A Social-Technological Alignment Matrix

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***Abstract*—This paper refers to the term "implementation" as the process of integrating a new technology into established workflows. Especially in health care this has proven to be a very critical phase and many large-scale projects have failed on this very last mile. Although strategies such as requirements engineering, co-designing and user interaction design have been proposed to reduce the risk of end-user rejection and subsequently project failur. There is still no tool to analyze, predict and quantify user acceptance and identify critical areas which might be addressed before the start of the implementation phase in order to reduce resistance and increase the effectiveness and efficiency.**

Keywords — Social-Technological Alignment, mHealth, FI-STAR, Requirements Engineering, User Interaction Design, Acceptance, Implementation, Instantiation

I. Introduction

The global Digital Health market is currently one of the fastest growing with lots of opportunities for in particular m-Health products for mobile devices and building blocks for e-health platforms such as Generic Enablers and Specific Enablers [1]. However, the associated risks for developers have been quite substantial and many products seem to fail on the last mile not because of technological deficiencies but because of lack of acceptance by the user. Consultations into the e-health plan 2012-2020 by the European Commission show that the lack of adoption of e-health technology in EU member states is frequently not associated with technological shortcomings but with the lack of readiness of the user – in this case frequently the health care providing organizations [2]. However, huge efforts have been undertaken in recent years to develop and establish technologies to prevent the failure of potentially useful and seemingly well-developed technologies.

A. Development and Implementation Models

The waterfall model has long been the choice for developers for product and process design [3]. Strict sequential development implies that development steps are not reversible and once a product design was completed changes could not be applied. However, the plan-driven nature of the waterfall model offers a structured way to create results and is still a desirable approach where teams are experienced in the kind of system they develop and coordination is critical. The iterative approach offers the opportunity to get users involved throughout the whole development process and allows for continuous feedback and as the system is being developed [4, 5]. The rational behind this approach is the risk reduction although this might require more time for the development process all-together. In recent years iterative approaches have become more and more fashionable where user input and innovation maybe added at any point in time and iterative cycles are not necessarily completed if it is clear that a change in process may be beneficial. This speeded up the development process, made progress more transparent and manageable, and resulted in better alignment of the technical solution with the social context where the solution would be deployed.

B. Design Strategies

In order to involve users from a very early stage in the design process and reduce the risk of an end product being rejected several strategies have emerged. Requirements Engineering is an emerging specialty of Engineering which is using a structured approach to explore processes at the very beginning of development cycles in order to operate as closely as possible to the real word requirements thus optimizing the "Specification" phase [6]. Scenarios are explored in sessions with users and are plotted into diagrams using UML and other techniques to achieve a shared understanding between stakeholders and the development team [7]. Co-designing and user interaction design aiming at involvement of users in order to maximize the level of ownership and acceptance all along the product development.

II. Social-Technological Alignment

There are major examples for last mile failures of technologies especially in the health care industry, which are well known for their large-scale losses. On the one hand there is Google Health, which was withdrawn from the markets in 2013 [8] and there is the UK National Project for IT, which did not make it through the implementation stage with a loss of millions of British Pound [9]. Both multi million Euro failures would have been avoidable if tools had been available to measure and predict resistance with regards to the implementation stage. Social-technological alignment is an active process to identify

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the imperatives of social and technological determinism [10] in individual scenarios and take measures to anticipate and counteract potentially conflicting situations during the implementation phase. Hereby needs to be considered that there are interdependencies between user groups, technology and society as a whole, which clearly go beyond the scope of this paper [11]. However, there can be no doubt that it would be useful and certainly of economic value to have a structured set of parameters to support the implementation planning and serve as a checklist for both, technology providers and users, in order to identify and smooth out potential obstacles to successful implementation. Successful technologies have followed one of four pathways from being a niche innovation to becoming used in a wide social context [12]. One possible pathway, the transformation pathway, involves initially small technological changes that gain momentum and modify the direction of an industry's innovation activities. The de-alignment and re-alignment pathway involves growing niche-level innovations that destabilize existing solutions and ultimately lead to dominance of some of the niche innovations. The technological substitution pathway involves a finished technology that breaks through and replaces existing solutions. The reconfiguration pathway involves continuous adoption of niche innovations that change how technology is used. All pathways have in common that first the technology's usefulness is demonstrated in the small to then grow and become used. For this process to happen, the right innovation-enabling parameters must be in place [13]. The technology must be ready for use and people ready to adopt the technology. The technology must be built on values that are shared with the social context so that people are able utilize their existing beliefs and knowledge when interacting with the technology. People must perceive that the technology provides value for them when appropriating with it. With increasing experience, people adapt the technology and the way of using it. Technologies then survive if the right conditions and incentives are set to sustain the technology even if it means adaptation where social order changes.

