NORTH ATLANTIC TREATY ORGANIZATION

SCIENCE AND TECHNOLOGY ORGANIZATION

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STO TECHNICAL REPORT **TR-SAS-123**

Futures Assessed alongside socio-Technical Evolutions (FATE)

(Évaluation du futur et des évolutions socio-techniques (FATE))

Final report of the SAS-123 Research Task Group.

Published May 2021

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The NATO Science and Technology Organization

Science & Technology (S&T) in the NATO context is defined as the selective and rigorous generation and application of state-of-the-art, validated knowledge for defence and security purposes. S&T activities embrace scientific research, technology development, transition, application and field-testing, experimentation and a range of related scientific activities that include systems engineering, operational research and analysis, synthesis, integration and validation of knowledge derived through the scientific method.

In NATO, S&T is addressed using different business models, namely a collaborative business model where NATO provides a forum where NATO Nations and partner Nations elect to use their national resources to define, conduct and promote cooperative research and information exchange, and secondly an in-house delivery business model where S&T activities are conducted in a NATO dedicated executive body, having its own personnel, capabilities and infrastructure.

The mission of the NATO Science & Technology Organization (STO) is to help position the Nations' and NATO's S&T investments as a strategic enabler of the knowledge and technology advantage for the defence and security posture of NATO Nations and partner Nations, by conducting and promoting S&T activities that augment and leverage the capabilities and programmes of the Alliance, of the NATO Nations and the partner Nations, in support of NATO's objectives, and contributing to NATO's ability to enable and influence security and defence related capability development and threat mitigation in NATO Nations and partner Nations, in accordance with NATO policies.

The total spectrum of this collaborative effort is addressed by six Technical Panels who manage a wide range of scientific research activities, a Group specialising in modelling and simulation, plus a Committee dedicated to supporting the information management needs of the organization.

- AVT Applied Vehicle Technology Panel
- HFM Human Factors and Medicine Panel
- IST Information Systems Technology Panel
- NMSG NATO Modelling and Simulation Group
- SAS System Analysis and Studies Panel
- SCI Systems Concepts and Integration Panel
- SET Sensors and Electronics Technology Panel

These Panels and Group are the power-house of the collaborative model and are made up of national representatives as well as recognised world-class scientists, engineers and information specialists. In addition to providing critical technical oversight, they also provide a communication link to military users and other NATO bodies.

The scientific and technological work is carried out by Technical Teams, created under one or more of these eight bodies, for specific research activities which have a defined duration. These research activities can take a variety of forms, including Task Groups, Workshops, Symposia, Specialists' Meetings, Lecture Series and Technical Courses.

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List of Acronyms

DRDC	Defence Research and Development Canada
Dstl	Defence Science and Technology Laboratory, United Kingdom
FATE	Futures Assessed alongside socio-Technical Evolutions
FOI	Swedish Defence Research Agency
MLP	Multi-Level Perspective
MLF	Multi Layered Framework
NATO	North Atlantic Treaty Organization
OPPTI	Organization, People, Processes, Technology, and Infrastructure
OPPPTI	Components of a Socio-Technical System, described as Organization, Processes, People, Policy, Technology, and Infrastructure
PESTLE	Political, Economic, Social, Technological, Legal, and Environmental
PoW	Program of Work
RTG	Research Task Group
SAS	Systems Analysis and Studies
SME	Subject Matter Expert
SoW	State(s) of the World
STS	Socio-Technical System
TEMPLES	Technological, Economical, Military, Political, Legal, Environmental and Social
TNO	The Netherlands Organisation for Applied Scientific Research (The Netherlands)

Glossary

Antifragility	A property of systems that increases their capability to thrive as a result of stressors, shocks, volatility, noise, mistakes, faults, attacks, or failure.
Baseline STS	A scenario agnostic description of components of a socio-technical system as known in the present context.
Baseline Future STS	A socio-technical system as extrapolated into the Future i.e., a scenario agnostic future projection/ extrapolation of the Baseline STS, often done automatically as one is developing a Baseline STS. This is different from a Futuristic STS which is derived from the interaction between a Baseline STS and a Scenario of the future.
Changes	Alterations in state of one or more components in the Socio-Technical System (STS) that can be observed or identified.
Drivers	The causal factors that can be attributed to the promotion of the ‘change’. These promote an alteration in a system or environment from its standard state.
Effectors	An agnostic way of describing both Drivers and Resistors – the causal factors to which the ‘change’ can be attributed.
FATE	Futures Assessed alongside socio-Technical Evolutions with the aim to evaluate and analyse the simultaneous interactions between the two variables: Scenarios of the future and Socio-Technical Systems and assess their consequent ability to cause disruptions in defence and security. It should be noted that the use of the lower case “s” for the word socio in the title FATE is intentional. This is done to highlight social ramifications often being overlooked in studying technological disruptions.
Futuristic STS	A Baseline STS which has evolved into a future. That is to say with new information added to the Baseline STS in the context of a future described in a scenario.
Insights	These are characteristics of interests that arise from using the FATE Method, often associated with Changes and Effectors (Drivers and Resistors). The purpose of the Insights is to retain and include observations and discoveries from the FATE Method (such as components of STS) that were not thought of previously. The Cambridge dictionary[1] defines an Insight as (the ability to have) a clear, deep, and sometimes sudden understanding of a complicated problem or situation.
Landscape	**“**The macro-level of landscape consists of slow changing external factors, providing gradients for the trajectories.”[2]

[1] https://dictionary.cambridge.org/dictionary/english/insight, Accessed on 2 March 2020.

[2] Geels, F.W. (2002). Technological Transitions as Evolutionary Reconfiguration Processes: A Multi-Level Perspective and a Case Study. Research Policy, 31(8-9) 1257-1274, p. 1216.

Multi Layered Framework	A framework developed by Geels (2002)[2] consisting of Landscape, Regime and Niches.
Multi-Level Perspective	A description of the relation between the three concepts of Landscape, Regime and Niches developed by Geels[2] which can be understood as a nested hierarchy. It is abbreviated as MLP. Often used interchangeably with Multi Layered Framework. "The multi-level perspective (MLP) is a middle-range theory that conceptualizes overall dynamic patterns in socio-technical transitions"[3].
Niche	"The micro-level of niches accounts for the generation and development of radical innovations." [2]
Regimes	"The meso-level of ST-regimes accounts for stability of existing technological development and the occurrence of trajectories." [2]
Resistors	Are the causal links that can be attributed to the occurrence of the 'change', by blocking or inhibiting in some way the normal function of a system or environment.
Rich Picture	A technique that helps explore, acknowledge, and define a situation or an idea by expressing it through graphical means, thus creating a "mental model." Rich pictures may consist of diagrams, symbols, cartoons, and words.
State of the World	An image or instance of how the world (usually in the future) could unfold (i.e., synonymous with scenario).
Socio-Technical System	Socio-Technical Systems' (STS) describe: 1) The interplay between social systems and the technologies (or systems of technologies) employed (or proposed to be employed) within them; 2) The influence of these two components on each other; and 3) The effects these may have on future technology adoption, utilization and impacts, foreseen or unforeseen.
So Whats	Are the Insights derived from the work on the STS, both baseline and futuristic; and thus, may be Insights on the STS itself, the consequences for Defence and Security and client issue, including the impact on a specified capability or domain of interest.

[3] Geels, F.W. (2011). The Multi-Level Perspective on Sustainability Transitions: Responses to Seven Criticisms. Environmental Innovation and Societal Transitions. 1(1) 24-40, p. 24.

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The FATE team acknowledges with thanks the contributions of Ms. Clara E. Peters (TNO, The Netherlands) and Major John Kivelin III (US Marine Corps, The United States of America). Both Clara and John were integral members of the team until October 2019 and April 2018 respectively and FATE would not have been the same without their perspectives. Additionally, our thanks to H. Breitenbauch from Denmark, G. Walters from Fraunhofer Institute, Germany; Senior Lieutenant Colonel F. Bin Hassan, Lieutenant Colonel Zhifeng Lim and Major Wei Lung, from Ministry of Defence, Singapore; J. Wilkins, J. Robbins and K. Bown from Dstl, The United Kingdom; Lieutenant Colonel P. Kirchener from the US Marine Corps, The United States of America, for their contributions as participants for various lengths of time in the team. We acknowledge Marcel-Paul Hasberg from TNO, The Netherlands, and Kerry Fosher from Marine Corps University, The United States of America, for reviewing this report.

The work of several academics influenced our thinking in developing FATE, in particular: Frank Geels, for his MLP framework, Roberto Poli who attended the meeting in Rome, 2017 and James Derbyshire for his work on antifragility.

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Futures Assessed alongside socio-Technical Evolutions (FATE)

(TR-SAS-123)

Executive Summary

Identifying a need to systematically monitor emerging technologies and identify socio-technical disruptions, the Systems Analysis Studies Research Task Group 123 (SAS-123) was created. During its three-year mandate (subsequently extended by one year), the study attracted steady participation from nine NATO Nations, Allied Command Transformation, Sweden and, in a first for the STO, Singapore. The Task Group had two main objectives:

- Develop criteria to evaluate and analyze the simultaneous interactions between two variables, namely, scenarios of the future and Socio-Technical Systems (STS); and
- Assess the ability of these interacting variables to cause disruptions within the defence and security sectors.

In response to these objectives, the SAS-123 team developed the method entitled "Futures Assessed alongside socio-Technical Evolutions (FATE)".

This Final Report encapsulates the FATE Method and provides a companion 'Facilitators Guide' to assist in the employment of the method. It provides an introduction to the background and development of the FATE Method in accordance with the Program of Work approved by the Systems Analysis and Studies Panel.

The Task Group conducted a Literature Search in order to prepare a theoretical foundation for the assessment of STS against scenarios of the future. Very little was found within current research that simultaneously considered these two interacting variables although there are a wide range of methods, usually associated with foresight studies, that do individually consider each variable. These searches are presented graphically in Chapter 2. After considering the many existing methods, the Task Group settled on the theoretical foundation of the Multi-Level Perspective (MLP) most recently described by Frank W. Geels.

The MLP can best be understood as a nest hierarchy, which views technological transitions as non-linear processes that result from the interplay of developments at three socio-technical analytical levels:

- Niches – the locus for radical innovations;
- Regimes – the locus of established practices and associated rules that stabilize existing systems; and
- Landscape – an exogenous socio-technical system within which niches and regimes interact.

This hierarchy has within current literature been used to retrospectively describe how technologies have transitioned from niches to become dominant across landscapes facilitated by changes within the existing regimes. The FATE Method provides a mechanism to prospectively explore these technological transitions.

Within FATE, technologies and/or socio-economic issues are examined as part of an STS in terms of both what is known today and as an extrapolation into the future. The use of a scenario agnostic Baseline STS provides an understanding of how the technology, and the system within which it resides, appears today.

The Baseline STS is then analyzed in the context of possible futures producing Futuristic STS. This future visualization of the STS enables an understanding of how the STS might evolve given the many social factors that might have a bearing on the adoption of a technology in the future. The insights that are derived from the exploration of this Futuristic STS, in the form of drivers and resistors, are then assessed for possible impacts on Defence and Security.

This FATE Method was developed iteratively through presentation at a number of academic events and the conduct of trials in several defence settings. The method provides a tool to assess the inevitable uncertainty regarding likely social changes that influence the development and uptake of technologies in an emerging complex future. It could allow defence and security organizations to make better informed decisions about longer-term plans and strategies that will have to be, to the extent possible, future-proofed.

Évaluation du futur et des évolutions socio-techniques (FATE)

(STO-TR-SAS-123)

Synthèse

La nécessité d'un suivi systématique des technologies émergentes et d'une identification des ruptures socio-techniques a entraîné la création du groupe de recherche 123 de la Commission d'analyse et étude des systèmes (SAS-123). Pendant sa mission de trois ans (prolongée d'un an par la suite), le groupe de travail a bénéficié d'une participation constante de neuf pays de l'OTAN, du Commandement allié Transformation, de la Suède et de Singapour, ce qui était une première pour la STO. Le groupe de travail avait deux objectifs principaux :

- Élaborer des critères afin d'évaluer et analyser les interactions simultanées entre deux variables, à savoir, des scénarios du futur et des systèmes socio-techniques (STS), et
- Évaluer la capacité de ces variables interactives à provoquer des ruptures dans les secteurs de la défense et de la sécurité.

En réponse à ces objectifs, l'équipe du SAS-123 a mis au point la méthode intitulée « Futures Assessed alongside socio-Technical Evolutions (FATE) » (évaluation du futur et des évolutions socio-techniques).

Le présent rapport final résume la méthode FATE et fournit un « guide de l'animateur », qui aide à utiliser la méthode. Il introduit le contexte et le développement de la méthode FATE conformément au programme des travaux approuvé par la Commission d'analyse et étude des systèmes.

Le groupe de travail a effectué un dépouillement de la littérature, afin de préparer une base théorique à l'évaluation des systèmes socio-techniques par rapport aux scénarios de l'avenir. Ce dépouillement n'a révélé que très peu de recherches actuelles considérant simultanément ces deux variables interactives, bien qu'il existe une large palette de méthodes, habituellement associées à des études prospectives, qui étudient individuellement chaque variable. Ces recherches sont présentées graphiquement au chapitre 2. Après avoir étudié les nombreuses méthodes existantes, le groupe de travail a choisi le fondement théorique de la perspective multi-niveau (MLP, Multi-Level Perspective) décrite en dernier lieu par Frank W. Geels.

La MLP est un type de hiérarchie inclusive, qui conçoit les transitions technologiques comme des processus non linéaires découlant de l'interaction d'évolutions à trois niveaux d'analyse socio-technique :

- Les niches – lieu des innovations radicales,
- Les régimes – lieu des pratiques établies et des règles associées qui stabilisent les systèmes existants, et
- Le paysage – système socio-technique exogène au sein duquel les niches et les régimes interagissent.

Cette hiérarchie sert dans la littérature actuelle à décrire rétrospectivement comment les technologies ont quitté leurs niches pour devenir dominantes dans l'ensemble des paysages, avec l'aide de changements au sein des régimes existants. La méthode FATE propose un mécanisme d'étude prospective de ces transitions technologiques.

Dans le cadre de FATE, les technologies et/ou les questions socio-économiques sont examinées en tant qu'éléments d'un STS, à la fois par rapport à ce qui est connu actuellement et dans une extrapolation futuriste. L'utilisation d'un STS de référence indépendant de tout scénario permet de comprendre l'apparence actuelle de la technologie et du système dans lequel elle réside. Le STS de référence est ensuite analysé dans le contexte des futurs possibles, ce qui produit un STS futuriste. Cette visualisation future du STS permet de comprendre comment la STS pourrait évoluer étant donné les nombreux facteurs sociaux susceptibles d'intervenir dans l'adoption d'une technologie à l'avenir. Les connaissances tirées de l'examen de ce STS futuriste, sous la forme de facteurs favorables et défavorables, sont ensuite évaluées. Il s'agit d'établir leurs possibles effets sur la défense et la sécurité.

La méthode FATE a été mise au point de manière itérative, au fil de ses présentations lors d'un certain nombre d'événements de recherche et par des essais dans plusieurs contextes de défense. Elle constitue un outil d'évaluation de l'inévitable incertitude touchant les changements sociaux probables qui influencent le développement et l'adoption de technologies dans un avenir émergent complexe. Cette méthode pourrait permettre aux organisations de la défense et de la sécurité de prendre des décisions plus éclairées quant à leurs plans et stratégies à long terme, lesquels devront, dans la mesure du possible, être pérennes.

FUTURES ASSESSED ALONGSIDE SOCIO-TECHNICAL EVOLUTIONS (FATE)

1.0 INTRODUCTION TO FATE

1.1 Introduction

The North Atlantic Treaty Organization Systems Analysis Studies Research Task Group 123 (NATO RTG SAS-123) was created to:

1) Develop criteria to evaluate and analyse the simultaneous interactions between two variables, namely, scenarios of the future and Socio-Technical Systems (STS); and
2) Assess the ability of these (interacting) variables to cause disruptions in defence and security.

In response to these objectives, the SAS-123 team developed a method called Futures Assessed alongside socio-Technical Evolutions or FATE.

This method was initially presented as a symposium workshop at the 11th Annual NATO Operations Research & Analysis Conference to solicit input from the operations research community, then as a concept for academic peer review at the ANTICIPATION 2017 Conference and reported in an interim scientific report 2018 [1]. It has since been play tested at the Defence science and technology laboratory (Dstl), United Kingdom [2] and Fraunhofer Institute, Germany, in the presence of members of SAS-123 and once independently of the team by and at the Royal Danish Defence College, Denmark. With each iteration, the method was refined. One such improvement was to include a guide for facilitators and others who undertake the use of FATE. This piece of work is a significant addition, that goes beyond the original undertaking set out by the team in their Program of Work (PoW) (see Annex A).

Through the establishment of this method, the team addressed all parts of the PoW; the means for both studying the interaction between futures and socio-technical systems; and detecting and recognizing socio-technical evolutions. The method also proposes a way to assess potential impacts of the evolutions on defence and security. The reader is reminded that the first part of the PoW was amended from the beginning to utilizing pre-written scenarios of the future rather the developing them within the team. This turned out to be a good decision, one that is also practical in enhancing the utility of the method within other organizations.

This report summarizes the work done over the three-year period of the RTG with an extension of a year, explaining the output of the work, and how it might be useful and used by NATO and NATO Member Nations. Chapter 2 explains how the method was developed (with prevalent methods and tools cited in Annex B, and a listing of various STS explored in Annex C, respectively). Chapter 3 provides an overview of the FATE method itself and introduces a use case, which is elaborated in a presentation made at the ANTICIPATION 2019 Conference (see Annex D). Chapter 4 discusses the reasoning behind some of its design and the utility of FATE. Chapter 5 provides a conclusion with recommendations for how the work could be further developed and exploited. The Guide for Facilitators, designed to assist organizations in using the FATE Method, from here on referred to as the Facilitator's Guide is available in Annex E. This Guide is expected to aid a greater exploitation of FATE.

