, the 2009 roadmap anticipates the expansion of robotics into new markets and areas of use. “*With increased flexibility and ease of use, robots are at the dawn of a new era, turning them into ubiquitous helpers to improve our quality of life by delivering efficient services in our homes, offices and public spaces*” (2009, p.7). Increasing attention has since been drawn to societal challenges to better understand what is at stake. It cannot be known in advance how the new devices will be received. Prospective users may not care enough or feel that they need autonomous or semi-autonomous machines for assistive purposes and companionship. For comparison, the lesson to be learned from experiments in so-called living labs throughout the 2000s, is how visions of autonomous gadgets and smart environments are often disconnected from ordinary everyday needs and interests. The stated aim of these labs are to make user-centred and situatedly realistic designs, however, the research has largely been preoccupied with discovery of gadgets and services to sell people. As retrospectively stated by two key visionaries in the field: “*…the newly proposed prototypes are still based on what is known as technology-push, despite new approaches such as user-centric design. They are still not focused at solving real problems and they are still too deeply rooted in the classical western materialistic needs…*” (Aarts and Grotenhuis, 2009, 4).

As far as goes the overall robotics agenda, societal issues and new markets are mostly treated like conquests. As prescribed by Bischoff et al. (2010), press and media relations must be taken care of;[23] entrepreneurship must be fostered in new areas, markets must be analysed and appropriate standards and safety measures must be put into place. The agenda is increasingly infused with social and moral ambitions. After all, if all aspects of life are to be filled with new robotic helpers and companions, i.e. private, professional and public spheres, then society at large needs to actively collaborated with so that it may accept the new innovation

21 See for instance articles 1:234 and 1:378 BW of the Dutch Civil Code.

22 A robot might more speculatively be taken as an electronic slave without capacity to bear rights or obligations, while being able to act in its own name and enter into contracts in its master’s name (Leroux et al., 2012).

23 euRobotics thus set up its own press centre in Brussels

programmes, while boundaries are erected to provide stability, predictability and safety of autonomous robots. A significant development in this direction is recent mobilisation of legal expertise by euRobotics, i.e., to have direct impact on legislation and regulation, but ELSi practitioners were already involved in EUROP early on and ELSi issues were foregrounded in the 2009 roadmap as *barriers* or *obstacles* that need to be removed, preferably before they arise. In short, the work of EUROP and more recently euRobotics recognises that *society* and *the user* are crucial players in illuminating responsibilities, novel uses and new markets, and so must be featured into strategic push for certain innovation trajectories. However, strategies to better understand users, citizens, societal needs and ordinary interests are more or less missing. They tend to be treated as given when the argument is made that advanced robotics are crucial to solving societal problems—a position which is likely to exacerbate existing gaps between robotic visions and societal interests and needs or, say, increase the uncertainty regarding the direction and the purposes for which robotics developments are strategised.

We can further argue that robotics, as a domain of innovation, has always had to manage blurred and unstable boundaries between visions and what is actually achievable at any given time. Prevailing visions of artificial autonomy and intelligence have partially come true, but there is currently no such thing as robot autonomy akin to how we experience and recognise human autonomy and intelligence. Robot autonomy is always partial and, importantly, it is always contestable in reference to perceptions of our own. But the fascination with robot autonomy as an aim in scientific research is a great source of uncertainty and disconnected from pragmatic priorities of industrial production.

The RCC proposal went to great lengths in the attempt to satisfy the FET flagship requirement of demonstrating industrial and societal utility. But, the contents of the proposal belong to a radically different socio-technical universe from that of industry and, in fact, the consortium barely consulted industry experts. That said, the flagship proposal identifies with a number of concerns raised in the EUROP 2009 roadmap. For example, it talks about overcoming the barriers between the operating environments of traditional mechatronic systems and the wider world of everyday lives. The proposal argues that existing procedures by which robots operate (navigate, act, perceive, think, etc.) must be radically challenged because the gradual improvements on today’s mechatronic systems will not do the job. Mechatronic systems consist of multiple composite parts, and incrementally improving the functionalities of each single part only adds to, rather than detracts from, existing operational complexities.