III. Conceptual Reference Model

Work conducted in the area of requirements engineering clearly proves the interdependency of technological and social domains [14]. Our current work is conceptually based on work conducted earlier by Mepham and Beauchamp and Childress on bioethics in particular the ethical matrix [15, 16]. The authors propose a conceptual approach, namely a matrix in order to specify ethical principles for different interests groups. Mepham lines out that *"the impacts defined for each of the separate "cells" depend on rigorous examination of objective (often scientific) data"* and that *"construction of the Matrix is in principle ethically neutral, i.e., it is an analytical tool"*. With regards to the qualitative assessment of social-technological alignment we are following Mepham in the adoption of Rawls' "logic of the argument approach" [17]. "*Then an explication of these judgments is defined as a set of principles, such that, if any competent man (sic) were to employ them intelligently and consistently to the same cases under review, his judgments, made systematically non-intuitive by the explicit and conscious use of the principles, would be, nevertheless identical, case by case, with the considered judgments of the group of competent judges"* [17]. Based on the highlighted concept we are proposing a social-technological alignment matrix whereby the dimensions social and technological are intelligently and consistently linked to the same defined and validated parameters. These parameters form a consistent and coherent grid for qualitative analysis and potentially for empirical studies.

IV. Parameters Relevant to Social-Technological Alignment

We are proposing a social-technological alignment matrix for enabling an innovation project to check whether the innovation-enabling parameters are in place and thus predict innovation success. The matrix guides the assessment of whether the technology is ready to be used and whether the concerned stakeholders are ready to adopt, use, and adapt to the technology. Table 1 shows this matrix. The table offers specific guidance for healthcare innovation by giving references to relevant existing measurement tools. The remainder of this section elaborates the parameters.

A. Readiness Levels

The concept of readiness levels as introduced by NASA and the US Department of Defense in the early 2000 is well established in the industry [18]. This covers well the different stages of any given technology and subsequently its roboustness, resilience and reliability. With regards to social readiness levels there is no clear concept of readiness of defined groups for adoption of change within organization despite continuous work since the early 80s [19]. It seems that readiness for societal change seems to require some kind of external pressure and a deep routed change commitment within the enterprise or group to allow for collective behavior change.

B. Standards and Interoperability

Technologies, which are not compliant with existing standards or lack interoperability, are unlikely to being picked up for a variety of reasons. This could be lack of cost-effectiveness or legal and ethical incompatibilities. However, open source technology seems to have many advantages but is not always suitable due to concerns with regards to reliability and maintenance.

C. Appeal, Familiarity and Recognition

Technologies which are perceived as attractive and desirable might trigger a more positive reaction when to be implemented in work processes and introduced to groups. Here similar mechanisms and trends such as used in the fashion industry or car manufacturing industry in order for products to appeal to consumers might be considered and play a role when implementing technologies.

D. Time

Time is a system immanent factor when talking about change as change is defined as the "delta" of a state over a time "delta". However, on the other hand some changes "happen" quite rapidly in certain enterprises whereas others fail to change and go under [20].Overall time might be relevant with regards to the scale and granularity of a deployment but not really relevant with regards to the readiness of an enterprise or a social group. Time is in principle measurable in the technological as in the social domain with a similar methodology. However time-lines might deviate with regards to desired outcomes or expected effects. Technological evolution typically takes significantly less time than social evolution although both processes can be measured by using the same scales.

E. Motivation

Many approaches to improve healthcare delivery involve collective behavior change in the form of redesign – often multiple simultaneous changes in staffing, work flow, decision making, communication and reward system. To implement an effective organizational change, members must adopt different behaviors, processes, frameworks, routines, values, or goals. Motivation, one of the key factors in implementing change, is a set of active forces that establish work-related behavior, duration and intensity [21]. Furthermore, motivation is closely linked with positive incentives – an anticipated reward available in the environment. On the other hand, motivation can also be used as a tool to predict behavior, and together with environmental factors it has the potential to influence performance and behaviors of