2.0 PATH TO FATE

2.1 Literature Search

The theoretical starting point for developing the FATE method was based on the given research aim: understanding and analyzing Socio-Technical Systems (STS) and their potential evolutions into the future while assessing the impact on defence and security. The first consideration was to determine what had been done before in this area – if anything. A literature search (see Adlakha-Hutcheon et al., 2018 [1]) was conducted and then repeated more recently to find relevant studies to meet this objective. In the searches none of the methods appear to simultaneously explore scenarios, STS, their evolutions, and conditions that drive or resist such changes even though a wide range of methods are in use in foresight studies, such as scenario planning, the Delphi Method (Helmer-Hirschberg, 1967 [3]), Futures Wheel (Glenn, 1972 [4]), etc. (also see Annex B).

The more recent search revealed that academic publications relating to both scenarios and/or futures and defence are spread across diverse disciplines, with engineering being the most prominent. This is illustrated in Figure 1 and Figure 2 for a subset of 7715 publications at the level of nations and scholarly fields, respectively. Similarly, publications related to both STS and defence were spread across several subject areas; mainly computer science, mechanical engineering, and operations research (Figure 3 and Figure 4). However, a methodology that could be applied specifically to the research question was not obvious.

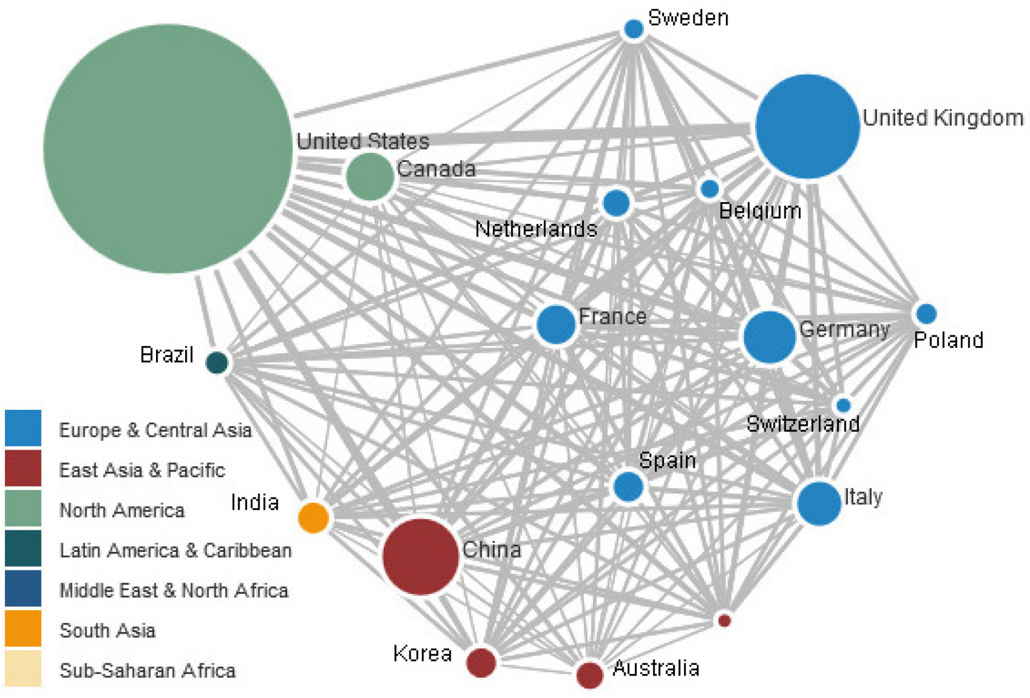

Figure 1: Graphical Representation of Co-Publishing Networks by Country. A network graph of a subset of 7715 publications on scenarios and/or futures in the defence context. The color code refers to the world regions as defined by the World Bank.

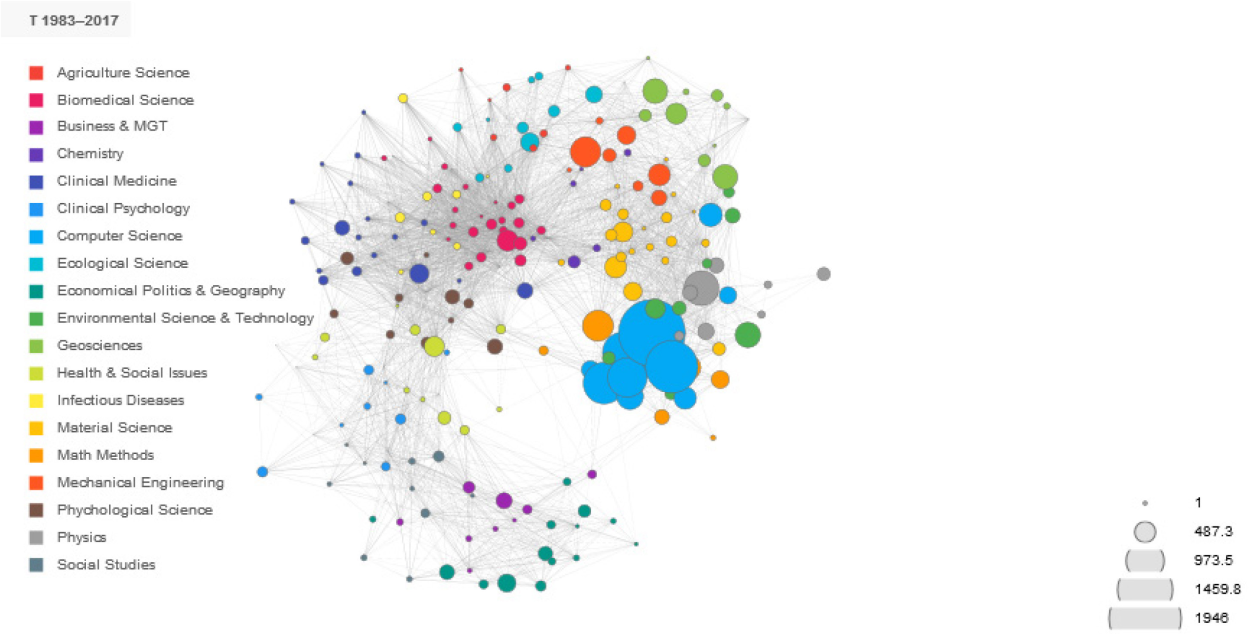

Figure 2: Graphical Representation of Co-Publishing Networks by Discipline. A science overlay map for a subset of close to 8000 publications on scenarios and/or futures in the defence context. The color code refers the top-level domains of the Web of Science taxonomy. The size of dots reflects its relative extent; and the 2D-arrangements of sub disciplines is a fixed arrangement based on the concept of Rafols, Porter and Leyesdorff [5]).

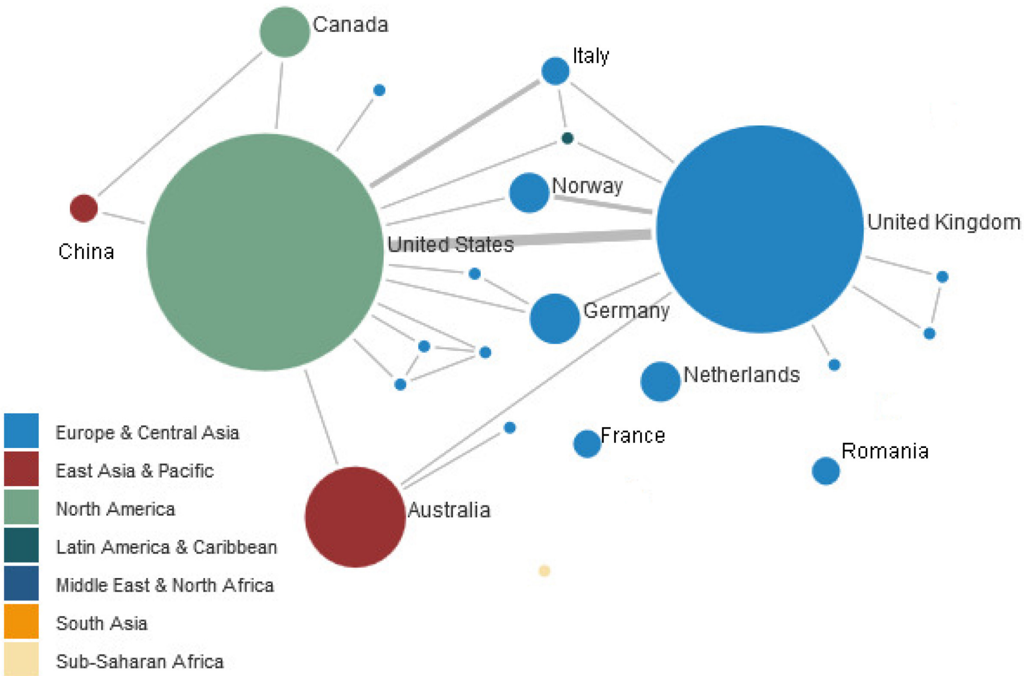

Figure 3: Graphical Representation of Co-Publishing Networks by Country. The figure represents a subset of 112 publications on socio-technical systems in the defence context (legend details on graphics: see Figure 1).

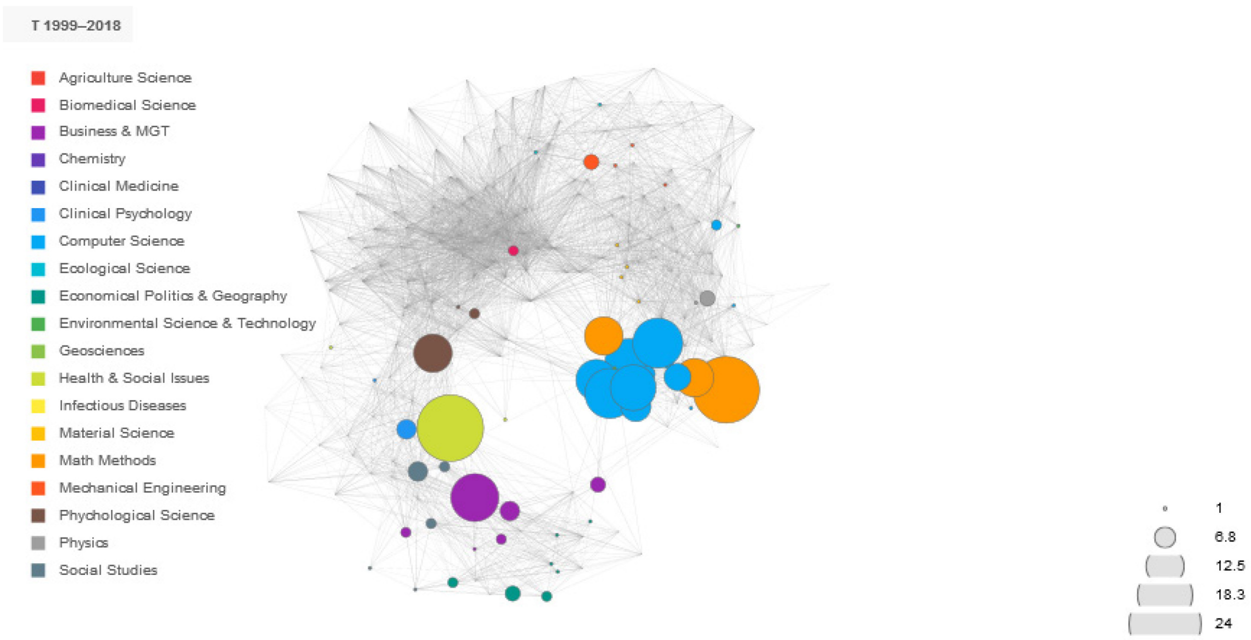

Figure 4: Graphical Representation of Co-Publishing Networks by Discipline. A network map for a subset of 112 publications on STS in the defence context. The color code refers the top-level domains from the Web of Science taxonomy. The size of dots reflects its relative extent; and the 2D-arrangements of sub disciplines is a fixed arrangement based on the concept of Rafols, Porter and Leyesdorff [5]).

The crossover between the two publication pools ({defence + scenarios} and {defence + STS}) is small. The first pool is better researched with more than an order of magnitude greater number of publications (7715 papers in the web of science core collection) than the latter (112 papers). The disciplines implicated in both are engineering and computer science (Web of Science 'categories' and 'research areas'). Among the defence and STS publications, the predominant disciplines were material sciences, health and social sciences and ecological studies. The main countries involved in such studies were typically, the United States of America and the United Kingdom, and to a lesser extent Australia, and a few European countries. Complementary searches with different data sets such as Scopus resulted in slightly different results and numbers, but confirmed the overall findings, including the focus on disciplines like (systems) engineering being implicated. These searches not only illustrated the lack of studies on the objective set forth by the NATO SAS-123 but highlighted the need for a better understanding of the synergistic impacts of technologies when introduced into people-centric environments.

2.2 Development of a Method

Given this context, the NATO SAS-123 group used its biannual face-to-face meetings and monthly teleconferences to come up with the following approach to arrive at the FATE method:

1) Reviewing methods directly connected to **STS**, **trend analysis** and **impact assessment**;
2) Broadening the scope of the review to methods associated with foresight (see Annex B) with a focus on **scenario-related methods** plus methods dedicated to the **analysis of complex systems** (e.g., systems theory);
3) **Building** a methodological framework for exploration, and assessment;
4) **Testing** the methodological framework; and

5) **Iteratively improving** the framework by making procedural adjustments; adding, changing, or removing selected methods applied.

For the iterative advancement of the FATE method, the following existing methods were taken into account, either on their own, as variants, and/or in combinations, tried and further refined:

- Brainstorming (Osborn, 1957 [6]);
- Mind mapping (Buzan, 1974 [7] and Buzan and Buzan 2000 [8]);
- Morphological analysis (Zwicky, 1959 [9] and Zwicky, 1969 [10]);
- Multi-level perspective (Geels 2002 [11], 2004 [12]; Geels and Schot, 2007 [13]);
- Causal-layer analysis (Inayatullah, 1998 [14]);
- Rich pictures (Checkland, 1981 [15]; 1990 [16]; 2000 [17]);
- Back casting (Cole and Curnow, 1973 [18]; Johansson and Steen, 1978 [19]; Robinson, JB, 1982 [20]);
- Cross impact analysis (Gordan and Hayward, 1968 [21] and Gordan and Becker, 1972 [22]); and
- Antifragility (Taleb, 2012 [23]).

2.3 The Theoretical Background

An impetus for FATE was to investigate social implications which are often overlooked in conventional future studies driven by a technological 'push' perspective. Thus it was central to associate social and technological angles; the team opted to do this through the use of Socio-Technical Systems, which are well understood in social sciences (Trist and Bamforth, [24] Bostrom and Heinen [25], [26], Walker et al. [27] and Baxter and Sommerville [28]). In terms of bringing-in the perspective of a future, pre-described scenarios were used as an input to the FATE method. Consequently, criteria for the selection of scenarios for use within the FATE method were described by Adlakha-Hutcheon et al., 2018 [1].

The theoretical base for studying the interaction between STS and future scenarios and assessing technological evolutions within Defence and Security was the Multi-Level Perspective (MLP) expounded by Geels ([11], [12], [13]).

MLP is a theory consisting of Landscape, Regime and Niches which can be understood as a nested hierarchy. It is used interchangeably with Multi Layered Framework. "The MLP views transitions as non-linear processes that results from the interplay of developments at three analytical levels: niches (the locus for radical innovations), socio-technical regimes (the locus of established practices and associated rules that stabilize existing systems), and an exogenous socio-technical landscape (Rip and Kemp, 1998 [29] Geels, 2002 [11]). Each 'level' refers to a heterogeneous configuration of elements; 'higher' levels are more stable than 'lower' levels in terms of number of actors and degrees of alignment between the elements" (Geels, 2011 [30]).

Together, the systems theory, STS, use of scenarios and a study of transitions founded on MLP led to the formulation of the four-step FATE method, which is described in Section 3.0.

3.0 THE FATE METHOD

The FATE method is a means to address a question raised by a client about a technology or a social issue. It does this using a system-based analysis through an interpretation of the posed question in the form of a Socio-Technical System (STS) and its analysis in various future scenarios. Thereby, technologies and/or socio-economic issues are examined as an STS in terms of both what is known today and as an extrapolation into the future.

First, the STS as it is understood today is created or refined if it already exists. This is referred to as a Baseline STS. Thus, a Baseline STS is a scenario agnostic description of all components of a socio-technical system as known in the present context.

Second, the Baseline STS is analyzed from the perception of what the future may bring, thus rendering a scenario agnostic Baseline Future STS. An analysis of these Baseline STS's in the context of possible scenarios set in the future (descriptions of the state of the world in the future) then provides a Futuristic STS, enabling an understanding of how the STS might evolve. How social factors including socio-economics, cultural factors etc. have a bearing on adoption of technology in the future as well as future technological dependencies are also revealed by looking at possible evolutions within the STS following its interaction with a scenario and subsequently across multiple scenarios.

It should be noted that a socio-technical system as extrapolated into the Future, i.e., a scenario agnostic future projection/extrapolation of the Baseline STS, often occurs automatically as one is developing a Baseline STS. This is referred to as Baseline Future STS and is different from a Futuristic STS which is derived from the interaction between a Scenario and the STS.

3.1 The Four Steps of the FATE Method

A high-level overview of the four steps of the FATE method is provided below and illustrated in Figure 5. The mechanics of how these steps should be undertaken is described in the FATE Guide for Facilitator's (see Annex E).