In taking this position, the RCC consortium is in clear opposition to dominant thinking within the industry and responding to a perceived weakness in the EUROP 2009 strategy. Namely, incremental improvements along existing lines of research[24] are not likely to lead to genuine robot autonomy, as envisaged by the RCC consortium, but rather to “*a gradual loss of controllability and robustness, and this will ultimately lead to a substantial cost in efficiency and safety*” (RCC 2012, 5). To overcome the limitations of existing systems, the consortium proposes instead a unified science-based solution by radically re-casting the technoscientific basis from which machine autonomy is believed to emerge. It promises to bridge the existing gap between today's and tomorrow's robots through a new and intensified merger of foundational science and engineering, thus breaking away from existing incremental and piecemeal approach. It promises to provide industry with new and more cost-effective technologies capable of transgressing many of the limitations of today’s machines.

That said, the academic research communities have been seen by industry experts as necessary, precisely because of the innovative capacity they demonstrate and the potential therein to foster the “*integration of diverse technologies from a variety of fundamental*

24 Recall that euRobotics operated with no less than 66 main technological challenges (Guhl and Zhang 2011).

domains into one coherent system" (EUROP, 36). They are also seen as necessary because of their potential to identify future markets and novel designs through visionary work and experimentation, although, successes are far from inevitable or even probable in some instances. It is in fact well recognised that basic research is long-term and risk-laden, and in ways in which ordinary product development does not get away with. As stated in EUROP 2009: "*Europe cannot afford to only concentrate on areas of strength, it will also need to foster technologies that could become critical barriers to market*" (p.27).

The main purpose of bringing together the two networks EUROP and EURON is to establish closer links between industry and academic research, "*to identify and close the gaps between industry and academia*" (Bischof et al. 2010, 729). A follow up document to the 2009 roadmap stated the problem as follows: "*[R]esearchers often believe that a particular robotics problem has been solved for some time. While these academic solutions are generally feasible, they may not be sufficient from an industrial point of view*" (Bischof et al. 2010, 730). Following this line of argumentation, laments what is seen as the fundamental discrepancies between the perspectives of academic researchers versus those of industry experts. The divisions between them are described in great detail as a set of technical gaps (Guhl and Zhang 2011), partially evident already in the EUROP 2009 roadmap but later taken through expert consultations and a ranking of their importance and priority (66 gaps in all)[25] These are the obstacles or hindrances that get in the way of the robotics community strategising the expansion of robot capabilities, of discovering novel application areas and breaking into new markets. But once the gaps have been mapped, the dynamics between the "*market pull of industry*" and the "*technology push of academic research and development*" can be improved and synergies achieved.[26]

In important ways, the RCC proposal embodies experimental philosophy aimed at understanding life through its artificial recreation. As Riskin puts it, "*[a]iming to re-enact Creation, at least in part, to produce life or some of its aspects artificially, philosophers and engineers have hoped to understand the connection between spirit and body, mind and matter, the subjective and objective experiences of life*" (Riskin 2007, 1). This motivation, which was most forcefully expressed in the proposal, to *uncover the underlying principles of bodies, minds and brains*, sets the RCC consortium far apart from the industrial regime. The proposal also articulates utopian ideals, a promise of new renaissance for Europe, enabled through the new *unity of science paradigm*, a promise of profound social, political and economic utility which will be ultimately manifested in new robotic *helpers* populating European society (RCC 2012).

Legal scholarship, being inspired by the latest developments, is still grappling with how to translate between the objectives of basic research, concrete engineering and legal analysis, in articulating a raster of legal relevancies with gradient and fine enough resolution to actually impact on legislation and regulation. The methodological approach of creating a taxonomy of robot abilities is clearly visible in the Green Paper, in which some of the legal analysis is preceded by an account of state-of-the-art in robot abilities, including scenario-building to address the R&D challenges of creating future *autonomous service robots* (RCC, p. 14). The technological challenges in these scenarios seem clear. They pertain to *sensors, actuators, computing systems, self-localisation, navigation, physical interaction, non-physical*

25 Among the highest ranked gaps we mention 3D mapping, Multi-robot simultaneous localisation and mapping (SLAM), modelling of human- robot interaction, cooperative navigation and mapping, swarm intelligence and human emotion recognition.

