The Use of FATE for Illuminating Disruptions

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ABSTRACT

FATE is a new method developed through research conducted by the NATO Systems Analysis Studies Research Task Group 123 (NATO SAS-123). FATE is the acronym for Futures Assessed alongside socio Technical Evolutions. The method was developed to anticipate the evolution of technologies with the potential to be disruptive in the context of social factors that drive or retard their diffusion. FATE is achieved systematically by examining technologies as a part of a socio-technical system (STS); additionally, it is undertaken in relation to pre-composed descriptions of 'states of the world' in the future or future scenarios. It is our belief that this is a unique, first of its kind, operational research method, which analyses socio-technical evolutions of emerging or disruptive technologies relative to future scenarios. FATE is a tool that facilitates assessment of the uncertainties associated with social changes that influence technological advancement and adoption in an emerging and complex future. Outputs of FATE serve to inform decision-makers in a holistic fashion on multiple future scenarios. Several STSs were evaluated for their possible implications on defence and security. The results from one of the trials of FATE held at the Defence Science & Technology Laboratory (Dstl) UK will be shared using measures such as the disruption calculus.

1.0 INTRODUCTION

It is rare for operational research analysts to respond to military clients enquiring about technologies or defence capabilities, by considering socio-economic factors as a part of a socio-technical system (STS[1]). This paper introduces a method called FATE, an acronym for Futures Assessed alongside socio Technical Evolutions, which provides a means to achieve this. It is our belief that this is a unique, first of its kind, operational research method, which considers socio-technical evolutions of emerging or disruptive technologies relative to future scenarios. FATE is a tool that facilitates looking at the inevitable uncertainties associated with social changes that influence technological advancement and adoption in an emerging and complex future.

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[1] Socio-Technical System (STS) are made of two systems that differ yet overlap—the social and the technical. They are entangled and influence each other.

The FATE method allows for an anticipatory, multi-disciplinary and participatory examination of transitions of technologies or social developments in the form of an STS, aiming at a better understanding of complex interactions and assessment of the potential impact, thus facilitating the development of options for mitigating undesirable impact or seizing opportunities, respectively.

The modular approach of the FATE method is described in Adlakha-Hutcheon et al (2020) and Adlakha-Hutcheon et al (2018). Briefly, it is based on four steps: in Step 1, the initial problem or research question is scoped as a socio-technical system, i.e. it is described using the OPPPTI ontology (Organization, People, Processes, Policies, Technology, Infrastructure) for STSs within the multi-level framework composed of niche, regime and landscape levels proposed by Geels (2002), and Geels and Schot (2007). A small set of at least two pre-defined future scenarios is explored in Step 2. The scenarios are transformed into the TEMPLES scheme (Technological, Economic, Military, Political, Legal, Environmental and Social) for each scenario if not already laid out as such in the scenario. Step 3 is centred around interactions between future scenario(s) and the STS, focusing on determining the evolution of the STS from its baseline in the present to its transitions in to future states. The accompanying assessment includes both individual and group insights. The cumulative output and insights from these three steps are assessed for impact and relevance for defence and security in Step 4. The impact assessment in this step can be conducted on a set of capabilities, (i.e. what influences the client's desired end state and what has to be done to reach it?) following which actionable options are derived to respond to the client questions. FATE is conducted in a participatory workshop style.

The four steps of FATE are:

Step 1: The problem is scoped as an STS

Step 2: Pre-defined future scenarios are transformed into the TEMPLES

Step 3: Evolution(s) of STS from its baseline to future states are determined from the analysis of the interaction between the STS and the scenarios

Step 4: Impact of the evolutions in the STS is assessed for relevance (e.g. on a set of capabilities)

2.0 THE USE OF FATE METHOD ILLUSTRATED

Two questions from clients were used to illustrate the FATE method in action:

1. What is the impact of delivery to front lines by autonomous means?
2. How could wearables (such as smart devices) affect urban operations?