FATE Step 1: Build the STS:

- **Aim**: Expand the STS into its components from the groups understanding of the system as it is today.
    - **How**: Through a structured brainstorming build and elaborate the components of the STS. (This is Baseline STS; it is scenario agnostic and built from what is known today).
    - **Output**: Organization, People, Policies, Processes, Technology, and Infrastructure (OPPPTI) components laid out primarily in the Regime level of the multi-level perspective of Landscape, Regime, and Niche.

FATE Step 2: Break down scenarios into TEMPLES:

- **Aim**: Extract the macro environment (scenario components in the format of Technological, Economical, Military, Political, Legal, Environmental and Social (TEMPLES)) from the pre-selected scenarios[1] that may affect the STS. Thereby enhancing the participant's understanding of the scenario.
    - **How**: By individual reading and/or group using Rich Pictures, break down scenarios into the scenario components (TEMPLES).
    - **Output**: TEMPLES components of the scenario tabulated.

[1] Scenarios are chosen from existing futures libraries. The scenario should be appropriate in scope and timeframe to the question being explored.

FATE Step 3: Study the interaction of the STS with scenarios:

- **Aim**: Understand evolutions and the related Insights of an STS within different scenarios:
  - **How**: by analyzing the interaction between the STS and scenarios components and noting changes within the components of the Baseline STS into Futuristic STS as a consequence of the interaction with different scenarios that provides a futuristic context.
  - **Output**: Components in the STS that evolve (Changes), the Drivers or Resistors of these changes[2] presented in a matrix.
    - Documented Insights to the client's question and/or defence and security; and "so whats" relative to the components and effectors showing the pattern of evolution in each scenario and/or across scenarios.

FATE Step 4: Determine Impact:

- **Aim:** Determine/assess the impact of the STS evolutions and or insights on the client's specified interest:
  - **How:** by measuring the response to questions of probability, level of regret and disruption on the STS evolutions and or insights. And how this may affect defence and security, such as on the client question or capabilities.
  - **Output:** Representative patterns of STS evolutions in each and across scenarios as a means of determining potential actions to mitigate impact.

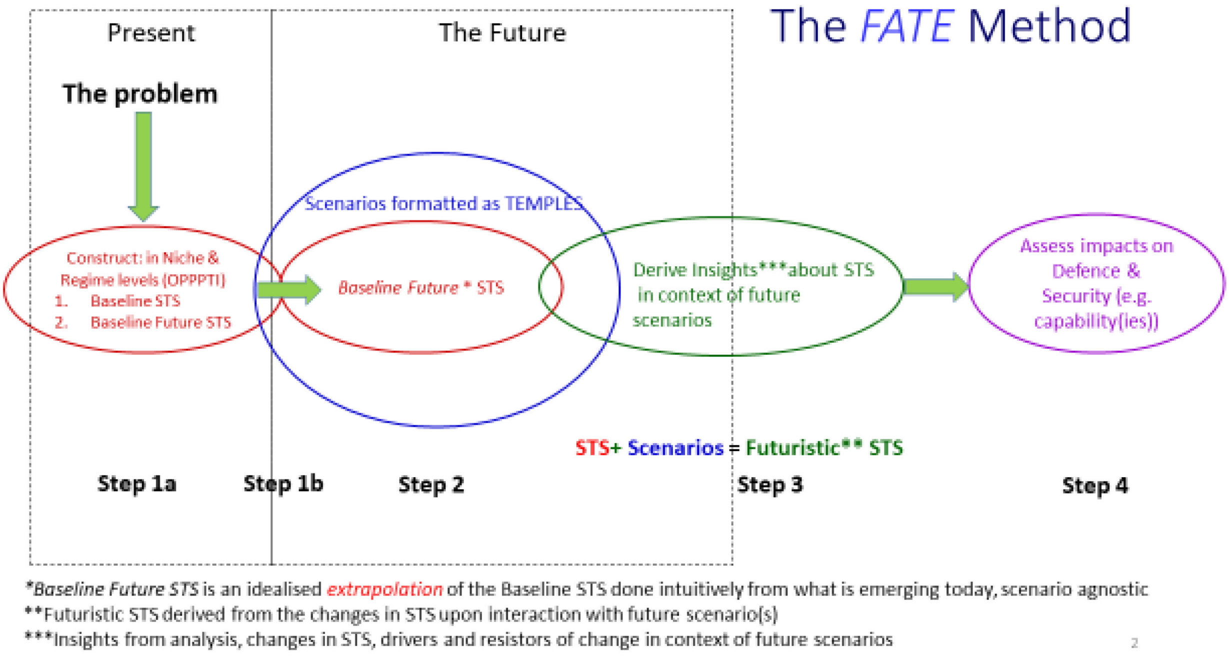

Figure 5: The FATE Method Is Detailed Along Its Four Steps.

The application of the FATE method, its results, what they impact and where FATE may be used are discussed in Section 4.0.

[2] Explanations about why changes occur in the STS.

4.0 RESULTS: FATE IN USE

The development of the FATE method fulfils the research objectives undertaken by SAS-123. The results that came about through the subsequent execution of the FATE Method are illustrated using the presentation made at the ANTICIPATION 19 Conference (see Annex D). To further assist the reader in getting a better understanding of FATE, these results are discussed below referring to slides within that presentation.

4.1 Logistical Autonomous Systems

Logistical autonomous systems, that is to say logistics of delivering supplies to the frontline through autonomous means is taken as the example of STS in the presentation. This was of interest to the client and was used in piloting the FATE Method at Dstl in September 2018 (Maltby et al., 2020, [2], Enclosure 2).

Through Step 1, FATE provided an understanding of all OPPPTI components of this STS known to participants based in the present times. This work established the Baseline STS. These are shown across multiple levels of niche, regime and landscape and illustrated in Slide 13.

Within Step 2 of FATE, a comparison is made of two scenarios using the Worlds 4 and 5 of the Future Worlds TM (FW; Maltby et al., 2014 [31]) in the form of pictures drawn by participants (using the Rich Pictures method) in Slide 14 and in terms of TEMPLES documented in tabular form in Slide 15.

The insights derived in Step 3 through the interaction between STS in the context of a future provided by the scenarios (Futuristic STS) is shown in the form of a table (Slide 16). The insights included effectors of change that are either neutral, drive, or retard a change. This visual representation is then interpreted in terms of impacts on defence and security. For example, impacts on defence capabilities could be ascertained through a series of questions, which constitute Step 4 (Slide 18). The impact is considered in multiple ways taking the example of the Logistical autonomous systems STS or 'last mile delivery to the frontline' on the sustain capability and its sub-capabilities (Slides 19 – 26).

4.2 Impacts Consequent to the Use of FATE

The FATE method provides a tool for addressing the inevitable, uncertainty and doubt regarding developments in the future. The method is therefore a good use case for technological areas with complex and/or uncertain evolutions where Defence and Security organizations may need to make informed decisions about current or long-term plans, and strategies.

In the FATE Method the interactions between scenarios of the future and the components of a socio-technical systems are studied to enhance understanding of socio-technical evolutions. Consequently, one gains insight into an overall context which includes non-military components and their implications for militaries such as changes that will impact adoption of technologies. In particular, the method is used to:

1) Better understand STS and their potential evolutions into the future;
2) Analyze these evolutions using the following criteria: components of the STS that change; drivers/resistors of change, and how the drivers and resistors of change affect components of STS; and
3) Assess the impact of the STS and their evolutions on defence and security.

FATE has been principally designed as a participatory method led by one or several facilitators in a workshop setting enabling the analysis of an STS across several scenarios. Nonetheless, it can be applied in different ways, such as obtaining a better understanding of components of an STS by conducting Step 1 alone. The Turkish Aerospace Industries did just this. At the end of a day long workshop on Step 1 on the subject of AI, they had an output with all components of OPPPTI worked out and an in-depth understanding among the participants. The Task Group did not consider these types of alternative modular applications of FATE in depth.

The challenge to go beyond studies that focus on single technologies or technological trends was one of the key issues that gave rise to the FATE research. A consideration of social factors was the second. The MLP framework was used as a foundation for the study because it considers both multi-dimensionality and structural change; includes transition patterns which precede technical shifts (Geels 2011, [30]); and goes further than studies driven by technology push.

In the FATE method, scenarios of the future are used to introduce changes in the exogenous socio-technical landscape. Rarely do scenarios introduce changes in the regime or niche levels. In FATE, the regime level of MLP has been explored in terms of OPPPTI, where overlaps with the Geels' dimensions of regime (policy, technology, sciences, markets…, industry) are observed.

Geels defines transitions as "shifts from one regime to another regime" and thus believes "the regime level to be of primary interest". He further points out that "the niche and landscape levels can be seen as 'derived concepts', because they are defined in relation to the regime, namely as practices or technologies that deviate substantially from the existing regime and as external environment that influences interactions between niche(s) and regime" (Geels 2011, [30]). While Geels looks back and uses transitions in transportation by sea to rail, the FATE Method uses the MLP to anticipate into the future and arrives at the same conclusion. Although the technical issues often lead to an initiation of studies, conducting the study and analysis of STS within the multi-level framework, as in the FATE Method, provides for a more holistic examination which yields a more actionable and thus potentially more useful products for the client. For example, within defence technologies in the niche level are often of great importance.

4.3 What Does the Use of FATE Yield?

FATE's ambition is to provide two key things, first a much broader investigation of the future developments, related to an STS and secondly to understand how those changes may impact Defence and Security. The first is about providing a much richer and broader exploration in the analysis of technological evolutions, which considers both the social aspects of the STS and the effect of multiple contexts (scenarios). The second relates to the aspect of avoiding the tendency to just describe the changes and not be explicit about the possible impacts – the "so whats". These two factors, social aspects of STS[3] and the effect of multiple contexts are illustrated in the act of kicking a ball (see Figure 6).

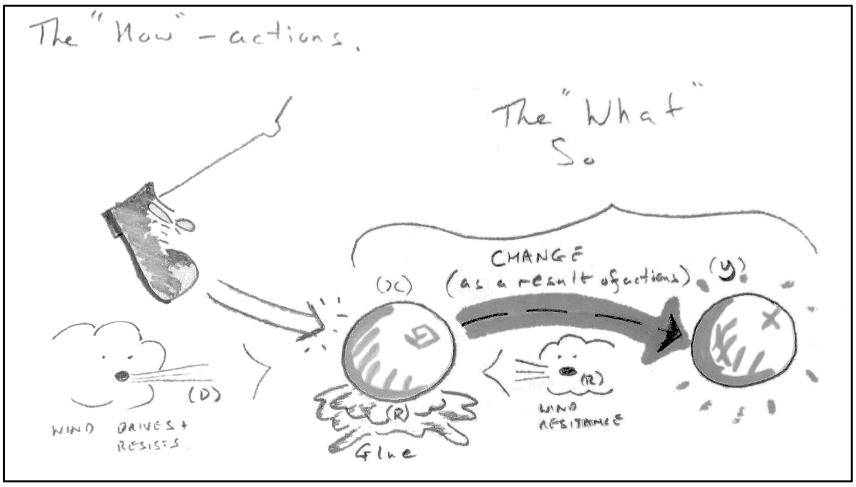

Figure 6: The Act of Kicking a Ball. In kicking a ball, the interactions between the foot and the ball, external and internal factors such as presence or absence of wind, the speed with which the foot strikes the ball, and the constitution of the ball need to be considered.

[3] This is the reason for the team to have opted to use a lower case's' in the word "socio" in the title of FATE and even omit it entirely in the acronym.

For example, when considering Figure 6, we can describe the foot is swinging to strike the ball. From this, we can reasonably easily infer that the impact of this described action or change will move the ball from its current position (x) to another position (y). However, the actual impact of the movement of the ball from its starting position (x) to another position (y) is rarely well described. This constitutes the missing "so what" from many pieces of futures work.

This is important, firstly, because in many cases it is not clear what the impact is to those not involved in the exploration. Secondly, the impact can be changed dramatically by small variations that are more easily forgiven by the outsider if it is understood that they were missed. For example, in the Figure 6, if those exploring the problem missed the possibility that the ball was actually glued to the ground, then the kick would have no impact, or the wind was blowing head-on, then too the change consequent to the ball being kicked would be very different. The FATE Method, explores the circumstances brought on by the uncertainties associated with the future, illustrated here by the wind and the glue. Furthermore, FATE does not only capture external circumstances that could vary such as those in future scenarios, but also internal ones like the STS and its components. In Figure 6 this is shown by the interaction between the foot and the ball. These two are not static, they depend upon variables such as: the speed with which the foot makes contact with the ball, the composition of the ball, whether it is completely still and so on.

The FATE approach thus uncovers knowledge about a much richer and complex set of interactions. This arises from first considering the elements of the STS, then how they may change from today (Baseline STS) by an extrapolation (Baseline future STS) through the changing context future (scenarios), finally yielding the Futuristic STS. Subsequent exploration considers how these changes might impact on Defence and Security.

4.4 Key Attributes of FATE

4.4.1 Describing (and Attributing) Change

There is a tendency to avoid complex interactions, and making explicit what enables these changes, and stating what the actual change might be. However, it is our belief that the justification for oversimplifying and shortening this process (a "reductive tendency") is unfounded. It has been shown (e.g., Spiro et al., 1995 [32] Feltovich et al., 2001 [33], [34]) that understanding uncertainty and complex interactions requires users "to preserve the functional complexity … of material" (Ward et al., 2017 p. 5 [35]).

FATE thus seeks to aid users in providing this ability. Assisting the users in providing both an ability for describing the changes that are discovered, but also the ability to explain, record and attribute their reasoning about how they came to that conclusion. This ability to explain ones reasoning is a key skill, not possessed by many and attributed to a rare few Superforecasters (Mellers et al., 2015, [36]) and Adaptive Experts (Hatano et al., 1986 [37] and Ward et al., 2017 [35]).

4.4.2 Assessing Possible Impact

How those changes might impact on what one does, is not only what underscores futures work (often referred to as the "so whats") but is also what is frequently missing or poorly done at best. Even though, an understanding of the impact of future events is essential in providing the applicability to such work.

Assessing impact is difficult and futures methods are generally poor at providing assessment criteria for this: here we take the perspective that the commonly used risk assessment of likelihood and impact is not a good enough or useful measurement (e.g., see Derbyshire 2016 [38]). Thus FATE suggests (and experimented with) using a variety of assessments (e.g., workshop at NATO OR&A Conference [39] and ANTICIPATION 17 [40] where impact was considered using the concept of antifragility (Derbyshire and Wright, 2014, [41]) to help explore the impacts of the characteristics of the changes. Some example questions considering these characteristics are thus:

- What are the characteristics of these changes?
- What is the scale of change relative to current resources and evolution?
- Are impacts from Futuristic STS coupled in different scenarios?

One difficulty is judging what is the "impact on", what does it affect. However, defence is quite good at describing its capability, having many frameworks (Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities (DOTMLPF) is an example of a commonly known and used framework) and structures to describe its capability's. We can therefore use these frameworks as a basis from which to ascribe if there is impact on those capabilities. A key question of the impact assessment is thus:

- Do the changes in Futuristic STS impact Defence and Security capabilities?

This can be as broad as the 'whole of Defence' or a specific capability area such as Armored Infantry. This initial assessment (just a yes or no without a judgement of impact; Slide 18, Annex C) thus provides a useful indication whether the change impacts everything (even if just a little bit; Slide 19), or if it is more specific to individual capabilities under consideration.

Does something impact everything or just specific capabilities / area of capability? Is the impact dependent upon another factor?

4.4.2.1 Deepening the Impact Assessments

One can consider the impact (characteristics) in multiple ways (Slides 21 – 26). FATE has trialed and adopted a few different approaches: (1) a Disruption Calculus of changes represented by the ability to respond in response to a game changing impact (Slides 21 and 24), and (2) on a regret scale in which the emotion of regret at not having a capability (sub-capability) or access to it is used for determining assessment of impact (Slides 22, 23) and in terms of when a change occurs:

1) Disruption Calculus = Game changing / Ability to respond, where when one can respond is in terms of the earliest and the latest.
2) Regret = Using emotion to aid assessment. Regret is known to provide a more emotive, and thus better, assessment (see Levitt, [42]).
3) When = Time of occurrence of an effect.

Preliminary observations of the impacts of the STS 'logistical autonomous delivery' on sustain capabilities in terms of four different future scenarios in relation to the time that they might occur is illustrated in Slide 25.

4.4.3 Iteration

The audit trail, although more cumbersome, allows the users to go back and revise and adjust assessments made earlier in the analytical process (Annex E, appendix II, Facilitators Guide). It also enables a deeper assessment focusing on identified areas of interest. For example, helping explain in more detail why things might have a high impact, or understanding why a certain scenario creates a lesser impact. For instance, Slide 20 shows a high impact in both FW 4 and 5 as a consequence of a different set of drivers and resisters, which, in turn, can provide planners an ability to prepare differently for either eventuality.

5.0 THE WAY AHEAD FOR FATE

5.1 Where to Use FATE

FATE has been designed for use where there is a need for:

- Anticipation;
- Exploration of a wider uncertainty;
- Avoidance of technological determinism;
- Addressing problems not addressed in other foresight approaches; and
- Taking into consideration of human and societal factors.

It is vital to note that FATE is not designed to be quick to execute or provide simple answers. Nonetheless, the effort to apply FATE is worthwhile for addressing complexity.

5.2 Exploitation of FATE

The FATE method is applicable to complex problems and consequently may be difficult to grasp easily from a cold start. A better understanding of FATE is facilitated by the papers written during its evolution (Adlakha et al., 2018 [1] and Maltby et al., 2020 [2]) and those that formed the basis for its application. The process of executing FATE resembles other methods within foresight and operations research in that it deals with complex problems and uncertainties associated with the future. What is new and core to the FATE method is the focus on the socio technical complexity in combination with the different layers in the MLP framework. FATE is also broader in scope than most approaches, as non-military components and evolutions are brought into its execution. Military questions often relate to technical systems and may miss the civilian role in the development of STS. Given that everything is constructed socially, no technology can stand alone (Slaughter, 2015 [43]). FATE allows planners to investigate contributions of non-technocentric disciplines.