26 Proposed measures fall under the general heading of improved "technology transfer". Included here is initiatives such as education (euRobotics summer school, etc.), part-taking in robot competitions (RoboCup, ELROB, FIRA and ICRA robot challenge, etc.) and events (…), and the setting up of a press office in Brussels.

interaction and learning. However, it remains unclear how exactly those kinds of challenges translate into legal analysis. In fact, the Green Paper recognises how different the disciplinary terrains are, robotics engineering and law, but how to bridge the gap between them and traverse from one terrain to the other is not really articulated in the Green Paper. Rather, the contributions of philosophers engaged in the shaping of robolaw are presented as investigations, for example, into whether human enhancement and overcoming disabilities through robotics might challenge the *distinction between persons and things, human and nonhuman*. The articulation of this philosophical work within the legal work is then clarified by raising a set of questions, singled out for legal treatment. These are questions about the robot's legal status, its legal capacity for engaging in legal transactions, and for the allocation of liabilities for damage in tort and insurance law.

A fine-grained analysis considers different kinds of robots capabilities, proposing qualifications on a gradient of legal concepts that refer to liability (Boscarato, 2011).[27] The first concerns the question of who is responsible for the damages to things and harm to people caused by the actions of a robot.[28] It could be *product liability* for producing a defective product—the manufacturing or the programming made liable which is not much different from liabilities for conventional machines. Within the traditional legal regime of product liability for faulty products,[29] an injured person has the burden of proof for the damage, the defect and the causal relationship between defect and damage (article 4), but not for the liability of the producer. The robot is considered here a *product,* a mere *physical object*. It is *strict liability* for providing a robotic device with erroneous instructions however, users or owners are made liable, which is much the same as the liability of operators of a poorly managed installation that causes damage or harm (Article VI. 3:206 of the European Civil Code). The robot is then qualified as an *installation*, operated as a kind of *instrument*. If however, the *fault liability* is for the robotic device taking wrong decisions,[30] the robot itself becomes liable in way that takes robotics devices to different degrees of legal capacity. The abilities of a robot of locomotion and adaptivity might be relevant to liability for animals (article VI. 3:203 of the European Civil Code). If it leaves confines of its user or owner and causes harm or damage, with a little *interpretational effort* it could be qualified as an *animal* but the custodian is still liable. This qualification becomes especially relevant considering that some robots are actually modelled after animals (as in the bio-mimetic approach among members of the RCC consortium). It is also useful in order to break away from the artefact qualification towards the qualifications applicable to *adaptive capabilities* (Boscarato, 2011, p. 395). In this sense the legal concept of *animal* can be taken as a connection point between the concept of *artefact* and the concept of (human) *person*.

To move further along this continuum would be the ability of robotic devices to display decisional cognitive skill and learning capabilities. Artificial neural networks or other learning systems built to simulate human activity and decision-making, are intended for purposes in which they should be able to learn new behaviours, not directly commanded by the producer or programmer. If this kind of machine behaviour then causes damage or harm, the robotic device may be qualified as a *child* or a *supervised person*, including the mentally disabled (article VI. 3:104 of the European Civil Code). In such cases the supervising party is held liable given that the supervision has been deficient. As a legal qualification this code

27 An extract of this analysis constitutes the section on liability in the Green Paper (Leroux et al., 2012).

28 See (Karnow, 1996).

29 Directive 85/374/EC.

30 The legal regime on product liability has been harmonized by the European Product Liability Law Directive 85/374/EC, that of tort law covering strict and fault liabilities, has not. The project for a common European Civil Code however has codifies the principles of European Private Law. See (von Bar, Clive, & Schulte-Nölke, 2009).

presupposes a certain degree of agency on part of the legal entity Consequently, the robotic device is qualified as a *person*, albeit, one with limited abilities and under supervision while exhibiting some independence of action.[31] In short, a limited form of legal personhood could be attributed to such a robotic device (Boscarato, 2011). This type of gradient analysis provides a good example of the making of qualifications so typical for law,[32] and provides us with still another example of gaps to be minded and uncertainties in the makings of robot autonomy. A range of existing legal concepts appear to suffice in qualifying liabilities that robotic technologies might raise.[33] They only need 'stretching' over to the terrain of various robotic capabilities. The issue still left open however, is the liability of unsupervised robotic devices. Article 3:103 of the European Civil Code is as far as this exercise goes, placing robotics at best on par with supervised and partially independent (human) persons. Substituting completely the word *person* for *robot* provides still quite a challenge to legal qualification which requires more than minimal interpretive effort, and opinions diverge on this point.