The first was trialled at the Defence Science & Technology Laboratory (Dstl) in UK (Maltby et al (2020)) and the second was tested at the Institute of Military Technology at Royal Danish Defence College in Denmark. Each FATE analysis was preceded by dialogue with the client where the client's question was analysed for assumptions about a desired end state, how the results would be used, as well as views on a future socio-technical system. (This interaction with the client may be considered as a 'pre-FATE Step' in the process).

2.1 Step 1 – Socio-technical System

In Step 1, the specific system of interest to the client's question is analysed by assembling all known components from the broadest to the narrowest specifics of the Geel's multi-level framework, e.g. landscape, regime, and niche as understood in the present. For the two example questions above, the STS regarded 'autonomy' and 'wearables' as the key components to establish a baseline for the STS in the current timeframe.

Information of importance to the analysed issue, at the macro-level, is collected in the landscape. It includes all the areas that could influence a specific technical development, i.e. people living in big cities, migrations, climate changes, and overload of information. Some of these areas will retard development while others will accelerate it. Information on organization, policy etc. (OPPPTI) is included in the regime level representing the meso-level in the multi-level framework. Components of the regime level may include a need for new doctrines, organization and technologies, which again would demand new training of the military units. In technical foresight, individual techniques and specific prerequisites for development and transition are in focus. Such detailed information constitutes the micro-level, i.e. the niche of the framework. Technical niches are often emphasised; this is important, as niches frequently include elements (including and surrounding the technology itself) that need further innovation and/or development in order to reach the desired end-state in regimes and landscapes, respectively. However, in FATE we also look at and highlight the societal changes needed for technologies and systems to transition and evolve into the future.

While these two examples contrast somewhat (traditional operation versus an operation within a city environment, i.e. an urban operation), they rely on specific technologies emerging at the niche level, which would have an impact on regimes with greater development around all parts of OPPPTI ontology and also affect the landscape. Automated delivery relies on unmanned ground and aerial vehicles at the niche level, and thus the benefit to the logistic chain during combat operations, is in the provision of speed and reduction of threats to personnel. On the other hand, data collected through wearable technology could facilitate closer to real-time operations within a difficult urban setting. Thus, desired developments in both examples must address the relevant needs of respective operational environment and identification of the resistors and drivers for such developments. By discussing the socio-technical system around the client's question, the FATE method enables one to obtain knowledge and insights not easily established by focussing on the technology alone.

2.2 Step 2 – Future scenarios

In Step 2, FATE uses existing scenarios (or descriptions of the state of the world) rather than developing its own, because it is both more economical and considered better (being unbiased) practice (see Derbyshire (2020)). These pre-existing scenarios are broken down into the TEMPLES (Technological, Economic, Military, Political, Legal, Environmental and Social) factors, to help enrich the user's understanding of the scenarios and to provide a uniform structure to understand and compare different scenarios. Digesting the scenarios as an individual and then collectively arriving at a common understanding of the scenario, this is facilitated by the rich pictures technique. The TEMPLES factors of each scenario are then drawn out and captured in a table.

In the FATE work, Dstl's Future Worlds™ (FW; Maltby et al (2014)) were used, as the authors had considerable experience in their use, these descriptions were already broken down into a structure similar to TEMPLES, and were readily available. The FWs are constructed from 3 different axes of uncertainty (global power dynamics, state control, and resource sustainment). For example, the Future Worlds™ 4 and 5 are broken down into their TEMPLES factors in Table 1. These FWs are at opposites ends of the axes of uncertainty: FW 4 has very weak 'global power dynamics', a high level of 'state control', and low 'resource sustainment', resulting in power being regionalised, geographical and resource constrained, with stability challenged by the resource need and pockets of unrest. In contrast, FW 5 has very strong 'global power dynamics', a low level of 'state control', and high 'resource sustainment', resulting in a thriving, cohesive globe that adequately adapts to local changes. These key differences across the TEMPLES factors are highlighted in the table (Table 1).

