RESILIENT SUSTAINABLE AUTOMOTIVE STRATEGY
DECISION SUPPORT

Twenty Four Month Report

Abstract
This is a transfer dissertation for the University of Surrey Industrial Doctorate (EngD) Programme in Sustainability for Engineering and Energy Systems. It summarises research conducted and findings made thus far, and plans for future work. The project is researching strategic decision support approaches, to select resilient sustainable strategies for manufacturing companies and in particular the host, Ford Motor Company.

A theoretical review has established that business resilience and sustainability are each needed for successful delivery of either, and for businesses to flourish in the long term. Resilience was identified as looking at external effects on the business, whereas business sustainability concentrates on activity impacts and feedback loops. Unsustainability causes external (resilience) input-side issues whilst lack of resilience can lead to unwanted outputs and therefore unsustainability. Co-ordinating corporate activities to improve sustainability and resilience is a strategic activity.

This EngD is developing a holistic approach based on these two areas, which can be used at various levels within Ford to generate and select improved strategies for corporate level activities, products and services, or technologies. It aims to produce both an approach and individual elements such as tools and related metrics. These can be used by managers to assess the implications, in sustainability and resilience terms, of different solutions for addressing opportunities or threats.

Interviews and observations within the company, looking at current practice in strategic decision-making, established that traditional economics-based assessments predominate, and sustainable product design methods are available but not globally used. Some participants needed new ways to handle non-economic factors in strategy settings, especially environmental and social ones; and to capture risk and uncertainty in future scenarios. Lastly the company’s strategic decision-making process is iterative, discursive, flexible, and consensus-seeking, and decision-making authority is concentrated in higher management levels. Formal and externally developed tools are not favoured, requiring the
research to use as far as possible familiar elements to enhance acceptability. These results confirm the need for the project’s outputs within the company.

A search for practical approaches identified Krumdieck et al.’s recent ‘Transition Engineering’ (TE) approach, used to develop system resilience to sustainability-related issues. This will be modified for system-analysis appropriate to Ford, by adapting design-based tools from ‘Robustness Engineering’ (RE). These are compatible with TE and familiar to Ford. Both approaches are complex system engineering-based but will work for business strategists as they allow prioritisation of company resources across different needs. Some parts of the method have been developed through early case studies. Although some potential metrics have been identified during the research these have not yet been tested.

A flexible communication tool was developed; a large set of Teachable Point of View (TPoV) slides covering sustainability science, business resilience and their strategic criticality, the developing research, and finally opportunities for the audience arising from participating in case studies. This has been used to raise awareness and generate case studies internally, and with academic supervisors and the general public externally.

The approach methods and metrics will be further developed and piloted within the host company using mainly case studies in an action-research approach. A mosaic of short studies inside the company will be chosen to cover the data gathering needs identified by the research design. A set of related objectives is described in more detail in the final section of this report, along with risks and contingency plans. There are three main activity types; foundation tasks setting criteria and designs for the main research tasks, delivery ones wherein most of the research data is collected, and confirmation ones which analyse, interpret and report the results. Together these activities will deliver the research aims and objectives by the end of the project.

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# Table of Contents

1 Introduction ........................................................................................................................................ 1  
1.1 Aims ............................................................................................................................................. 1  
1.2 Methodology general approach ..................................................................................................... 2  
1.3 Expected contribution to knowledge ............................................................................................ 2  
1.4 Papers for publication .................................................................................................................. 2  

2 Context of the research ...................................................................................................................... 3  
2.1 Sustainability theory and business ............................................................................................... 3  
2.2 Resilience theory and business .................................................................................................... 4  
2.3 The relationship between sustainability and resilience ............................................................... 5  
2.4 Sustainability, resilience and the automotive sector ..................................................................... 6  
2.5 Resilient Sustainability: practical approaches ............................................................................. 6  

3 The state of knowledge and practice in the sector .......................................................................... 9  
3.1 Establishing the nature of strategic decision processes at Ford ................................................ 10  
3.2 Communicating the research ....................................................................................................... 11  
3.3 Working with initial case study teams .......................................................................................... 13  
3.4 Developing the approach framework and tools ......................................................................... 14  

4 Research plan and objectives .......................................................................................................... 18  
4.1 Foundation objectives .................................................................................................................. 18  
4.1.1 Development of candidate metrics ......................................................................................... 18  
4.1.2 Completing analysis of Ford current practice ....................................................................... 19  
4.1.3 Setting the test criteria for success of the objectives ............................................................... 20  
4.1.4 Research method design ....................................................................................................... 20  
4.1.5 Identifying sources of data .................................................................................................... 21  
4.2 Delivery objectives ...................................................................................................................... 23  
4.2.1 Develop missing approach elements .................................................................................... 23  
4.2.2 Use case studies to demonstrate the benefits of the approach ......................................... 23  
4.3 Confirmation objectives .............................................................................................................. 26  
4.3.1 Analysis of case studies and other research ....................................................................... 26  
4.3.2 Interpretation of the body of work ....................................................................................... 26  
4.3.3 Reporting the results ............................................................................................................ 27  
4.4 Timing plan .................................................................................................................................. 27
Acknowledgements ........................................................................................................... 27