In the use of FATE, knowledge of OR methods, project management, and facilitation skills are required. Experienced facilitators and/or analysts familiar with the use of OR tools will be able to run FATE based on the Guide for Facilitators (Annex E). To reach other analysts and to enhance its wider exploitation, the group recommends the development of a NATO Research Lecture Series. This could include a worked-out example with practices for participants that are filmed facilitating access to those that are unable to attend the lectures and for access later in time.

Each of the four steps of FATE can be regarded as an independent module, where each module consists of different analytical elements that may prove useful in of themselves for other research solutions. An example is the work on a deeper exploration of an STS, as was done by the Turkish Aviation Industries. Scenario analysis is a widely used method which is modified and applied in step 2. Modules and/or elements of FATE could be used in other processes for example by other SAS RTG or NATO STO panels. Thus, the group recommends an application of FATE in its entirety or one of its modules to other NATO SAS Exploratory Teams or Task Groups considering future developments.

The research by NATO SAS-123 led to the development of the FATE method for use in a participatory workshop setting. The problem sets to which FATE applies could also be potentially explored in a distributed design setting whereby individuals complete the process independently which is then followed up by a comparison of results at the end. This may be a more efficient means to use FATE when options for face-to-face interactions are limited. However, if the entire FATE method is conducted in a distributed manner one risks the loss of arriving at a common understanding of complex problems, as well as reducing the possibility of producing relevant insights and “so whats” which require interaction. The optimal option may be a hybrid version of a workshop and individual response. Individual information gathering is complemented by a face-to-face or online discussion. While the current development of analysis of impact was mainly done on table-based calculation software like Excel spreadsheets, other online platforms could enable a more expedient way of data analysis. For example, the FutureScraper, a platform trialed by the UK MOD (https://www.futurescraper.com/#about).

Overall, a recommended option for the use and exploitation of FATE is a hybrid form of FATE, one that incorporates an individual/online survey approach followed by a face-to-face/online workshop.

5.3 Recommendations

Recommendations for the way ahead for FATE include:

1) Conducting a follow-on NATO Research Lecture Series using a worked example to help the exploitation of this work and recording the series.
2) Other NATO SAS Exploratory Teams and Task Groups undertaking research on developments in the futures consider applying FATE or one of its steps to advance their research objectives.
3) Consider a hybrid form of FATE – individual/online survey approach followed by a face-to-face/ online workshop as an alternative means for exploitation of FATE.

5.4 Conclusion

Futures work tends to be rather linear, deterministic and techno centric. However, the interaction of humans and social factors is much more important than it is often given weight.

> *"Developing the technology turns out to be a lot easier than getting people – and particularly companies – to use it properly"* [44].

It is with the intent to address this gap that the FATE method was created.

FATE provides an anticipatory answer by examining the STS itself, implications of the convergence of STS and scenarios and how this subsequently impacts on Defence and Security.

FATE provides a structured way to understand:

1) How technology links to the social factors (addressed in FATE through STS);
2) How changes in the technology and social factors in combination might evolve (observing differences between Futuristic STS and Baseline STS);
3) How Future STS might manifest in different scenarios; and what that might mean for Defence and Security.

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Annex A – PROGRAM OF WORK: NATO SAS-123

A.1 PROGRAM OF WORK OF THE NATO SAS-123

RTG SAS-123 Technical Activity Description

TOPICS TO BE COVERED:

- Develop method(s) to study the interactions between diverse futures and socio-technical evolutions concurrently
  - Develop criteria to evaluate and analyze the interactions between the two variables
  - Assess the ability of these two variables to cause disruptions in defence and security

Program of Work

1) Identify means[1] to develop diverse futures
   - "Develop" replaced through consensus with utilize pre-existing scenario narratives of diverse futures.
2) Identify means to detect and recognize socio-technical evolutions
3) Develop* the means and criteria to study the interactions between diverse futures and socio-technical evolutions concurrently
4) Assess* potential impacts of socio-technical systems relevant to defence and security within diverse futures (proof of concept)

   *Steps 3 and 4 are iterative

DELIVERABLES:

1) Final Technical Report
   - The FATE method(s)
   - List of potential socio-technical systems' impact relevant to defence and security within diverse futures
2) Symposium
3) An inventory of identified means including, but not limited to, methods, tools, institutions, recognized experts for studying futures and socio-technical evolutions/systems

[1] Including but not limited to tools, methods, resources.

Annex B – INVENTORIES

In accordance with the Program of Work, this annex provides a range of methods and tools used in the field of foresight studies as well as academic or other institutions where researchers can be reached.

B.1 METHODS AND TOOLS

This annex provides an overview of methods and tools used in the field of foresight (see Program of Work, Annex A). Some of these methods and tools formed the basis for the development of the FATE method.

A subset of the methods and tools explored within SAS-123 is listed in Table B-1. This list is neither exhaustive nor specific to either scenario building or STS.

Table B-1: A Selection of Methods Used in Foresight Studies.

• Brainstorming	• Literature studies	• Fault tree analysis
• Delphi method	• Scientometric studies	• Trend analysis
• Expert opinion	• Technology radar	• Scenario technique
• Interviews	• Mind mapping	• Storytelling
• Surveys	• Technology road-mapping	• Impact assessment
• Crowd sourcing	• Logical reasoning	• Multi-criteria decision analysis
• Workshops	• 2 x 2 matrix	• Future visions
• Games	• Morphological analysis	• Futures wheel
• What ifs	• Wild cards	• Fault tree analysis

A subset of methods explicitly considered when developing the FATE method is tabulated in Table B-2.

Table B-2: Methods Relevant to the Development of FATE Method.

Method Title	Source (company, author, etc.)	Description	References
Pictures of the Future ™	Siemens AG	Two strands, both originating in current situation description: • Extrapolatory road-mapping from present to mid-term; and • Strategic visioning -scenarios for Siemens sectors – normative road-mapping (retrospective extrapolation from long-term to mid-term. Based upon that, a detailed scenario is sketched comprising all important influencing factors (socio-economic, political, ecological, and technical) for a selected time horizon that may be specific for one sector-align extra- and reverse-engineering (retropolation) to identify tasks and milestones crucial for striving for and reaching the visionary goal.	Pilkahn, 2008 [1]

Method Title	Source (company, author, etc.)	Description	References
Scenario Technique	Gausemeier (scenario management)	• Topic identification and definition of overall goal. • Define area(s) of interest (while excluding other areas). • Analyse the area(s) of interest: Identify key influencing factors. • Describe possible states of key factors, cross-check factors for consistency. • Build a raw scenario based on key factors, states and interdependencies. • Refine and sharpen few selected scenarios. • Find potentially game changing incidents (subject-related wild cards). • Check scenarios for stability. • Analyse consequences for your unit. • Search for early indicators. • Propose possible actions (pro and counter actions). • Refine possible measures, combine to a strategy. • Focus: either explorative or normative (last four steps are especially important).	
Delphi Method	RAND	The Delphi Method is a forecasting process framework that solicits the advice of subject matter experts. A panel of experts is sent multiple rounds of questionnaires, their anonymized responses are aggregated and shared with the group after each round[1].	Helmer-Herschberg, 1967 [2]
Multi-Level Perspective		The multi-level perspective is an analytical tool that attempts to deal with this complexity and resistance to change. Focussing on the dynamics of wider transitionary developments as opposed to discrete technological innovations, the MLP concerns itself with socio-technical system transformations, particularly with transitions towards sustainability and resilience (Geels and Schot, 2007) [6]. As the name implies, the MLP posits three analytical and heuristic levels on which processes interact and align to result in socio-technical system transformations: landscape (macro-level), regimes (meso-level) and niches (micro-level).[2]	Geels, 2002 [3], 2004 [4], 2011 [5]
Impact assessment	e.g., Umwelt-bundesamt (German environment agency)		

[1] Adapted from https://www.investopedia.com/terms/d/delphi-method.asp. Accessed on 3 March 2020.

[2] Adapted from https://en.wikipedia.org/wiki/Technological_transitions. Accessed on 3 March 2020.

Method Title	Source (company, author, etc.)	Description	References
Antifragility approach			Taleb, 2012 [7]
A combination of scenario planning and antifragility	UK		Derbyshire, Wright, 2014 [8]

A list of users of these tools is listed below. Other stakeholders use scenarios specific to topics like risk/crisis management, defence, forestry, environment, and climate studies. The concept of socio-technical systems used since the seminal work of Trist and Bamforth 1951 [9] and explicitly defined by Bostrom and Heinen in 1977 [10] may be directly considered, but their combination with scenarios is rare. More often, the widening of scope into the social domain is skipped or considered indirectly, generally by taking external factors through STEEP framework or its variants into account [11], without the use of a systematic systems-based approach. Early use of the concept of socio-technical systems seems to be prevalent in design, systems engineering, enterprise systems modelling and strategy organizations [12], [13].

Known users of tools such as future scenarios include the following organizations:

- Shell GBN.
- World Economic Forum.
- Club of Rome.
- NATO Allied Command Transformation (ACT).
- Military tactical scenarios (nation specific).
- RAND.
- Future Operating Environment (GBR).
- Joint Operating Environment (USA).
- US Office Tech. Assessment.
- Departments of Defence (AUS, USA) and Ministries of Defence (e.g., DEU, GBR, NLD, RUS).
- National Risk Assessment (e.g., CH, NLD).
- Innovation Platform (e.g., NLD).

B.2 ACADEMIC AND OTHER INSTITUTIONS

Interested stakeholders would be able to consult researchers within the following types of organizations:

- Aarhus University, School of Business and Social Sciences, Denmark.
- Copenhagen Institute for Futures Studies, Denmark.
- ETH Zurich, Switzerland.
- Free University of Berlin, Department of Education and Psychology, Institut Futur, Germany.

- Institute For The Future (IFTF), USA.
- Institute for Futures Research IFR, USA.
- Ontario College of Art and Design University (OCAD), Canada.
- University of Houston, College of Technology, USA.
- University of Denver, The Pardee Center for International Futures, USA.
- University of Trento, Department of Sociology and Social Research, Italy.
- University of Turku, Turku School of Economics, Finland Futures Research Centre, Finland.
- University of Technology Sydney, Institute for Sustainable Futures, Australia.

B.3 REFERENCES

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[2] Helmer-Hirschberg, O., (1967). Analysis of the Future: The Delphi Method. Santa Monica, CA: RAND Corporation.

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[9] Trist, E.L. and Bamforth, K.W., (1951). Some Social and Psychological Consequences of the Longwall Method of Coal-Getting. Human Relations, 4(3), pp. 3-38.

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Annex C – SOCIO-TECHNICAL SYSTEMS

Listed below are all the Socio-Technical Systems (STS) that were either client questions (STS numbers 10, 11, 13 – 15 below), worked out or trialed at different junctures during the research term of the NATO SAS-123. A valuable source of other STS is the book Societal Transformation by Linturi and Kuusi, 2018 [1], which explores 20 regimes and 100 anticipated radical technologies:

1) Production systems/manufacturing.
2) Data.
3) Education.
4) Personal mobility.
5) Electricity/Energy.
6) Currency.
7) Water.
8) Trust.
9) Ethics.
10) Last Mile Delivery using Autonomous Transportation, used at Trial, see Maltby et al., 2020 [2].
11) Personal identification through electronic means*.
12) Augmented Reality / Virtual Reality.
13) How will the development of VR impact Force Protection?
14) Social media platforms as broadcasters.
15) How could wearables affect urban operations?

It should be noted that socio-technical systems 1 – 9 are also cited in Adlakha-Hutcheon et al., 2018 [3].

*As the thinking of the team developed it was proposed that technology centric topics proposed by clients be expanded into a question format to facilitate elaboration of components of an STS for easier utilization within the FATE method. This is exemplified by the topic on Personal Identification through electronic means. This could be better explored in the form of "How would Personal Identification through electronic means (social media, so a person's presence or lack thereof on social media may identify them) affect operations, particularly intelligence operations?" Other questions proposed by the team that merit exploration through FATE include:

1) How would Human Augmentation (mechanical, biological, cybernetic, or anything else) from a combatant and non-combatant point of view impact operations? A version of this question was examined by FATE trialed at The Institute for Military Technology in Denmark independent of the presence of the NATO SAS-123 team (STS #15 above).

2) How would digitalization of personal and sensory data, its processing and AI affect operations?

3) How would a world divided along possession or lacking access to technology with the potential of trade war and one comprised of technophiles and technophobes affect the adoption of military AI technologies?

C.1 REFERENCES

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[2] Maltby, J.F., Bown, K.J., Adlakha-Hutcheon, G., Lindberg, A., Molder, C., Peters, C.E., Rizzo, G., and Roemer, S., (2020). FATE Method Trial: Trial of the Method Developed Under the Futures Assessed alongside socio-Technical Evolutions (FATE) NATO SAS-123 Research Task Group within the British Dstl publishing DSTL/TR112178, Enclosure 2.

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Annex D – PRESENTATION AT ANTICIPATION 19 CONFERENCE

This Section provides a copy of the abstract that received blind peer-review for the conference entitled 'ANTICIPATION 2019' following which a presentation was invited at the dialogue session of the conference. The PowerPoint presentation made to initiate the dialogue session at the conference forms the Appendix to this Annex.

Title: FATE – A Method Designed to Anticipate Socio-Technical Evolutions

Presented by: Dr G. Adlakha-Hutcheon on behalf of the NATO-SAS-123 team of K. Fosher, A. Lindberg, Z. Lim, J.F. Maltby, C. Molder, C. Peters, G. Rizzo, S. Roemer, A. Temiz, and M. Tocher

Traditionally the realm of defence seeks technological might through acquisition of better equipment. With such a focus on gaining a technical capability advantage, often scant attention is paid to social, economic, legal or environmental factors that shape technological diffusion. Increasingly the private sector dominates the development of technologies instead of states or governments. Furthermore, researchers in the field of future studies tend to guestimate the trends that will prevail in the future; others extrapolate such trends into scenarios of the future; and still others focus on forecasting disruptive technologies. Few study the intersection of disruptive technologies relative to a scenario described at a specific time set in the future. Thus, a method that enables a simultaneous examination of both is needed.

The North Atlantic Treaty Organization Systems Analysis Studies Research Task Group 123.

(NATO SAS-123) was created with just such an intention. Its objective is to study over a three-year term the interactions between diverse futures and socio-technical evolutions concurrently. It was formed in particular to assess the ability of these two variables to cause disruptions in defence and security. The novelty of the study meant that there was interest from a third of NATO member nations and NATO Allied Command Transformation (NATO ACT). Our NATO SAS-123 study group has designed a method titled Futures Assessed alongside socio-Technical Evolutions (FATE). We believe this work to be of use for decision-makers, as it facilitates their ability to make better informed decisions on socio-technical disruptors in the context of described futures.

The FATE method relies on examining a technology and social factors as a part of a socio-technical system (STS). It consists of four steps that start with the selection of an STS and its deconstruction into Organization, People, Policy, Technology and Infrastructure or OPPTI. A baseline STS is established as understood in the present by considering how an STS develops across OPPTI in the present. Step two involves selecting pre-described narratives of future states of the world and elaborating these into TEMPLES or Technical, Economic, Military, Political, Legal, Environmental and Social elements; step three looks at the intersection of the two by placing the STS in the future scenario. In step four, the impact of the interaction is assessed by identifying drivers and resistors that impact the STS.

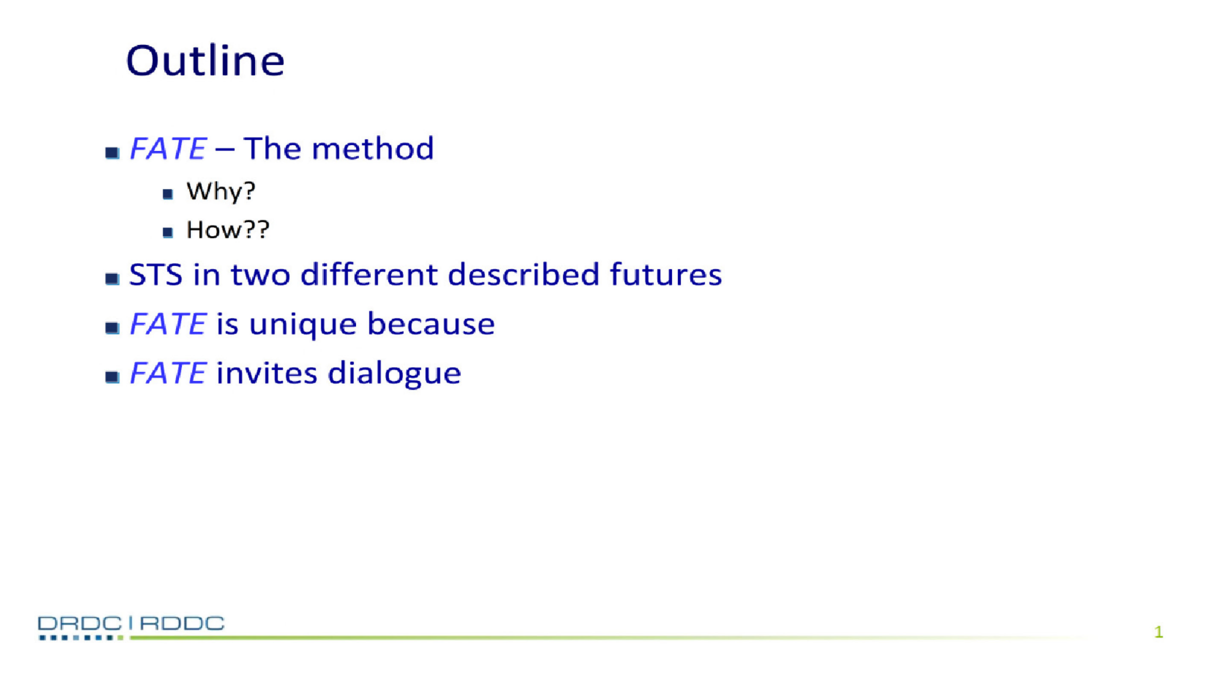
It should be pointed out that an early iteration of our approach was presented at ANTICIPATION in 2017. Through the feedback from the Anticipation Community among others, our idea has matured into a method, a means to derive practical insights for informing action from framed futures.