Table 1: The state of the world future scenarios of Future World 4 and Future World 5 broken down into TEMPLES.

TEMPLES	**Future World 4**	**Future World 5**
Technological	-**Innovation is driven by the military sector**. Positive drivers for technological growth pervasive presence in main aspects of life (transport, work, networking…)	-**Technology is flourishing** and is favoured by **deep innovation**
Economical	-**Large industry prevails**, with strong push from military requirements. It is able to mass-produce anything but without the agility to respond to quick changes	-**Industry is mainly small, agile and distributed**. It cannot flood the market as an organised, large-scale industry can but can capture and respond to the rapid changes of the landscape
Military	-Called to **operate in multiple contested domain** with multipurpose assets	-Armed forces are present mainly for **resolving small-scale sub-regional hot spots** without the need for global intervention
Political	-**Fragmented wo**rld, strong regionalism. -Strong control through **extensive global intelligence**. -Large **regional powers** in contrast	-Strong **global cohesion**. -The **UN is the main governing** body for resolving disputes and procuring funds. -Numerous **lobbyist entities** with contrasting interests
Legal	-**Lack of standards**	-**Standards** that are well supported
Environmental	-Resources are **scarce**	-Resources are **abundant**
Social	-Sharp **inequalities in income and satisfaction**, strongly dependent on the social group of belonging. There is **no peaceful coexistence** across mixed societies. -**Media outlets are varied** and heterogeneous.	-Income is satisfactory for everyone and there are **no sharp inequalities** ranging across social groups. **Societies are cohesive** and supportive. -**Media outlets are homogeneous**.

2.3 Step 3 – Interactions between the STS and future scenarios

In Step 3, the interactions between the STS and at least two scenarios are analysed. This step reveals how an STS may evolve into the future and why.

In facilitated discussions, the working group analyses the linkages and interactions between the components of the STS. That is, the components are examined within and between the niche, regime and landscape levels, and in relation to the scenarios. Components prone to change and transition are identified, providing knowledge of possible alternative evolutions and transitions of a baseline STS, in relation to different future scenarios. The analysis is rigorous and involves integrating individual and/or combined components of the STS with TEMPLES bullets from the scenarios.

The effectors of change, that is, the drivers and resistors of change to the STS components, are identified and the changes and transitions captured. The effectors of change may be components of the STS, bullets from the TEMPLES or new ideas gleaned from the analysis.

Insights are a result of the collective exploration and familiarization of the STS, as well as from the analysis of interactions and impacts. Insights, which may even be referred to as the “so what’s”, are new knowledge with relevance to defence and security (D&S) and/or the client question. Insights often originate from discussions on the STS when participants grasp the complex system relationships. The insights should be documented and are key in the learning process.

2.4 Step 4 – Analysis of impact stemming from the interaction of STS with scenarios

The analysis of interactions of the STS and scenarios provides plentiful information both on issues, which may cause the system to change, and on components within the STS itself that could transition. The impact assessment is made on the issues believed to be of most importance to D&S and the client question.

Impact is assessed using different criteria such as how influential is the effector for the STS and capabilities. That is, does it provide significant change, and is it specific to components within the STS or does it evolve the STS at large (as a whole)? Does it affect several capabilities, critical ones, or just a few? Assessment of impact on a defence or military Capability is the main one that we have used but other frameworks may be added. Using possible scenarios renders uncertainty in the findings. Probability provides a commonly used assessment and some level of confidence for action. Regret is a measure of "the consequence of decision-making under uncertainty" (Bell (1982)). It is referred to as 'decision regret' and is: "the difference between the utility of the outcome of the action taken and the utility of the outcome of another action we should have taken, in retrospect". Alternatively, "regret is a cognitively mediated emotion of pain and anger when agents observe that they took a … decision in the past and could have taken one with a better outcome" (Marcatto, F., and Ferrante, D. (2008)). It is measured in different ways, qualitatively (e.g. in Medicine; Gahm, J., Wickman, M., Brandberg, Y. (2010)) and quantitatively (e.g. in Complex Exploratory Modelling such as Robust Decision Making; Lempert, R. J. et al (2006)). Consequently, regret may also provide information on the 'urgency to respond'; therefore, we have used it as a gauge of the human emotional response (Loomes and Sudgen (1982)). Here, judgmental assessments were made to measure regret adopting a scale used previously (Maltby, 2016).