5. Concluding remarks: The politics of uncertainty

In this article we have described the main features of recent trends in the development of robotics in Europe, especially focusing on the makings of autonomous robots. The concept of *makings* introduces an intended ambiguity. On the one hand, technologies, artefacts, policies and different knowledge-based practices are already given in what Heidegger termed the *thrownness* of human existence. On the other hand, projects and proceedings follow from such *givens* (in Heideggarian terms: from *facticity*), out of which something new is envisioned and possibly *made*. In the making of EU robotics, one may observe how all the actors are thrown into the project of making more autonomous robots. This premise seems to be a *given* —a part of a vision shared far beyond Europe's borders. That vision, which is as old as robotics itself, is grounded in the wish to copy and remake life through the artificial and thereby better understand it. Thus, it may be appreciated how, in spite of the enormous resources invested in this, even powerful actors such as the robotics industry are trying to tie down and make more concrete something that *cannot be*, because it is based in a (technological) wish or dream. Then, the project is even more ambiguous when we take into consideration that the age-old dream is emboldened and projected onto the Europe-wide political scene, in which it is invested with expectations to rescue and renew Europe's society. We observe how the actors within this widening field of possibility which is predicated on diminishing possibilities in other domains (i.e. increasing unemployment, the selling of public properties, etc.), situate themselves and mobilise the power of the vision. This is especially so for the industry which has moved fast and now seems to have secured itself in the game through a technology platform and a public-private partnership. But it is also the case for academic researchers, who find themselves closer to the original dream of making artificial life with huge resources within close range, for example, FET flagship status.

With respect to the involvement of lawyers, it may at first seem as if there is no substantial principle or ontology underlying their efforts, and so they are not inclined to take part in the activities of wishing. At a closer look however, we observe that members of the robolaw community base their assumptions and future scenarios on the technical visions of roboticists.

31 On this point see also (Stradella et al., 2012).
32 (Cayla, 1993).
33 The analysis is an example of the use the legal tool of reasoning by analogy in order to apply a previous solution from a case in one legal field to another similar case for which no jurisprudence exists.

As we have described in this paper, each community involved in robotics developments raises uncertainties and possibly even contradictions. Although this differs from one community to the other, it seems that for all the variations on the vision of autonomy we have come across, the uncertainties are intrinsic to the very logics of the project, and not merely add-on considerations or unlucky side-effects. These uncertainties, at which we could only start to hint in this paper, can be expected to show up with greater force should at least parts of the autonomous robots dream come true. For example, in the case of industry, this manifests itself primarily in the control paradox. Increased autonomy comes along with fewer possibilities for prediction and control, the latter of which is after all a desired outcome within the industry. Indeed, should appropriate control mechanisms fail to be implemented, issues such as liability could be expected to increase exponentially. This generates the need for radically up-scaled efforts, including both increased R&D (and so requiring the contributions of the academic community), as well as the efforts of legal scholars. Here, the project of achieving robot autonomy is connected growth and expansion. However, the possibilities of success are largely predicated on the needs and perceptions of citizens, and these cannot be known in advance. Indeed, both within industry and the academic communities, we observe how citizens are imagined along the lines of the classic deficit model (Wynne and Irvin 2002), and so any expectations of who they are and what they need will most certainly come up against unforeseen limits. As far as goes for the RCC consortium, their aim at the making of robot autonomy and sentience has driven the designs toward biomimetic approaches and embodied cognition. However, the realisation of these visions have been cast in doubt already, i.e., that we can expect the achievements to come at the expense of (again) control and predictability.

In the case of legal uncertainties, the problems we already can see do not to pertain to changes to legal principles as such. The law is flexible and adapts to new circumstances and entities. The critical issues pertain to the propensities to base legal reasoning upon the logics of scientists and engineers, and the dominant industry rationale (see Jasanoff 1995). By pushing the limits of legal reasoning towards the speculative, and towards anticipations of future events, the unique character of legal practice may ultimately be at stake. Also, should the Green Paper eventually come to influence EU legislation and policy making, the industry will have taken further step into an area in which it does not really belong, i.e., writing law, although, even Transparency International recognises the basic legitimacy of lobbying and this lobby is out in the open. An outcome of this, traceable in the Green Paper, is the tendency towards emphasising the rights and statuses of machines in an evermore automated world, while downplaying the rights of human beings intended to interact with and use such machines. In the view of industry and robotics in general, the main emphasis is on machines, not humans.

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