It has since been revised after running a trial with participants not familiar with the method using the case study of Logistical autonomous systems (delivery to frontline by autonomous means). Examples of emerging technologies and their fate in about 15 years from today will be presented. The team's contention is that the FATE method is a collaborative action in the present that will help increase one's sensitivity to assumptions missed when planning for the future. Since the method relies on participation across disciplines it necessitates an active understanding of others' context which in turn, fosters commitment to decisions about the future.

Furthermore, as it transcends time horizons in looking at an STS in a future scenario relative to the current time, it is a representative of work in the present to anticipate actions for the future.

It is our belief that FATE is a much-needed anticipatory practice for decision professionals, one that enables awareness of drivers and resistors for determinants of disruption.

Appendix D1: PRESENTATION AT ANTICIPATION 19 CONFERENCE



Why *FATE* ?

The idea:

FATE – a means to conduct:

A concurrent assessment of **socio-technical** systems within imagined future scenarios

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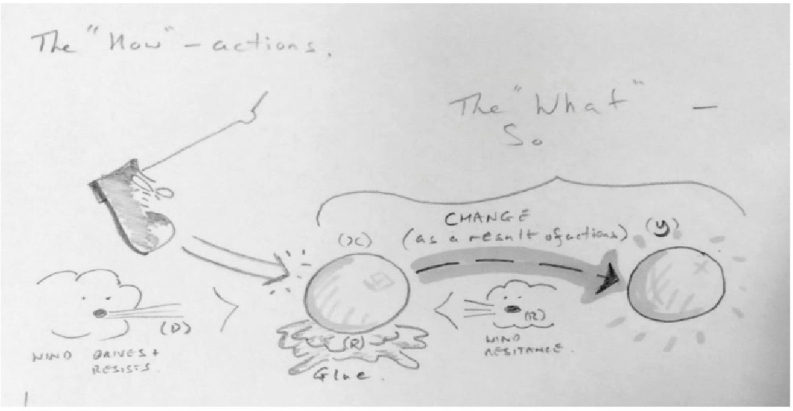

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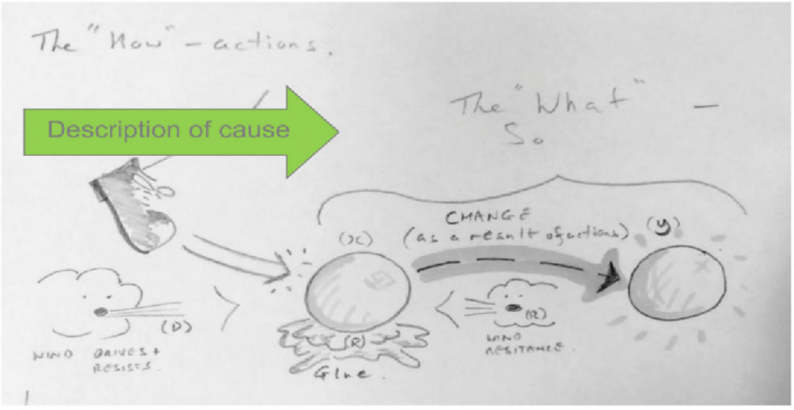

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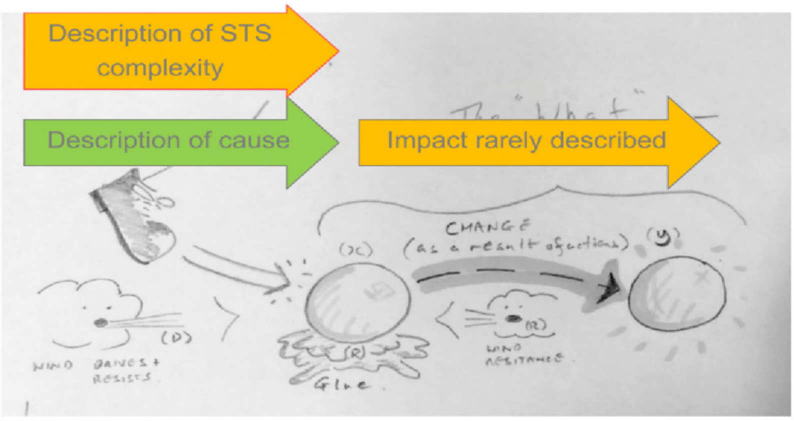

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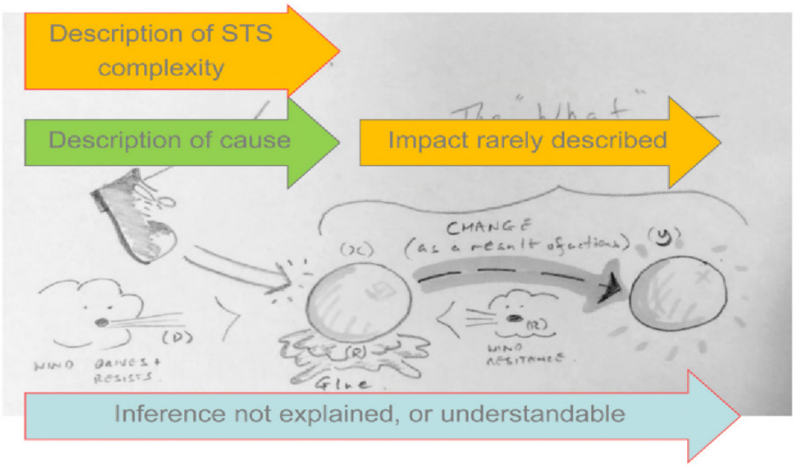

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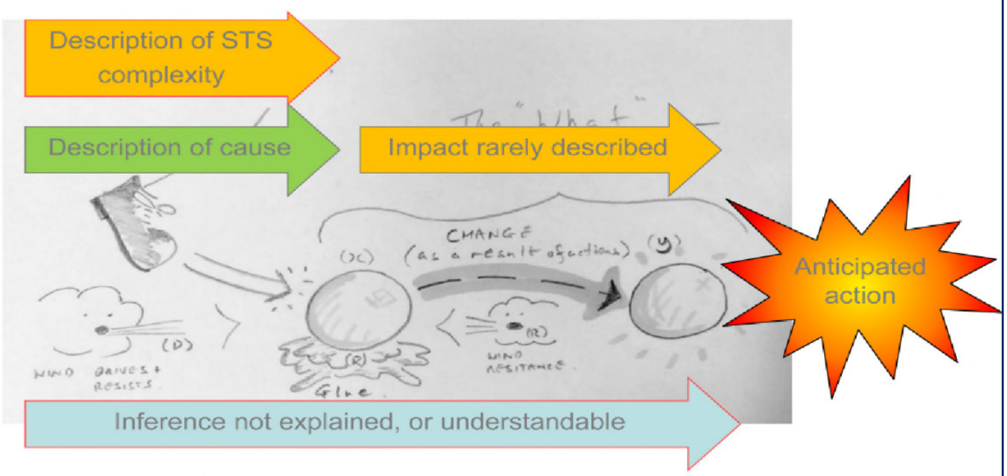

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The FATE Method

A problem – scope it as a Socio-Technical System (STS)

- **Step 1 – Socio-Technical System (STS)**
  Elaborate STS in to Niche and Regime levels and then with *OPPTI** ontology
- **Step 2 – Future scenario**
  Adapt a scenario into *TEMPLES#* if required
- **Step 3 – Interactions between future scenario + STS**
  3.1 How do you see the STS evolving?
  3.2 How do you see the STS in the described future scenarios?
  Output: personal, group insights, drivers and resisters (D and R) for scenarios from baseline STS in relation to *TEMPLES* derived from future Scenarios
- **Step 4 – Assess the impact on defence and security e.g. wrt capabilities**

Output: Impact mitigation options for client/customer from at least two scenarios

 # TEMPLES – Technological, Economical, Military, Political, Legal, Environmental and Social
** OPPTI – Organization, People, Processes, Technology, Infrastructure*

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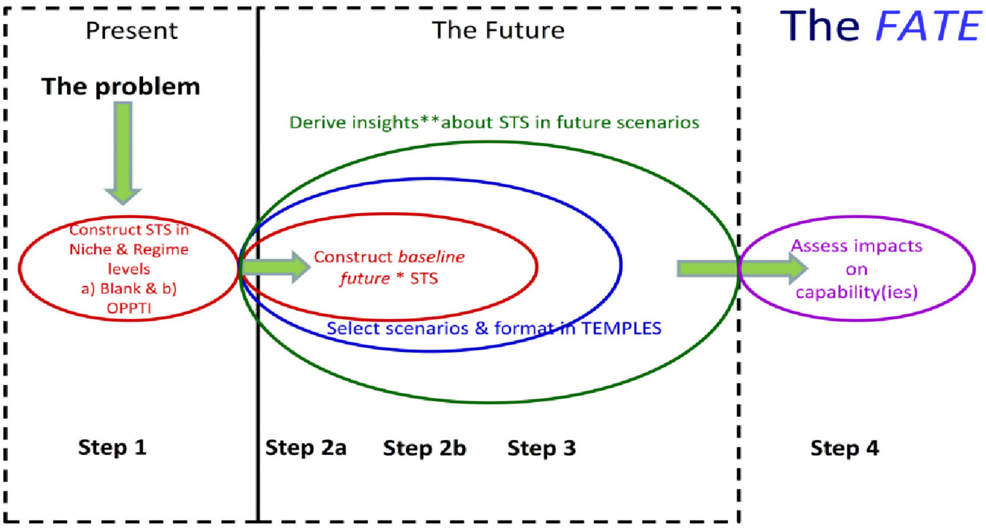
The *FATE* Method



* *Baseline future* is an idealised *extrapolation* of what is emerging today
**Insights from analysis, changes in STS, drivers and resistors of change in future scenarios and/or STS

DRDC I RDDC 9

FATE – a work in progress with examples

DRDC | RDDC 10

Step 1 – STS, examples

- Personal mobility
- Logistical autonomous systems
  Last mile logistics, i.e. delivery to frontline through autonomous means

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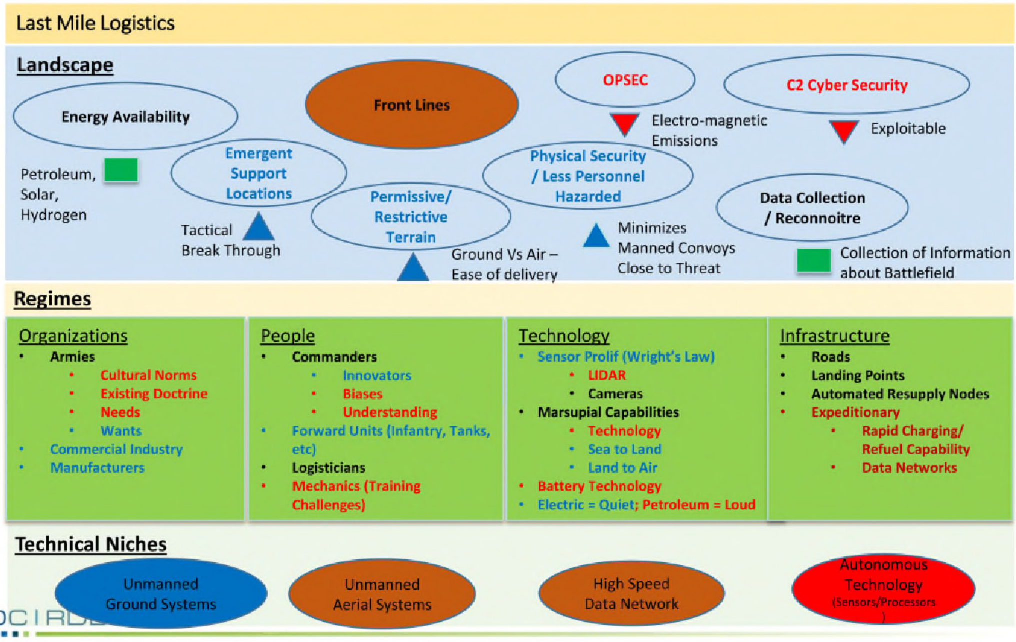
STS – Delivery to front lines by autonomous means



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Step 2 - Future scenarios

- *FATE* uses pre-described states of the world, e.g. Future worlds™ (FW)
- FW differentiated along 3 axes:
  - Global power dynamics
  - State control
  - Resource sustainment
- FW 4 and 5
- FW 2 and 7

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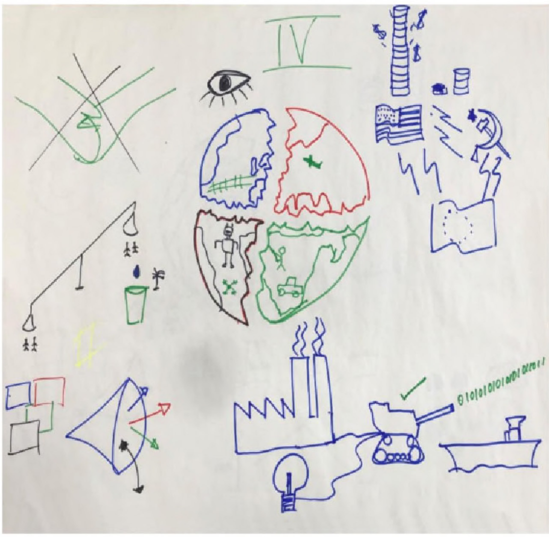
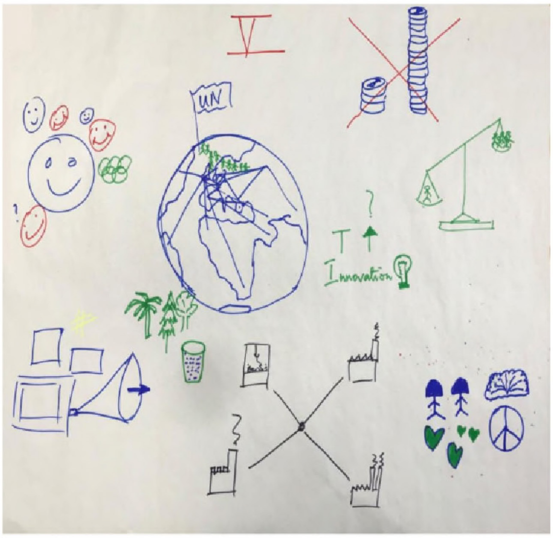
Step 2 – FW 4 and 5





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Step 2 – FW 4 and 5

TEMPLES	Future World 4
Technological	-Innovation is driven by the military sector. Positive drivers for technological growth pervasive presence in main aspects of life (transport, work, networking…)
Economic	-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
Military	-Called to operate in multiple contested domain with multipurpose assets
Political	-Fragmented world, strong regionalism. -Strong control through extensive global intelligence. --Large regional powers in contrast
Legal	-Lack of standards
Environmental	-Resources are scarce
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.

TEMPLES	Future World 5
Technological	-Technology is flourishing and is favoured by deep innovation
Economic	-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	-Armed forces are present mainly for resolving small-scale sub-regional hot spots without the need for global intervention
Political	-Strong global cohesion. -The UN is the main governing body for resolving disputes and procuring funds. -Numerous lobbyist entities with contrasting interests
Legal	-Standards that are well supported
Environmental	-Resources are abundant
Social	-Income is satisfactory for everyone and there are no sharp inequalities ranging across social groups. Societies are cohesive and supportive. -Media outlets are homogeneous.

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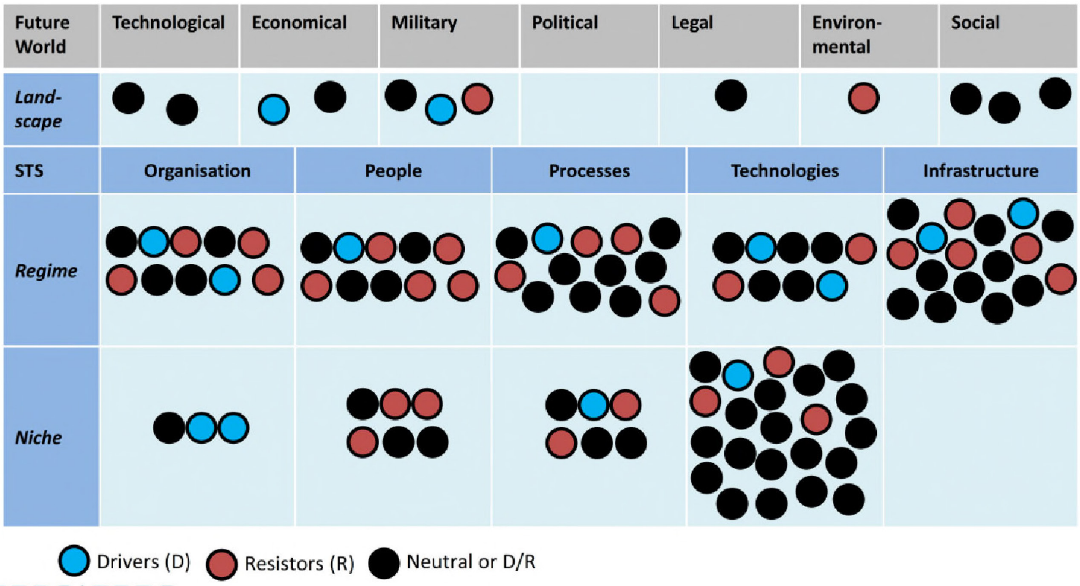
Step 3 – STS in Future world scenarios



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What does *FATE* mean for Defence and Security?