The impact analysis may be performed for each STS-scenario combination or as an aggregated analysis on effectors and issues, which occur in the STS for several scenarios. Knowledge and insight from the impact assessment may be used both to mitigate negative consequences and to take advantage of possibilities to influence drivers, resistors and activities (components) within the STS.

2.4.1 Impact visualized in terms of a Calculus of Disruption

The Disruption Calculus works on the basis of two measures: game-changing and the ability to respond, using the definition of "Disruptive change being a 'game changing' development which 'unfolds' faster than an organisation's ability to adapt to its consequences." (Holland-Smith (2015)). 'Game-changingness', the first measure assesses "would [the identified change (or STS evolution)] require substantial modification to the concept of (future) operation [or use], then the technology might have claim to be 'game-changing' " (Holland-Smith (2015)); and conversely if this is not the case, then can it be described as 'not game changing'? The second measure ('ability to respond') considers if the lead time required to adapt to the identified change (or STS evolution) is shorter than the organisational adaptation time to exploit or counter its effects, if this is the case then it is said that it 'cannot respond' (the converse being 'can respond'). Coupled together, if the identified change (or STS evolution) is both 'game-changing' and 'cannot respond' it is said to be 'disruptive'. The categorisation of the results from the calculus into four quadrants is shown in Figure 1.

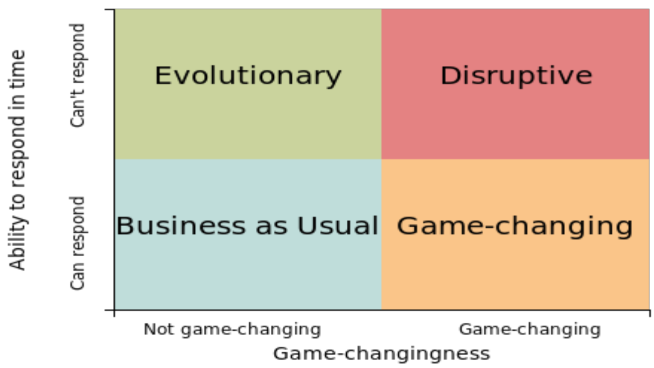

Figure 1: The four quadrants of the Disruption Calculus

We can consider some examples to illustrate the Disruption Calculus for each of the four measures; an example of a Disruptive situation was the nuclear bombing of Japan where anecdotal evidence suggests that the Japanese had no response to counter the strike. This event changed how nation states regarded security. An example of Game-changing technology where states can respond is the development of the Internet. This development changed the way operations are conducted but the development was slow enough to provide time to adapt. Examples of Evolutionary situations are counterinsurgency operations and hybrid warfare. The two forms of warfare have existed for a long time but the Western focus on Cold War threats in Europe led to the development of defences, and security systems that respond poorly to both forms of warfare (e.g. McCrystal (2015) and Smith (2007)). Finally, an example of Business as Usual is the quick development of machine learning algorithms that do not evolve faster than the development of appropriate responses.

2.4.2 The Impacts of ‘Logistical autonomous delivery’ on the sustain capability in terms of four different future scenarios

Some preliminary analysis is used in this section to demonstrate the impacts of the STS ‘logistical autonomous delivery’ on Sustain capability (and its sub capabilities). Figure 2 shows a sample Disruption Calculus (from the trial held at Dstl); it shows no changes in the ‘business as usual’ quadrant, in general these would be of little interest. The changes are concentrated in the evolutionary and disruptive impact quadrants, which are the ones of most interest, and of these, the evolutionary sector has the greater number; while overall there is little difference between the scenarios.