Table 1: The Social-Technological Alignment Matrix

Parameters	**Technological**	**Social**
Readiness levels: Increase the success rate of technology transition and likelihood of people's adoption of the new technology.	The Technology Readiness Levels (TRLs) are a technology management tool developed by the United States National Aeronautics and Space Administration (NASA) to evaluate the maturity of a technology prior to integrating this technology into a system [26].	The Technology Readiness Index (TRI) is a multiple-item scale to measure readiness to embrace new technologies [27, 28].
Shared values: This includes standards and aspects of appeal and design. Having shared goals and purpose will ensure new technology is fully interoperable and compatible with other technology and meet the highest standards of ethical compliance.	Conformance with open interoperability standards such as ISO 13407 (human centred design for interactive systems), ISO 13485, ISO 14971 and IEC 62304 (development process quality for medical device software) and ISO/IEC 27002 (information security management) and the NASA Reuse Readiness Levels (RRLs).	Societal acceptance of new technology requires sound ethical reflection and adherence to laws and regulations guided by individual, organisational, regional, national and international code of ethics and laws. Some ethical areas of concern relevant to health technology assessment include benefit and harm, autonomy, equity, stakeholder values, acceptability, quality of life and impact on family and caregivers.
Motivation: Social acceptance of new technology is the primary success factor of the new technology.	As an economic entity, the inner motivation of technological innovation for an organization is its profitability (in normal and rational economic environment). The decision of innovation then depends on the expected benefit from technological innovation, which can only be realized in market competition.	The Technology Acceptance Model (TAM) [29, 30, 31] and Unified Theory of Acceptance and Use of Technology [32] measure the perceived usefulness and perceived ease of use. Extrinsic motivation is captured by the perceived usefulness construct in TAM [31]. Intrinsic motivation can be measured by assessing an individual's level of computer playfulness [31].
Elasticity: Elasticity is a key priority in new technology acceptance.	Technology needs to be scalable in order to allow adjustment in keeping in user needs and demands (ISO 9241).	The higher the level of flexibility in user groups, the higher the chance of acceptance of a new technology - Openness [33].
Control: Improved control will ensure effective software acceptance.	The Unified Theory of Acceptance (UTAUT) is a tool for managers to assess the likelihood of success for new technology introductions and helps them understand the drivers of acceptance in order to implement interventions such as training and marketing for the target population of users who may be less likely to adopt and use new systems [30].	The ability to determine the rate of change and the fear, threats and trust of new technology can be measured by perceptions of internal control (computer self-efficacy [34]) and perceptions of external control [31].

employees leading to greater readiness and more successful change implementation [20]. The more organizational members find the change beneficial, the more they will want to implement it. In other words, the more resolve they will feel to engage in the course of action involved in change implementation. Motivation theories not only support these hypotheses, but also suggest that when organizational readiness is high, members will adopt more pro-social, and change-related behavior [22].

F. Elasticity

Emerging and innovative technologies need to be scalable in order to meet user needs and demands. The uptake of new technology is dependent on perceived flexibility, which is the extent to which a person believes he or she can acquire new skills to use the new technology when given sufficient time and space. The higher the level of perceived flexibility, the higher the level of perceived ease of use and behavioral intention to accept the new technology. Perceived technological determinism might cause adverse reactions following the frustration-aggression model [23]. In the socio-technological alignment matrix, flexibility is referred to as elasticity.

G. Control

The introduction of new technology needs to be well-planned and tightly controlled. Prior to introduction, time and resources are needed to fully understand the drivers of user acceptance. Intervention strategies such as training will increase user confidence and acceptance of new technology. New technology represents both threats and opportunities. For example, when it comes to management and control of IT functions within an organization, conflicts often exists between technical specialists and other managerial groups such as accountants [24, 25]. In the individual context, perception of internal and external control act as situational anchors in influencing their perceived ease of use of the new technology [26].

V. The Social-Technological Alignment Matrix

While in Engineering the concept of key performance indicators is well established and numeric measurements are straightforward in social sciences measurements and scalability are typically more complex. A typical form of making social phenomena "measurable" and allowing for quantification and comparison is the process of "operationalization" [27]. A typical example may be the Ethical Matrix developed as a decision support framework for public policies decision makers [28].

VI. Methodology

Building on previous work on the dichotomy of social-technological determinism [10, 11, 12], but also on conceptual references from similar work on food ethics [15] we conducted a literature review on the interdependencies of social and technological innovation. Starting from the assumption that similar parameters should be of relevance for the social as for the technological domain we were looking for validated methodologies to conduct parallel assessments of identical parameters for each of the two domains initially following a hermeneutic approach but with a clear intention to extend to an empiric approach in the future. We interrogated standard databases including Google scholar and IEEE Xplore in order to identify suitable strategies. The main focus was placed on a qualitative match. We did not conduct a full-scale meta analysis in order to investigate the quantitative aspects of the methodologies. After careful qualitative analysis we could identify validated methodologies to asses matched pairs of the following parameters: *Readiness Levels* (Increase the success rate of technology transition and likelihood of people's adoption of the new technology), *Shared Values* (This includes standards and aspects of appeal and design. Having shared goals and purpose will ensure new technology is fully interoperable and compatible with other technology and meet the highest standards of ethical compliance), *Motivation* (Social acceptance of new technology is the primary success factor of the new technology), *Elasticity* (Elasticity is a key priority in new technology acceptance), and *Control* (Improved control will ensure effective software acceptance).