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Steps 4– Relevance for Defence and Security

- **Impact** assessed using the following questions:
  1. Do the changes in *Future* STS impact Defence and Security (D&S) capabilities?
     1. Assess the potential for impact (Y/N)
     2. Assess the probability of impact coming true (high/Low)
     3. Assess the "level of regret" (A, B, C, D)
  2. What are the Drivers and Resistors of changes?
  3. Are impacts from *Future STS* coupled in different scenarios?

- **Propose Options for Mitigation of impact**

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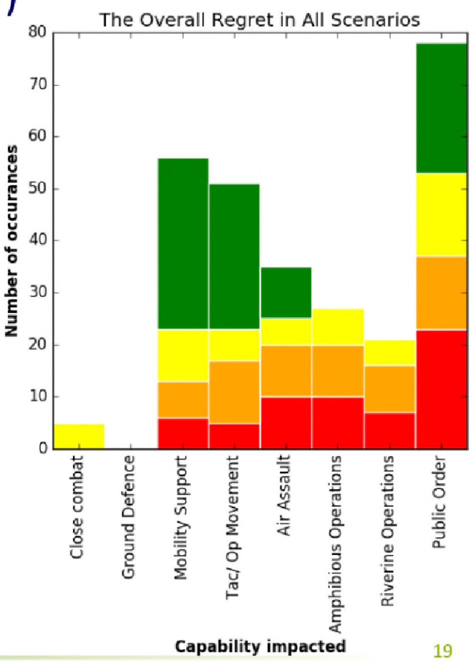
Impact is on: (Defence and Security)

- Defence and Security has well defined Frameworks to describe its capability
- Using these Frameworks we can ascribe if there is impact on those capabilities
  - Does something impact everything or just specific capabilities/ area of a capability?
- Then we characterise the impact i.e. is it of significance?



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Preliminary observations – impacts on sustain capabilities

Scenario	FW 4	FW 5
Drivers	• Fractured world • Need for better defence regionally	• Standardization • Innovation • Interconnectivity • Global industry
Resistors	• Isolationism (only countries with resources are able to develop autonomous solutions for last mile) • Regime level bullets regarding standards, data-driven logistics • Integration possible on a global/multi-actor environment	• Global stability discourages military innovation • Immature technologies
Impacts	High impact Weak infrastructure Transient networks Each to their own	High impact New vulnerabilities in infrastructure Distributed networks Commercial + ethical issues

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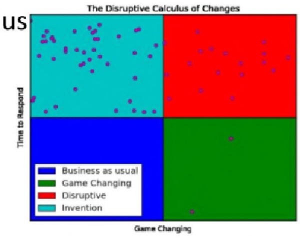
We can consider the impact (characteristics) in multiple ways

Disruption Calculus = Game changing / ability to respond

Regret = Using emotion to aid assessment

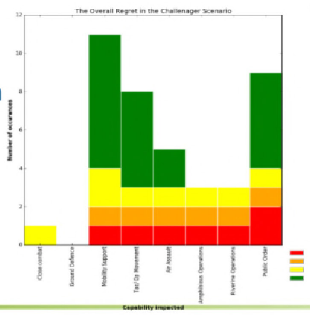
Time = earliest and latest it could occur

Disruption Calculus

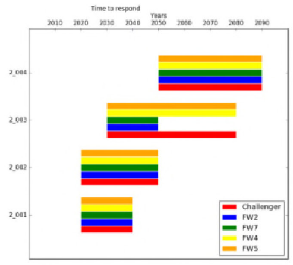


Regret

Provides a more *emotive*, and thus often a better assessment.



Time



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Impact

On a scale of regret and disruption in capabilities

Description	Total number	Scenario					List of top five Changes
		Challenger	FW 2	FW 7	FW 4	FW 5	
High regret impacting in most capabilities*	#	#	#	#	#	#	- Xsakdjfdka - Xsakdjfdka
Disruptive and impacting in most capabilities*	#	#	#	#	#	#	- Xsakdjfdka
High regret and Disruptive impacting in most capabilities*	#	#	#	#	#	#	- Xsakdjfdka
High regret and Disruptive impacting in any capabilities*	#	#	#	#	#	#	- Xsakdjfdka - Xsakdjfdka - Xsakdjfdka

*would be all but no impact in all in the dataset (max = 6/8 ~ most).

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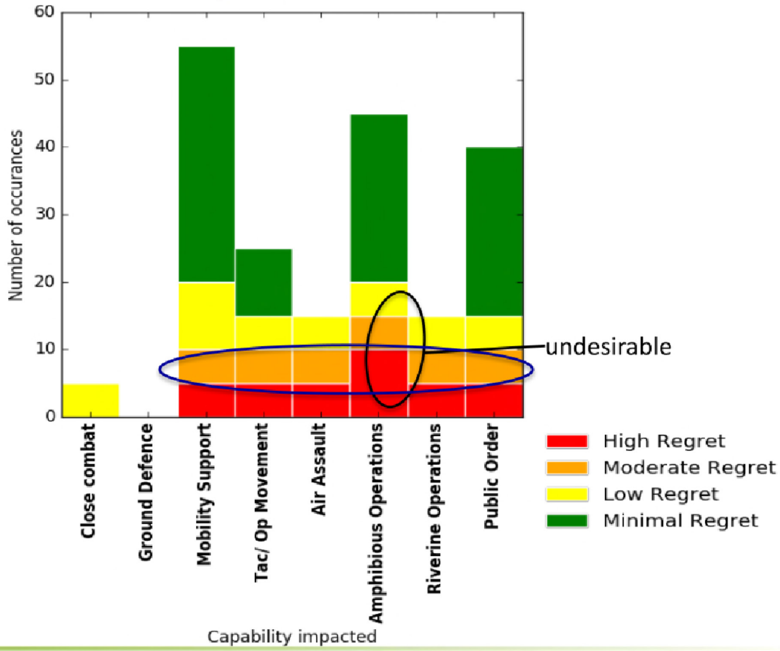
Impact relative to sub capabilities



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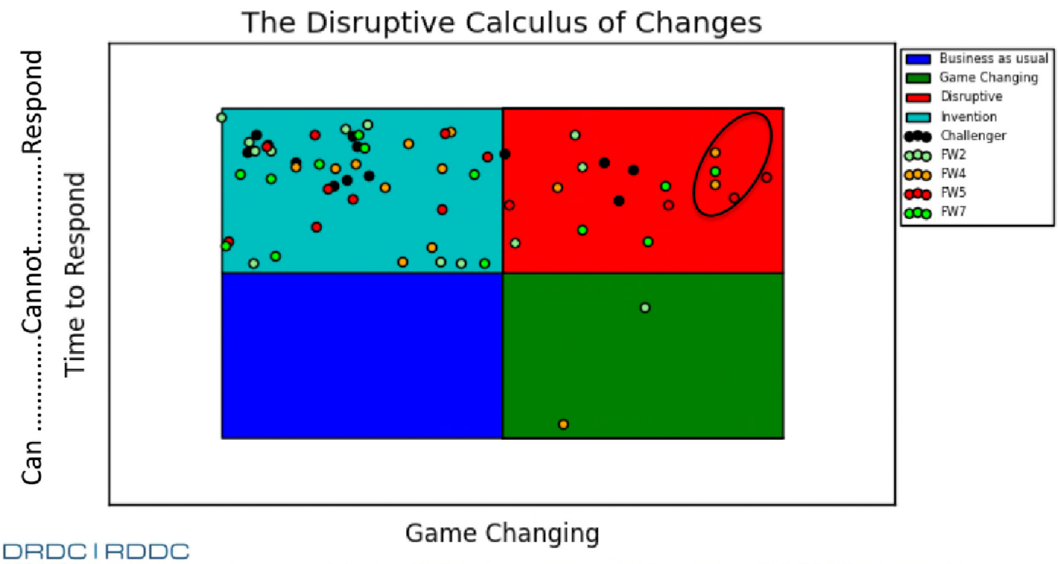
Another way of visualizing Impact – a calculus of change



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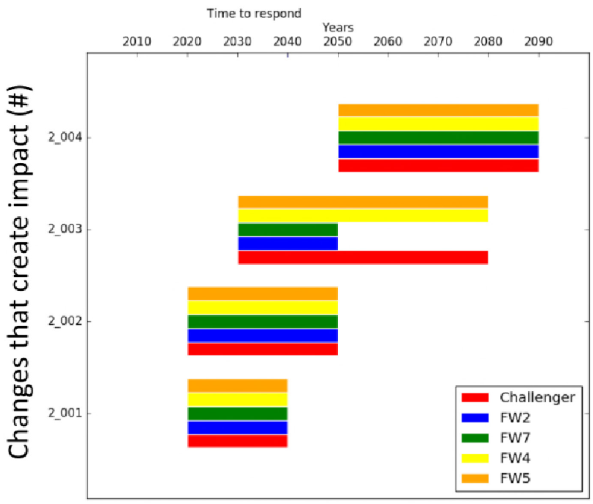
Changes cross different future in Time of their occurrence



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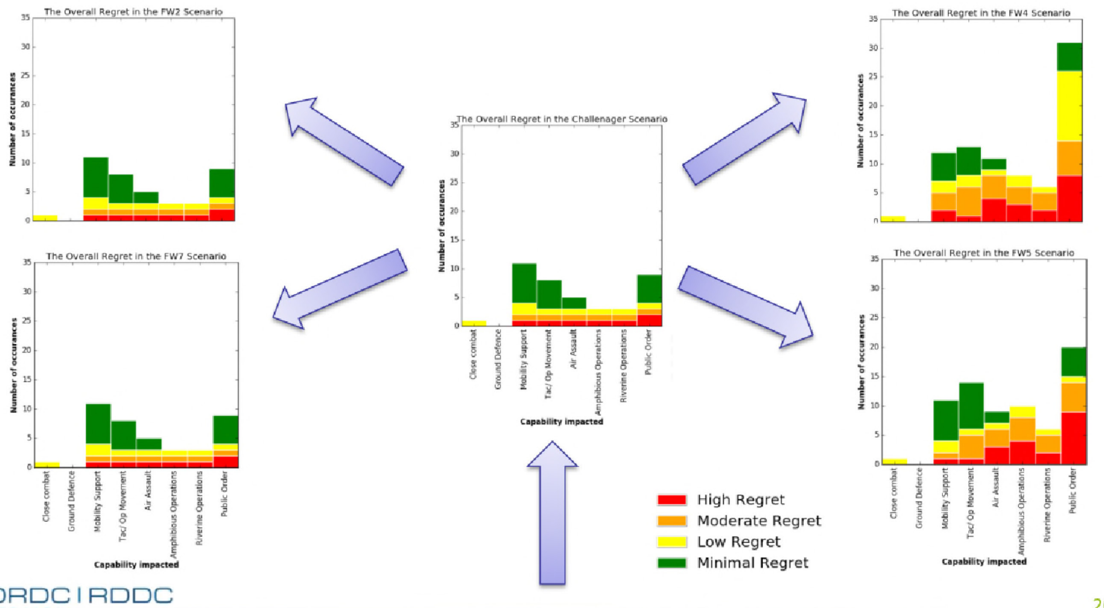
Are impacts from STS coupled in different scenarios?



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FATE is unique because it takes

- A multi-disciplinary examination of transitions of technologies
- An understanding of complex interactions that enable transitions
- An awareness of Drivers and Resisters

- All above in the context of Defence and Security
- All facilitate our understanding of how disruptions may occur, how to plan for them, how not to have regret….

………………………and thus *FATE* provides an *anticipatory* answer

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FATE would be even better if….

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SCIENCE, TECHNOLOGY AND KNOWLEDGE FOR CANADA'S DEFENCE AND SECURITY

SCIENCE, TECHNOLOGIE ET SAVOIR POUR LA DÉFENSE ET LA SÉCURITÉ DU CANADA

Theoretical foundation

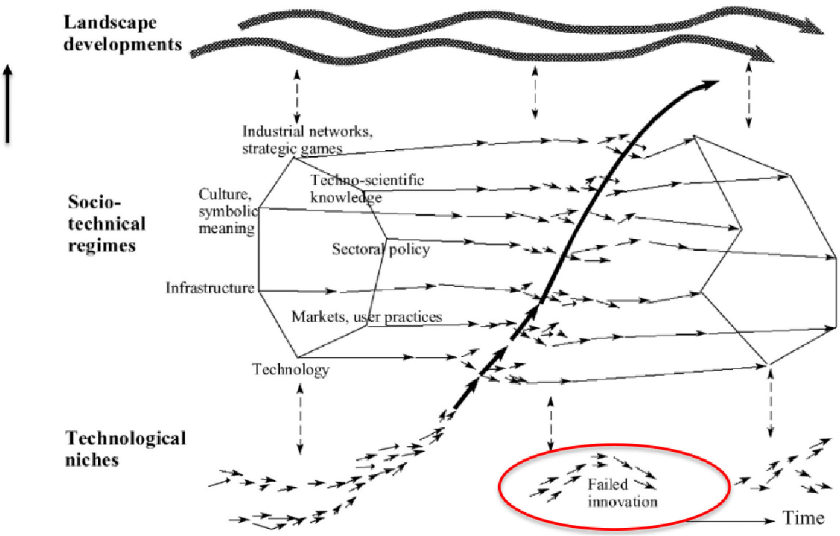
- Detection of technology transitions by looking at changes in both socio and technological aspects of systems
  - Theoretical base – adaptation of a body of work by several social scientists including Geels, Derbyshire, Bishop & Hines, Inayatullah, Curry, & Schultz, Splint & van Wijck

- Technical transitions across niches, regimes and landscapes examined retrospectively by Geels among others, we are using a prospective approach

- Signposts that indicate when technologies are moving out of niches that have allowed them to grow
  - These signposts can be derived from analyses of future scenarios to provide indicators where the technologies described in the scenario begin to breakout based on changes in socially set regimes and landscapes

DRDC | RDDC

Socio-technical transitions



Geels FW (2002, 2010)

DRDC | RDDC

Annex E – FACILITATORS' GUIDE

This Annex is the guide for facilitators to use in employing the FATE methodology (to be referred to as FATE henceforth in this Annex). It is recommended that FATE be applied with stakeholders and participants possessing relevant expertise in a workshop setting. This guide provides the instructions and associated tables for facilitating the application of FATE in such a workshop.

List of Figures

List of Tables

E.1 PREPARATIONS REQUIRED PRIOR TO THE USE OF FATE

Establishing the Use Case for FATE with the client.

First and foremost, the Use Case for the method needs to be clearly established. Towards this end, there must be a dialogue between a user of FATE (to be referred to as the "client" henceforth) and the project lead and/or the facilitator to understand the client's objectives and how the FATE method could be used to address them. This may include determining the client's interest(s) in the Socio-Technical System (STS)[1] or a sub part thereof. Often, an STS in the context of Defence could impact an important capability or be a key enabler for important capabilities, sometimes a part of an STS may even be a capability; in which case determining what is the socio-technical context relevant to the capability(ies) the STS provides/enables, and what are the future developments of interest to the client that could be affected by understanding STS evolutions becomes relevant. For example, possible component technology and/or social development that could affect the performance, availability or relevance of a capability.

At this time, the method specific details such as formulation of questions to be answered, choosing an STS and pointing to possible scenarios, proposing dates, venue and possibly participants for the workshop are also explored.

[1] "Socio-Technical Systems (STSs) are made of two systems that differ yet overlap–the social and the technical. They are entangled and influence each other [1]. These were initially defined by Bostrom and Heinen in 1977 [2], [3], who assumed that an organization or "organization work system" can be described as an STS." "... formal definition of STS is an open-system of interlinked social and technical elements (a mixture of Organisations [includes policies], People, Technology, Infrastructure [includes processes], etc.) with properties to enable performance of certain functions."

The client's objective and the problem to be answered is noted and this is framed into an STS as:

How could an STS evolve in different futures?

What could be the consequent potential impacts of STS evolutions on the client's objective(s)?

Output of Preparations: which STS and examples of scenarios to use, notes on the question to be analyzed, client's objectives agreed upon by client and project lead, the budget, and practical details such as access to workshop participants.

E.2 EXECUTION OF FATE WORKSHOP

This Section provides a step by step guide for executing FATE, whose four steps in general are performed in a workshop setting.

The workshop could adopt the following generic agenda:

- Welcome and Context Setting:
  - Introduction of the client question and issue to be discussed;
  - Introduction to FATE and process of work;
- Introduction of participants with or without an Ice breaker activity;
- Apply Steps 1 to 4 of FATE; and
  - Wrap up and end of workshop.

Participants. The workshop participants are identified and invited in relevance to the client's specific interests, ideally these should include those with expertise related to the STS (e.g., technical experts, sociologists, behavioural scientists, economists, philosophers), operational users and planners of the capability(ies) of interest and general analysts from the futures domain. Where possible, the elaborated use case, including the selected scenario(s) should be shared with the participants prior to the workshop.

Workshop Setup. The method requires regular workshop facilities equipped with a projector, white boards, flipcharts, post-it notes, marker pens etc. Ensure that the meeting room is suitable for group interactions, as well as one that enables individual thinking and recording at place, discussion of individual in/output, and working around wall/flipchart stands.

Introduction to the workshop. At the start of the workshop, participants are introduced to FATE method, the workshop, one another and the activities of the workshop. This includes at a minimum:

- An introduction to the client question, set in a context to better understand the objectives to be addressed through FATE;
- A presentation of the steps in the FATE method;
- Information on how the inputs of each step and their results will be used; and
- Further involvement of participants and communication with them after the workshop.