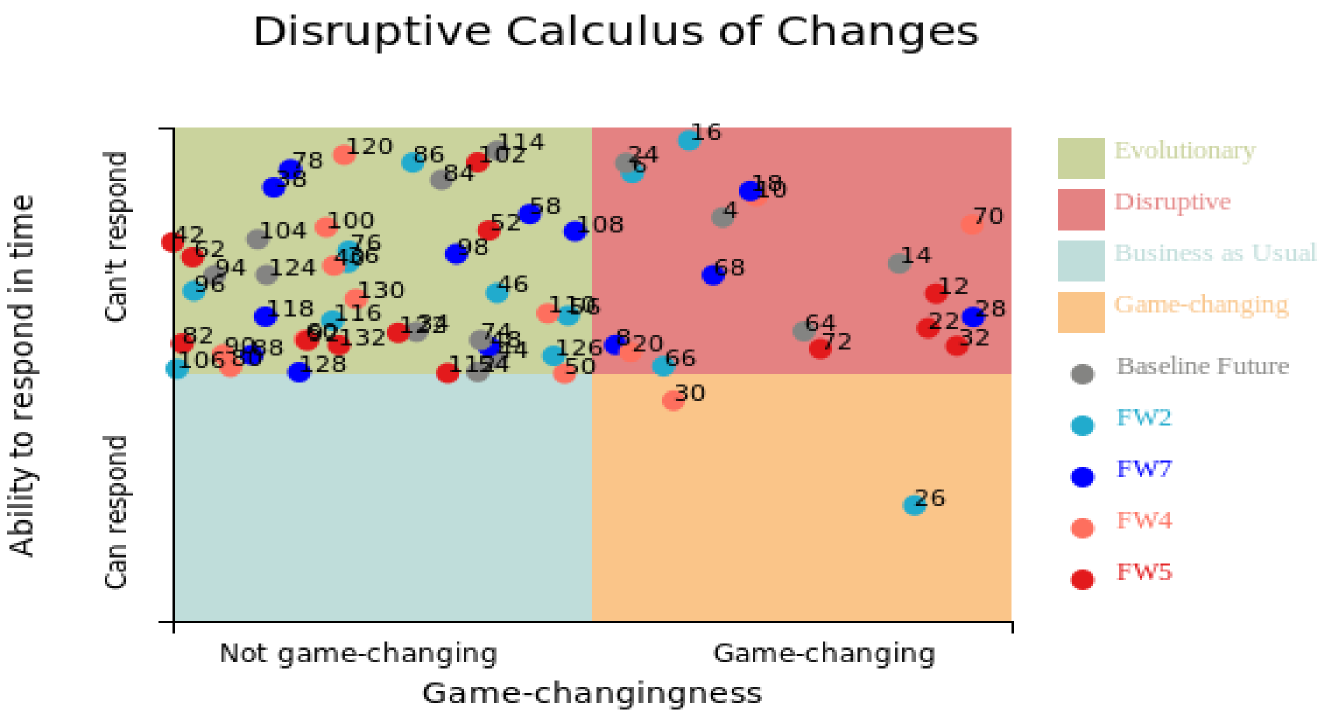

Figure 2: An example of the Disruption Calculus as applied to the ‘Logistical autonomous deliveries’ on the Sustain capabilities across four different future scenarios. The number within figure denotes the numerical identifier for ‘Insights’ for example ‘effectors of change, i.e. drivers or resisters’

2.4.3 Are impacts from STS coupled in different scenarios?

A comparison between the regret across four different future worlds is illustrated in Figure 3. These visualizations show that two sub-capabilities are not highly affected, irrespective of the four scenarios; the other six sub-capabilities are affected across the four scenarios, and the impact is greater in scenarios FW 4 and FW 5 (top and bottom right of Figure 3); with public order being the sub-capability that is particularly affected in FW 4 and 5.