VII. Discussion

The risk of product development especially in the health care domain, which is one of the fastest growing markets globally is a relevant issue as product developments and licensing are cost and time intensive. In the 1980s ideas that innovation is a linear process have been outlined by several authors [29]. However, it has never been possible to predict the success and/or the impact of software products in the healthcare, wellness and ambient assisted living domain. Over the years it has become clear that innovation in fact is a complex social activity associated with a lot of complexities and uncertainties [12]. This paper aims to dissect the process of social-technological alignment into its basic components in order to identify parameters, which might then be used to measure and predict the alignment process and advise on steps to enhance and facilitate the uptake of new technology by users or user groups. This tool must not be seen in isolation but might support efforts such as requirements engineering and user interaction design. Following early approaches to match Technology Readiness Levels and Human Factors Readiness Levels [35] we hereby propose a matrix to establish the state of social-technological alignment in complex social technological systems namely in the health care, wellness and ambient assisted living domain. The matrix, shown in Table 1, is an architecture for managing social-technological alignment. It proposes a logical structure for classifying and organizing the parameters of innovation readiness in the social and technical perspectives. The representation of these parameters and perspectives provides a means of measuring whether the conditions are so that the social environment is likely to accept a technological innovation. The matrix helps govern the innovation process with the dependency, coherence, and traceability needed for an innovation project to manage change, and to ensure that the alignment is achieved. Interesting enough it seems that large organizations with formal structures seem to have higher levels of success when implementing new technologies [36]. However, in order to understand the dynamics of implementation better we have identified 5 Parameters valid for the Technology and Social domains of any given use case scenario, which should be analyzed prior and monitored during the implementation in order to optimize the social-technological alignment process: 1. Readiness level, 2. Shared values, 3. Motivation, 4. Elasticity and 5. Control. Readiness levels can be measured for technologies thanks to the Technology Readiness Level developed by NASA [18]. A counterpart has been established for social readiness under the label Technology Readiness Level. The compliance with shared values can be established for technologies by comparing the specifications with existing technological standards such as ISO standards, IEEE standards, CE standards, interface standards and others while on a social level ethical norms and existing national legislation and European guidelines can be clearly analyzed and summarized applying hermeneutic principles. The Motivation of a technology needs to be understood as its market opportunity, its economic perspective and a product's competitiveness on an open market. On a social level it is certainly of interest if any incentives are linked to the successful implementation. Will the user obtain a higher payment or will he experience recognition. The elasticity of a technology refers to its scalability. How difficult would it be to apply changes requested by users? Is a product or a technology customizable? On a social level the Elasticity refers to the willingness and capability of users or a user group to accommodate a certain technology and to accept changes in their work-flow caused by the new technology. In accordance with Williams and Edge [10] there is a tension between technological and social determinism, which certainly is of relevance in the context of social-technological alignment. On the one hand technologies are expected to be deterministic in nature in order to deliver predictable and subsequently reliable outcomes. On the other hand users want to be in control of the technology, as too rapid change might be perceived as threatening and overwhelming. A scale to measure control and intrinsic motivation has been proposed by Venkatesh in 2000 [31]. The social-technological alignment matrix has a similar structure as the widely established Zachman framework that is used to manage social-technological alignment in an enterprise [37]. Even though the structure and intentions of Zachman framework are similar to the social-technological alignment matrix, there are important differences. While the Zachman framework addresses the alignment of IT/IS in an enterprise, the here proposed social-technological alignment matrix addresses innovation in a healthcare context. Healthcare has specific characteristics that need to be reflected in an alignment framework and comprises a social context that goes beyond a single organization. The here presented matrix considers these specifics with a focus on readiness evaluation.

VIII. Conclusion

Technological innovation is not a linear process but a complex social process. Operationalization of the process of social-technological alignment seems possible using the Social-Technological Alignment Matrix proposed containing a set of relevant parameters. Each parameter can be assessed in the technological and social domain by using relevant key performance indicators, which are listed and specified above. Further research will be needed in order to benchmark and validate the Social-Technological Alignment Matrix.

IX. Acknowledgment

The authors are members of the Future Internet – Social Technological Alignment Research (FI-STAR) project [38], partly funded by the European Commission and part of its Future Internet Private Public Partnership (FI-PPP). FI-STAR is a FI-PPP phase 2 project, which commenced on 1.April 2013 and will conduct early clinical and non-clinical digital health use-case trials in seven European countries.

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