E.2.1 FATE Step 1: Build the STS

What: Build a Baseline STS.

In this step a Baseline STS is created with all socio-technical components as known in the present time. This Baseline STS will form the basis for assessing the impact of future scenarios on the STS in subsequent steps.

Required Input	1) Key technology (or societal issue) of interest to the client formulated as STS or to be formulated as STS if the STS does not already exist. 2) Participants with expertise relevant to the STS.
Output	• A Baseline STS created with its components identified. • A preliminary list of insights on the components of STS and/or a relationship between them with perceived relevance to the future.
Time Needed	1 – 2 hours.

How: Participants brainstorm or discuss the socio-technical context of the STS into all components known **today**. This STS set in the current context constitutes the Baseline STS. Components that will become relevant in the near term may be included. To facilitate the subsequent impact assessment, the STS components should fit into the broad structure as shown in Table E-1.

Refer to Appendix E1 – A Sample Mind Map for FATE for an example of a template for a constructed STS. The facilitator guides and notes on whiteboard using the template structure found in Appendix E2. Insights on the components of the STS or the relationship between them that if changed could affect the capability(ies) in terms of performance, availability etc. are noted on a separate whiteboard. This data will be used for further analysis in Step 3.

Process in detail:

1) Develop Baseline STS by:
   a) Brainstorming: What are the components and systems that make up the Baseline STS? Results are documented in the STS template. For example: participants write individual notes on Post Its, which are then presented. The facilitator notes or places these inputs into the STS template, using the levels of Landscape, Regime and Niche as well as OPPPTI (*Step 1.1 on the Datasheet).*
   b) If/When the brainstorming stalls, the facilitator may use the mind map structure of OPPPTI[2] to revisit and revise the results of the brainstorm.
   c) Identification of perceived relevant components that might change (or relationships between components in the STS). The facilitator asks the participants which components/combinations of components of the STS that are the most relevant for the future, and may develop in relationship to client question? And why? (*Step 1.2 on the Datasheet).*
2) The facilitator and the analyst document insights on the client question and/or on the STS itself on a separate whiteboard, if possible, relating the insights to components or relationships between components in the STS.

It is useful to note that while a Baseline STS with greater granularity could lead to more insights during subsequent analysis, adding more details to the Baseline STS beyond identifying the key components are likely to have diminishing returns. Also, the Baseline STS can be updated subsequently in the Step 3, if required.

Similar to the STS components, the list of insights, and drivers/resistors can/is expected to be updated in Step 3, as a consequence of an interaction with a context of the future provided by a scenario.

[2] A Sample Mind Map for FATE.

When facilitating Step 1, the facilitator can invite participants to write their contributions (STS components and drivers/resistors; this takes place largely on the Regime level) on Post-It notes and paste them on a printed and enlarged copy of Table E-1. Note also that the process of developing the Baseline STS may generate insights that are useful (e.g., awareness of a particular STS component) to the client/participants. These should also be documented (separately).

Table E-1: Template for Creating a Baseline STS.

<table>
<tr><th colspan="5">Baseline STS</th><th>Insights</th></tr>
<tr><td colspan="5">LANDSCAPE (Global and/or greater regional level elements)</td><td rowspan="6">For each insight document:
• Whether a component of the STS is perceived to be a factor of change, i.e., a driver or a resistor of change;
• Which other STS component it effects or may effect; and
• The capability(ies) it can affect and how.</td></tr>
<tr><td colspan="5"><<components to be identified by workshop participants>></td></tr>
<tr><td colspan="5">REGIME (Regional and local systems analysis)</td></tr>
<tr><td>Organization</td><td>People</td><td>Process/ Policy</td><td>Technology</td><td>Infrastructure</td></tr>
<tr><td colspan="5"><<components to be identified by workshop participants>></td></tr>
<tr></tr>
<tr><td colspan="5">NICHE (Specific technologies and detailed prerequisites to make the technology work)</td><td></td></tr>
<tr><td colspan="5">Newly identified components</td><td></td></tr>
</table>

E.2.2 FATE Step 2: Break Down Scenarios into TEMPLES

What: Distill the relevant characteristics of each selected scenario(s) into the Technological, Economical, Military, Political, Legal, Environmental and Social (TEMPLES) framework.

Required input	A set of selected Scenario(s) of interest
Output	• Information extracted from each scenario related to each part of the TEMPLES framework; and • their relevance for the STS or the client's question.
Time Needed	Approximately 1 hour per scenario.

How: Where possible, the participants will have read the scenarios. To facilitate everyone arriving at a common understanding, there is a presentation on the selected scenario(s) followed by time for reading the scenario(s). For each scenario, participants discuss and list the impact of each part of TEMPLES and where/how these could affect the broader socio-technical context of the STS of interest. This can also be conducted with the use of the Rich Pictures technique[3] whereby all participants arrive at a common

[3] A technique that helps explore, acknowledge and define a situation or an idea by expressing it through graphical means, thus creating a "mental model." Rich pictures may consist of diagrams, symbols, cartoons and words. Source: NATO Alternative Analysis Handbook 2015. If used, output of pictures should also be captured in words.

understanding of the scenario as well as related to the TEMPLES framework. In either case, all interpretation of the scenario(s) is compiled in the form of Table E-2. These will serve as input for Step 3 in which the interaction between the future scenario(s) and the STS is analyzed.

In the case of a large number of participants, the facilitator can split the participants into smaller groups working on the same or different scenarios concurrently.

Table E-2: Sample Table to Document Components of TEMPLES Extracted from the Scenario(s). Make one table for each scenario.

Domains of the TEMPLES framework	Information extracted from scenario on each domain of the TEMPLES framework	Relevance to the STS
Technological	*e.g., there is a lack of government support for technological advancement.*	
Economical		
Military		
Political		
Legal		
Environmental		
Social		

E.2.3 FATE Step 3: Study the Interaction of the STS with Scenarios

What: Study the interactions between the Baseline STS and the components of a future scenario and repeat this with at least one other scenario. Derive a Futuristic STS, (an STS that will change because of the context provided by the scenario therefore different from the baseline) which in turn will enable an understanding of how the STS can evolve. Specifically:

1) Iteratively identify insights, i.e., the main components and/or relationships in the Baseline STS that are central for its evolution, including the drivers and resistors of change.
2) Document additional insights relevant to the client's question.

Required input	1) Baseline STS and preliminary list of insights (from Step 1) 2) Information from scenario(s) on the individual TEMPLES domains (from Step 2)
Output	Futuristic STS (Table E-3) • insights on the STS and/or client question, • factors of change in the STS, and drivers/resistors Additional insights such as impact on the capability(ies) of interest to the client
Time needed	Approximately 3 hours

How: The participants study the interaction of the Baseline STS with the results from the TEMPLES identified for the scenarios. To this end, the participants are to first update the Baseline STS derived in Step 1 by adding components that are now deemed to be relevant to the STS. Thereafter for each scenario, the participants will derive a Futuristic STS by identifying components of the Baseline STS affected and the relevant drivers/resistors. New STS components and drivers/resistors that are relevant in the future scenario may arise and should be included in the output for this step. In the process of identifying affected STS components and associated drivers/resistors, the participants should also note the impact that each of these could have on the capability (ies) of interest to the client, such as changes to performance and availability. For each scenario/futuristic STS, the discussion outcome should be documented using the template provided in Table E-3.

When facilitating Step 3, the facilitator should replicate the Baseline STS developed in Step 1 and invite participants to update it with new components, if any. Similar to Step 1, this can be done by writing on Post-Its and pasting them on a printed and enlarged copy of Table E-3. Drivers/resistors identified in Step 1 and deemed relevant in a particular scenario should also be replicated on Table E-3. Similar to Step 1, the process of developing the Futuristic STS may generate additional insights that are useful (e.g., awareness of a particular STS component) to the client/participants. These should be documented separately as required.

Table E-3: Template for Documenting the Interaction Between a Scenario and the Baseline STS.

<table>
<tr><th colspan="5">Futuristic STS, One for Each Scenario</th><th>Elaboration of Scenario Relevant Drivers/Resistors</th></tr>
<tr><td colspan="5">LANDSCAPE (Global and/or greater regional level elements)</td><td rowspan="7">Participants are to review the list of drivers/resistors from Step 1 and include only those that change as a consequence of the consideration of TEMPLES provided by each scenario.

Add new factors of change (drivers/resistors), for each of these elaborate:
• Description of the driver/resistor;
• which STS component they effect; and
• the capability(ies) it can affect and how.</td></tr>
<tr><td colspan="5">Taken from Step 1 and new components in STS from analysis of TEMPLES added (distinguish from Baseline with a different color).</td></tr>
<tr><td colspan="5">REGIME (Regional and local systems analysis)</td></tr>
<tr><td>Organization</td><td>People</td><td>Process/ Policy</td><td>Technology</td><td>Infrastructure</td></tr>
<tr><td colspan="5">Taken from Step 1 with newly identified components added.</td></tr>
<tr><td colspan="5">NICHE (Specific technologies and detailed prerequisites to make the technology work)</td></tr>
<tr><td colspan="5">Taken from Step 1 with newly identified components added</td></tr>
</table>

In consideration of more than one scenario, it is useful to take the total number of drivers/resistors from a scenario that effects an STS and a capability of interest and compare these across the scenarios. This data can be tabulated using Table E-4 and will be useful for support analysis in Step 4. This can be done by transferring the Post-It notes from the Table E-4 for each scenario onto Table E-4 and sorting the drivers/resistors according to the capability they effect. If a driver/resistor effects more than one capability, the Post It note should be duplicated and pasted under both capabilities impacted. The total number of drivers/resistors can subsequently be tabulated by counting the number of Post-Its in each cell in the table.

Table E-4: Template for Tabulating the Total Number of Drivers and Resistors that Effect Various Capabilities Relative to Each Scenario.

	Capability X	Capability Y	Capability Z
Scenario A			
Scenario B			
Scenario C			
Insights to be added as appropriate in this row across scenarios			

Relevant components of the STS and drivers/resistors from Table E-3 to be listed in these cells, with the total number of driver/resistor in each cell tabulated. Additional columns should be added to the table as required.

E.2.4 FATE Step 4: Impact Analysis

What: Assess the level of impact of the Futuristic STSs on the client's objective and compare the impact across the STSs. The specific output from this Step can be tailored to support the client's broader objectives for using FATE (e.g., technology investment decisions, capability development plan, and risk mitigation).

Required Input	• Futuristic STS, with affected STS components and relevant drivers/resistors • Preliminary assessment of the impact of Futuristic STS(s) on capability(ies) of interest (from Step 3, Table E-4)
Output	• Impact of Futuristic STS on client's question such as on capability(ies) • Consequent potential actions for mitigation
Time Needed	Approximately 2 hours (with the rest of steps) Additional time required for follow-on analysis

How: By assessing the impact of the effectors of change and insights (from Step 3) on a selection of applications of interest to the client (e.g., capability areas) through data collection (surveys), and interpretation (cumulative assessments).

Process in Detail: For each factor of change and insight, record:

1) Whether there is an impact on an application of interest (e.g., capability areas) (Y/N)? Explain why. To aid this, first the reasoning for the variation is written out – this helps to explain why something is of interest to those who have not been involved in the assessment process (Table E-4).

2) For applications that are impacted, collect data by responding to questions on:

   a) The "level of regret" on regret scale. Qualitatively note reasoning to quantitative measure. Regret: The level of regret is judged by considering: "What would be your level of regret if the impact did occur?" Using the categories (column W in datasheet, see (Table E-5).

   b) The level of disruption, is it game changing or not? (Y/N) Qualitatively note reasoning to quantitative measure.

   c) Time to response. Assess the earliest possible time to respond. Then the latest time to respond and finally assess if there is the capacity (currently) to respond.

For data interpretation, assess the overall implications across applications of interest: using the data recorded in the table, conduct an interpretation **by columns** instead of rows. Columns = different measures, level of regret, disruption, time to response, etc. ... Rows = each factor of change.

1) Taking the highest recorded "level of regret", "level of disruption" and "Time to response".
2) Cumulative score.
3) For each assessment, the impact recorded reflects the highest level of impact across the capabilities. For example, if one capability has a low assessment, the next a high assessment and the third a medium assessment then the highest assessment (high) would be recorded. This impact, arising from drivers and resistors, can then be judged in a variety of ways.
4) "Where is the impact anticipated to occur?" is then considered; against the capability (ies) of interest to client, identified in preparatory phase.

To assess the overall level of impact, the following survey questions can be considered for each futuristic STS:

- **What is the level of regret (for the client/client's organization) to not take actions to capitalize or mitigate the change to the capability of interest?** It is useful to review the drivers/resistors tabulated in Step 3 (Table E-4) before answering the question. The answers can use the regret scale as shown in Table E-5. The question should be repeated for each capability of interest that is assessed to be impacted.

Table E-5: Regret Scale for Not Taking Actions.

Scale	Description
1	I would have **no regret** in not taking actions; it would do me **no harm or no benefit.**
2	I would have **minimal regret** in not taking actions; it could do me **minimal harm or minimal benefit.**
3	I would **regret** not taking actions; it would do me **some harm or some benefit.**
4	I would **regret** not taking actions; it would do me **a lot of harm or benefit.**

- **What is the level of risk to effective response to the changes (to the capability of interest)?** This risk can generally be based on assessment on the state of readiness to address the change and impediments to change and could translate to inability to take action or to act in time. The risk scale in Table E-6 can be used. The question should be answered and repeated for every capability of interest that is assessed to be affected (i.e., capabilities with level of regret between 2 and 4).

Table E-6: Risks Scale for Effective Respond to Changes.

Scale	Description
1	There are **no plans** in place and **significant impediments** to taking actions.
2	There are **no plans** in place with **some impediments** to taking actions.
3	There are **some plans** in place with **some impediments** to taking actions.
4	There are **comprehensive plans** in place with **minimal impediments** to taking actions.

The following assessments that require comparison of changes/evolutions in STS's across scenarios enable additional interpretations that are useful to the client's broader interest in the use of FATE:

- **Which future scenario is the most disruptive?** The level of disruption of each scenario on each capability can be assessed with the ratio of "**level of regret**" and "**level of risks**". A high level of disruption would mean that a capability will be significantly be affected in a particular scenario and it would be difficult for the client to address the effects. This assessment can facilitate the prioritization of actions for mitigating or capitalizing on possible changes.
- Where there is more than one capability of interest, it may also be useful to assess **which capability is more vulnerable to disruption in the future**. This can be done by comparing the level of disruption for each capability across all the scenarios.
- Where there is interest to identify the "critical" STS components, it may be useful to assess **which STS components are most susceptible to change and have disruptive impact on the capability(ies) of interest**. This can be done by reorganizing the Post-Its on Table E-4 into Table E-7 below and counting the driver/resistors that could affect each STS component.

Table E-7: STS Components Relative to Each Scenario.

	STS Component X	STS Component Y	STS Component Z
Scenario A			
Scenario B		Relevant components, drivers/resistors from Table E-5 reorganised into these boxes, with the total number of driver/resistors in each cell tabulated. Additional columns should be added to the table as required.	
Scenario C			
Insights	Insights		

E.3 DOCUMENTING THE WORKSHOP OUTPUT

For traceability of the assessment from the workshop, the output from Steps 1 to 4 can be transferred into excel spreadsheet post workshop as shown in the diagrams below:

Step 1

Output	• A Baseline STS created with its components identified, • A preliminary list of insights on the components of STS and/or a relationship between them with perceived relevance to the future.

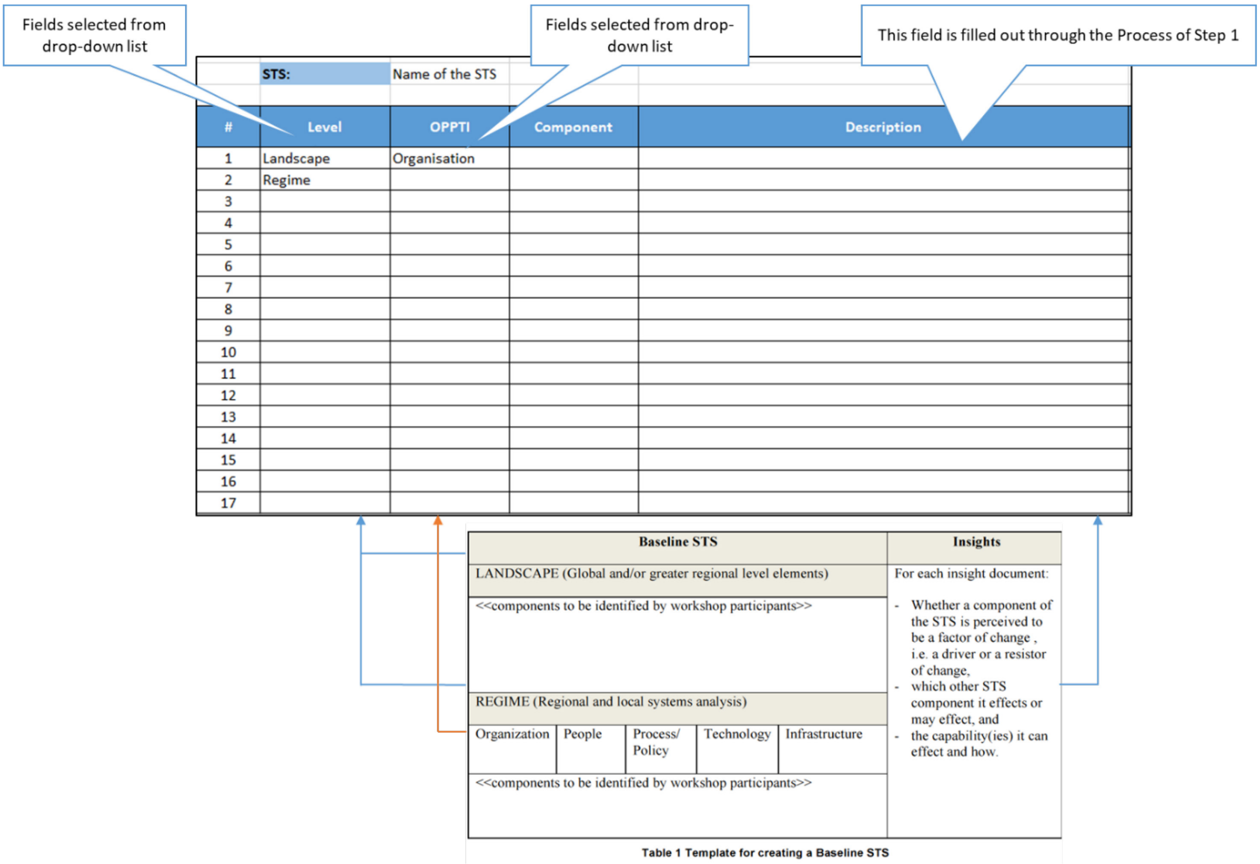


Figure E-1: Explanation of How to Work out Step 1.1 on a Spreadsheet.