This cross-comparison leads to a richer understanding and further useful lines of enquiry, for example: Does the low impact on the two capabilities identified apply across additional scenarios? What is different about the context in FW 4 and FW 5 that increases impact here, and what is it that causes a bigger impact on public order?

This type of analysis of impact enabled by FATE allows more effective anticipation of the future possibilities and what resilient responses entail, and the consequences of not planning for them.

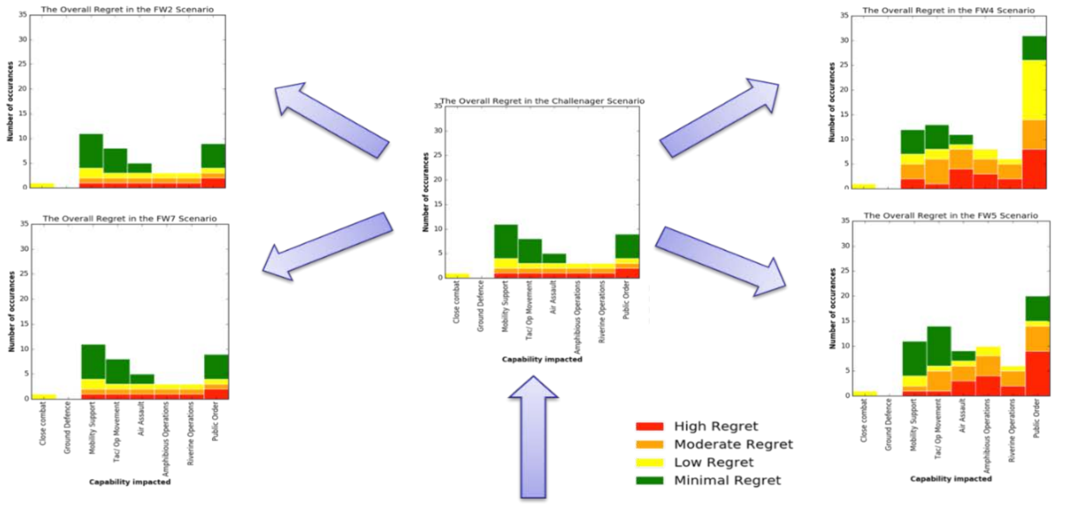

Figure 3: The impacts of the STS 'logistical autonomous delivery' on sustain capabilities in four scenarios.The graph in the centre shows the baseline STS and how the assessment deviates from this Challenger within each of the four scenarios (FWs: 2, 4, 5 and 7).

3.0 COMPLEMENTARY TOOLS TO FATE

As a standalone method, FATE allows a comprehensive and sophisticated analysis of socio-technical impacts and implications of novel technologies; additionally, other commonly used analysis tools can be used to be used to complement and augment FATE, techniques may include: (1) Lewin's Force Field Analysis for the identification of technology drivers and resisters (Lewin (1951)). (2) Defence technology acquisition cycles e.g. CADMID (Concept, Assessment, Demonstration, Manufacture, In-Service, Disposal/Termination), where FATE can augment this by identifying implications of training, system integration and human-factors on the introduced technology. (3) Capability management frameworks such as TEPIDOIL (Training, Equipment, Personnel, Information, Doctrine and concepts, Organisation, Infrastructure and Logistics) in the UK or DOTMLPF(I) in the US and NATO, respectively in order to identify areas that may impede or accelerate a technology's adoption and use. Other methods can also be used as communication tools to specific audiences of stakeholder groups in order to illustrate complex analyses in an intuitive visual form. Other techniques such as SWOT (strengths, weaknesses, opportunities, threats) analysis may be partnered with FATE to distil out its key outputs in a format that is familiar to practitioners, thereby combining the sophistication of FATE with the visual simplicity of SWOT.

4.0 POTENTIAL CONSEQUENCES OF NOT APPLYING A FATE-LIKE METHOD

Although new technologies may appear to offer beneficial impacts to users, the introduction of these technologies into social systems can often have complex, unforeseen effects with differing impacts. Unintended consequences may be of three types: unexpected benefits, unexpected adverse effects, and contrary effects.