For spreadsheet template see Appendix E2 – Datasheet Template.

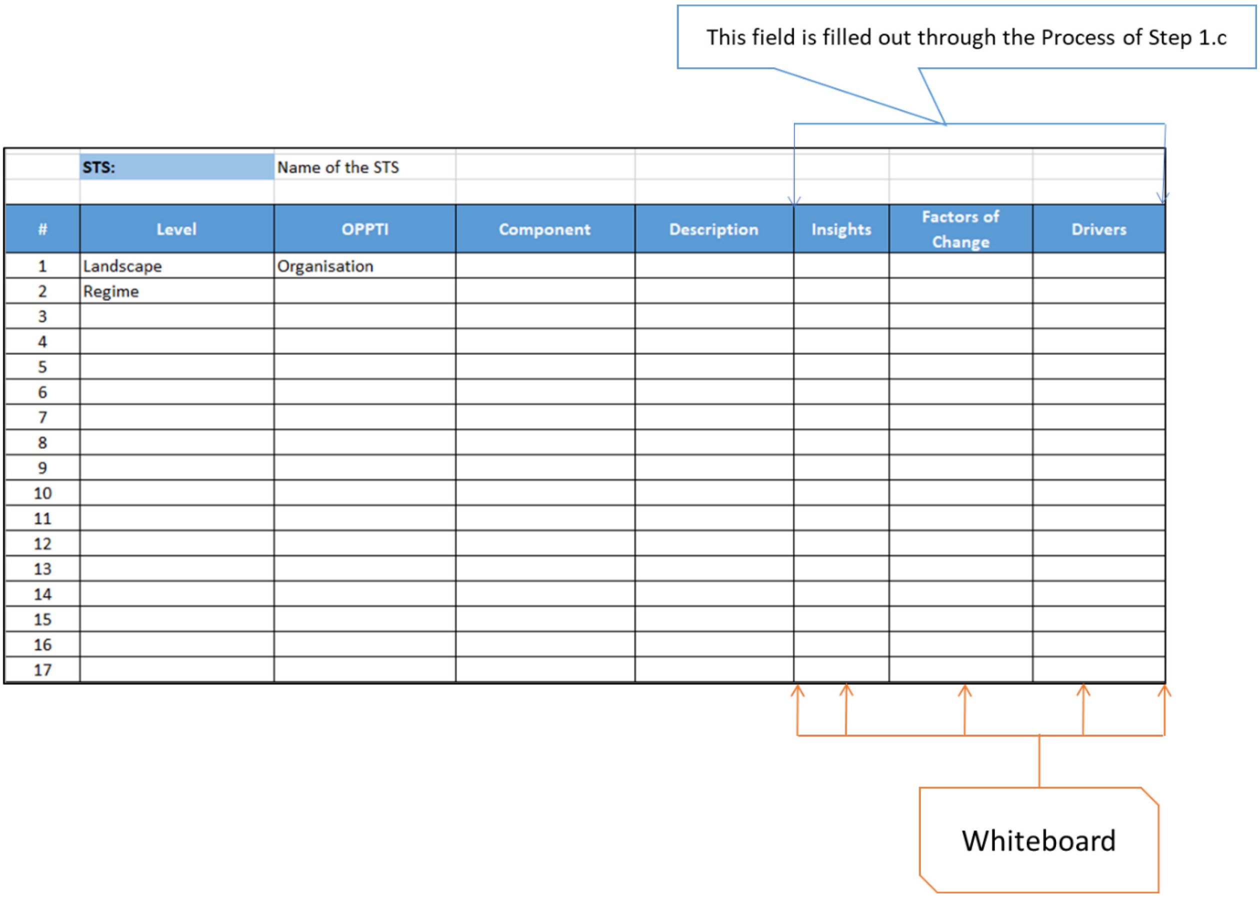


Figure E-2: Explanation of How to Work out Step 1.2 on a Spreadsheet.

For spreadsheet template see Appendix E2 – Datasheet Template.

Step 2

Output	• Scenario(s) of interest with impact broken down into TEMPLES domains and initial assessment on how these could affect the STS.

Table E-2 can be transferred onto spreadsheet as is. There should be one table for each scenario considered.

Step 3

Output	• A Futuristic STS (Table E-3) for each selected scenario with the relevant drivers/resistors identified. • Additional insights such as impact on the capability(ies) of interest to the client.

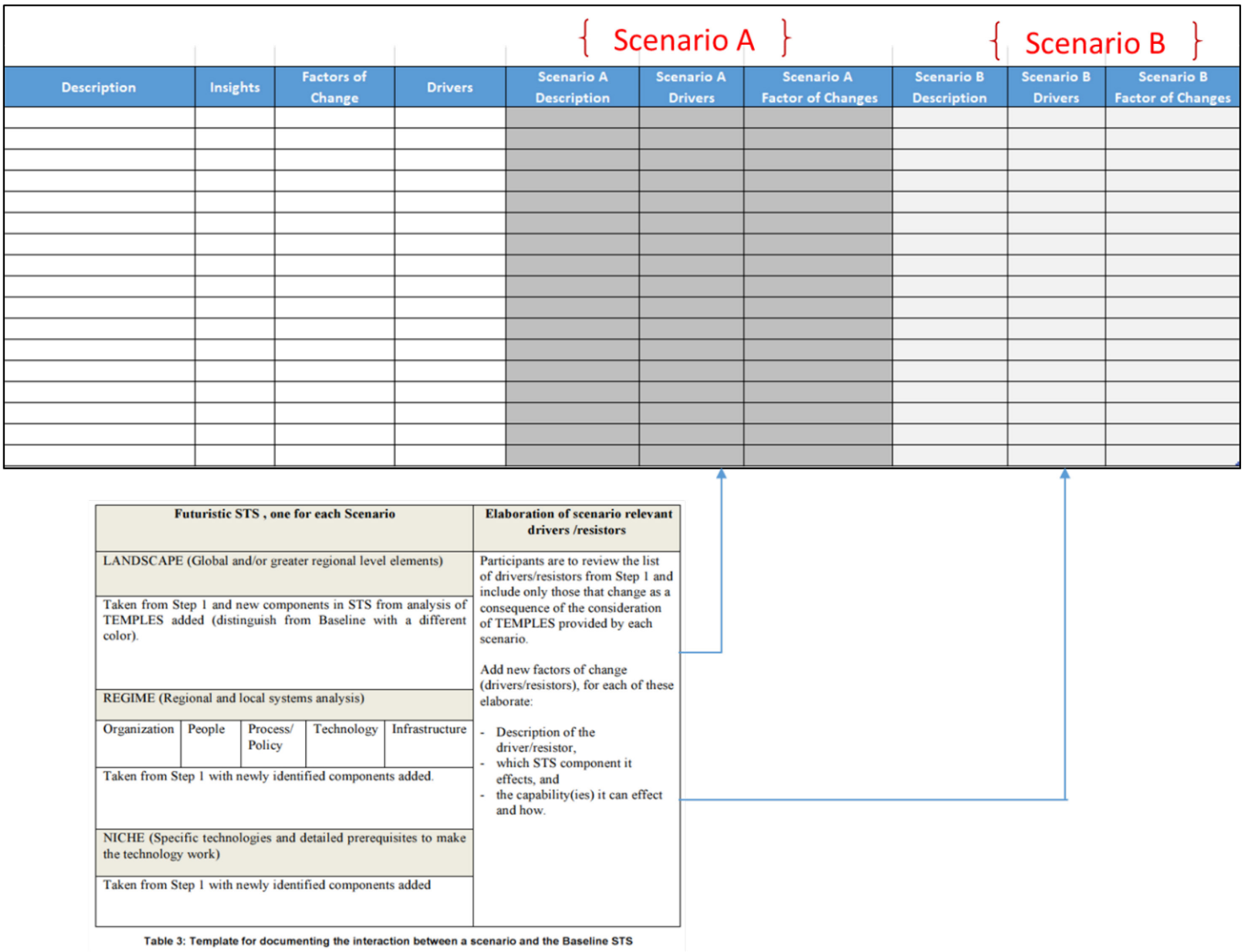


Figure E-3: Explanation of How to Work out Step 3 on a Spreadsheet.

Table E-4 (Comparison of drivers/resistors affecting each capability of interest across different scenarios) can be transferred to spreadsheet as is.

For spreadsheet template see Appendix E2 – Datasheet Template.

Step 4

Output	• Assessment of impact of STS's across scenarios. • Assessment of impact of Futuristic STS on client's interest such as capability(ies).

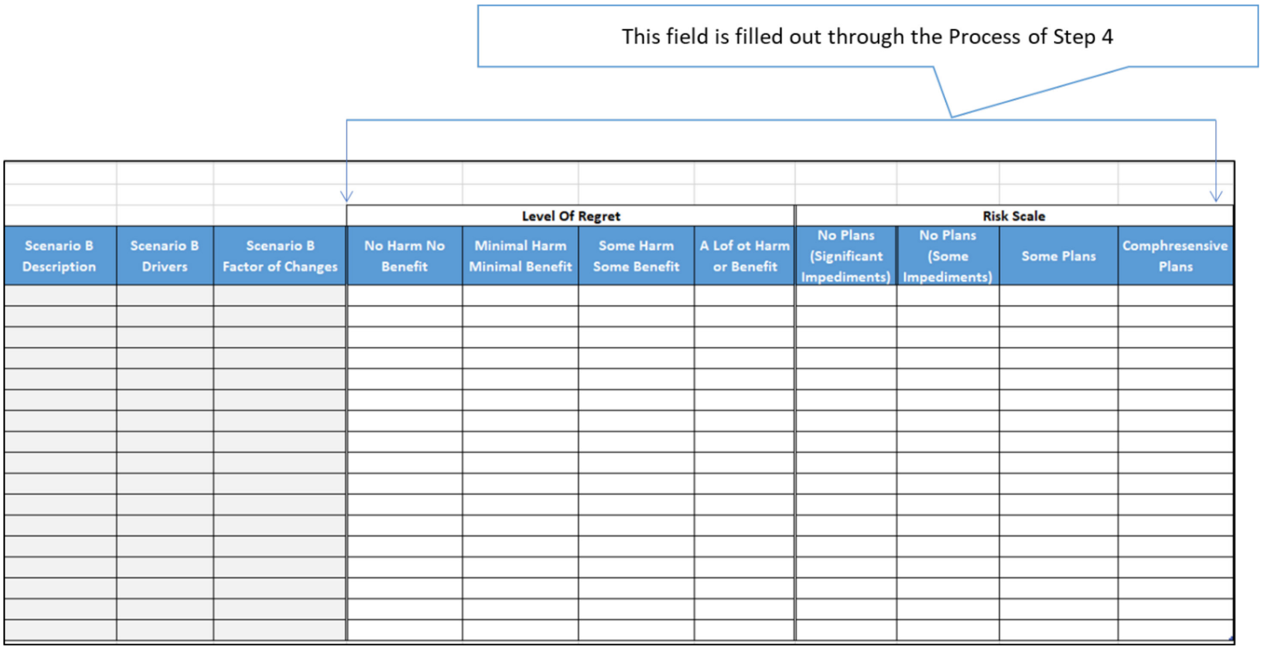


Figure E-4: Explanation of How to Work out Step 4 on a Spreadsheet.

For spreadsheet template see Appendix E2 – Datasheet Template.

E.4 REFERENCES

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[2] Bostrom, R.P. and Heinen, J.S., (1977). MIS Problems and Failures: A Socio-Technical Perspective – Part I: The Causes. MIS Quarterly, December, 1(4), pp. 11-28.

[3] Bostrom, R.P. and Heinen, J.S., (1977). MIS Problems and Failures: A Socio-Technical Perspective – Part II: The Application of Socio-Technical Theory. MIS Quarterly, September, 1(3), pp. 17-32.

Appendix E1: EXAMPLE OF CONSTRUCTED STS

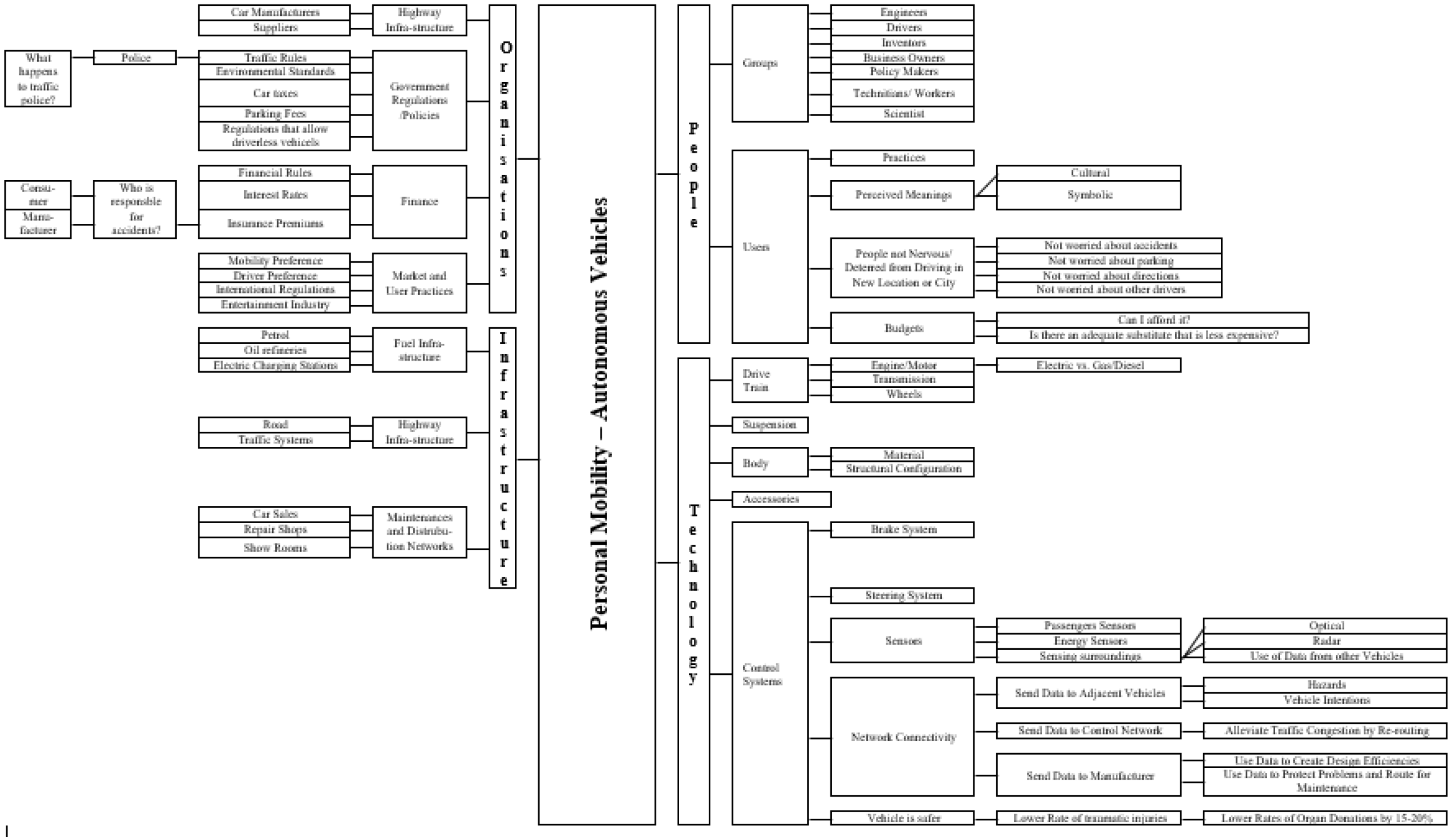

Figure EA-1: A Sample Mind Map for FATE.

Appendix E2: DATASHEET TEMPLATE

The datasheet template is an excel document, available separately.

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14. Abstract

The NATO SAS-123 was initiated in order to study both scenarios of the future and Socio-Technical Systems (STS) concurrently; develop and assess the criteria for their interactions; and determine how these interacting variables may cause disruptions within the defence and security sectors. The resultant of our research is the FATE method. This method evolved through an iterative process with a search of literature, exploration of various existing theories to assess how such interactions occur and evolve, presentation at academic fora and conducting trials in several defence settings. The literature search found little on the simultaneous interaction of the STS in concert with scenarios of the future even though the discipline of foresight studies these two variables independently. The prospective multilayer framework theory lay the foundation for FATE. The method provides a tool that enables a better understanding of synergistic impacts of socio technical systems that influence development, adoption, use and impacts of technologies, which in turn, would allow defence and security organisations to make more informed decisions about longer-term plans and strategies that will have to be, to the extent possible, future-proofed.

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