- Unexpected benefits – effects that have beneficial consequences either directly on the user-group or indirectly through 2nd, 3rd…. nth order effects; e.g., the increase in wildlife in demilitarised zones, wartime sinking of adversaries' ships in shallow waters forming artificial reefs, the use of aspirin in the prevention of strokes in addition to its original use as a painkiller.
- Unexpected adverse effects – effects with unforeseen detrimental consequences; e.g., the use of aspirin for stroke-prevention leading to increased bleeding. The 'rebound' effect of increased fuel-economy vehicles resulting in drivers travelling more miles. Indoor smoking bans leading to increased littering and an increase in the use of outdoor patio heaters, with adverse climate implications.
- Contrary or 'perverse' effects – effects having consequences that are in direct conflict with the original intent; e.g., awarding carbon credits for fluorocarbon reduction, resulting in a price drop and increased usage. The reliance on unit sales to pharma reward companies (the traditional market approach) has an inherent perverse incentive that contributes to the growth of antibiotic resistance.

5.0 EXAMPLES OF UNINTENDED CONSEQUENCES

The following examples indicate the types of situations where FATE may play a role in anticipating unintended outcomes.

5.1 Electronic Health Records (EHR)

The introduction of electronic health records into residential aged care homes in Australia was anticipated to improve the record keeping over that of paper-based records. However, unforeseen issues arose as a result of the electronic system. These issues included an inability/difficulty in data entry/retrieval, end-user resistance to system use, increased complexity of information management, end-user concerns over access, increased documentation burden, the reduction of communication, and a lack of space for computers in the workplace. The unintended consequences were caused by the initial conditions, the nature of the EHR system and the way the system was implemented and used by staff members (Yu et al (2013)). When viewed from the FATE multi-level framework, this would be a case of OPPPTI-needs not met by the introduction of EHR.

5.2 The use of fitness trackers by military personnel

The increased use of fitness trackers and associated apps, for example Fitbit, Strava, etc. by service personnel illustrated a potential vulnerability in revealing the locations of military bases (Sly (2018)). Socio-technical evaluation of the use of such technology may have anticipated this threat and provided strategies for mitigation. The breadth of data acquired by these devices and the linkage of data-sets from social media accounts (e.g. user location, pattern of life etc.) demonstrates a highly complex picture, the implications of which can only be determined through more holistic evaluations similar to a socio-technical evaluation.

6.0 BENEFITS OF FATE

The success of a method such as FATE lies in: 1) the quality of the outcome, and 2) the added value to the outcome that otherwise would not have been discovered. FATE offers the user a means to secure quality of the answer (to the client's question) by adding value and insights through a process manageable by staff seeking to answer a complex question about future technological developments. If this technique is implemented and used regularly by staff, the result will be more robust, providing holistic answers to questions about technical development and the need to react to desired developments.

There may be a resistance to exploring the complex interactions in the detail that FATE provides, since FATE demands thought, interaction, reflection and discussion. However, psychological research shows that the preservation of complexity is important for understanding (Ward et al (2018)) and discovering the interesting insights (Hoffman et al (2017) and Klein (2018)). In addition, we believe that through this approach, both the intended and unintended consequences can be considered. Furthermore, the modular nature of the method allows the analysis of dynamic situations where seemingly small, insignificant changes across large, complex systems that can be amplified along the causal chain to produce unexpected and undesired effects.

7.0 IMPLICATION: FATE IS UNIQUE AND SEEKS EXPLOITATION

The NATO SAS-123 team has developed and trialled FATE; proved that it works, and hold the view that FATE offers a unique ability to assess the impact of emerged or emerging technologies on defence and security. It enables anticipation of disruptions that emerged or emerging technologies could cause, and their unintended (beneficial or adverse) consequences. FATE would be even better if more people tested it to its limits, and if it were exploited beyond the borders of defence.

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