References .......................................................................................................................... 29

Appendix A Final draft of first journal paper................................................................. 32
Appendix B Question set used for semi-structured interviewing ......................... 44
Appendix C Ford metrics used in decision-making .................................................. 46
Appendix D Examples of Teachable Point of View (TPoV) slides ................. 47
Appendix E Blank analysis output form............................................................... 48

Table of Tables
  Table 1- Research Aims ........................................................................................................ 18
  Table 2- Possible sources of data for identifying significant change .............. 21
  Table 3- Data sourcing tasks .............................................................................................. 22
  Table 4- Types of case study ............................................................................................ 24
  Table 5- Generic steps for case studies........................................................................... 25

Table of Figures
  Figure 1- Company P-Diagram example ................................................................. 8
  Figure 2- example Teachable Point of View slide ................................................. 12
  Figure 3- Process flow chart for modified Transition Engineering approach ...... 16
  Figure 4- The Ford strategy development V process ............................................. 17
  Figure 5- Outline research plan for years 3 and 4 ................................................. 28
1 Introduction

This report gives an overview of all the research conducted, findings made so far in this EngD project, and the plans for future work. Some information has been covered in previous research reports or papers by the Research Engineer and is summarised here.

1.1 Aims

The aim of this EngD research is to develop a holistic approach for comparing strategic choices, which can be used within organisations to assist decision makers to improve the sustainability and resilience of their company strategies. This will be used at various levels e.g. business and operations strategies, specific products and services, or technology choices. The work will result in a method or methods useful to strategy analysts and decision-makers, and metrics or indicators which can be used to assess the status, implications and impacts of different options.

The overarching research aim is to show that resilience can be used to help deliver (product and operational) sustainability. In order to do this some supporting aims have also been identified:

- Use internal tools familiar to the host as far as possible, to overcome cultural issues and potential resistance.
- Use external existing tools as far as possible to support these.
- Develop new approaches where needed to handle concepts new to the host.
- Use case studies to demonstrate the benefits to strategy decisions, when supported by these sustainability and resilience approaches.
- Show that these approaches do one or more of: meet real world strategic needs, deliver significant change, deliver real results in the business world.

The project host is Ford of Britain Ltd, the UK division of Ford Motor Company. Ford is part of the global automotive industry which is resource- and capital- intensive, and has long product development times and product lifecycles, so is subject to many sustainability challenges (Wells, 2010). These arise from potential resource disruptions, restrictions due to its operational and product environmental impacts, recently increasing economic instability, disruption from continuing globalisation and a potential global mobility revolution (KPMG, 2012). These increasingly turbulent conditions require a more consciously proactive approach to building organisational resilience, simultaneously with improving the business’ sustainability strategies. As such it provides an eminently suitable setting for developing the desired approaches, and conducting action research to test their efficacy and utility.
1.2 Methodology general approach

The research concerns strategic management of an industrial company, therefore is primarily approached using management disciplines, utilising mainly social science methods and both qualitative and quantitative data. As it is conducted within a company using real business activities as case studies, an action research approach has been employed. So far several methods for collecting information have been used: literature review, practice review within the industry using websites and annual reports, plus interviewing, observation, communication and discussion sessions within the host company. Initial case studies have also been used to help develop the knowledge of practice within the firm, and drive the early development of the approach.

In the future it is planned to use predominantly case studies, for further development and testing. Data will be gathered before, during and after these using a mix of ethnographic interviews or surveys, observation, notes made during action research, and data mining within company systems where feasible. As the work is mainly strategic in nature and will lack detailed technical information, the data is expected to be mostly qualitative and will be analysed using methods such as textual analysis.

1.3 Expected contribution to knowledge

This work links organisational resilience and sustainability explicitly, and develops a holistic and pragmatic approach for working through their implications in strategic decision-making. It also seeks to demonstrate that a resilience approach can deliver better sustainability, and to develop an applied resilience approach for Ford.

1.4 Papers for publication

Two papers have been identified. Both are intended for submission to the Journal of Strategy and Management (JSMA). The first covers the concepts underlying the approaches to be developed and establishes from theory the potential benefits to businesses of adopting them. It has been written, approved by Ford, and will be submitted in October to the JSMA. The final draft (subject to journal review and approval) is included in Appendix A.

“Surviving or Flourishing? Integrating business resilience and sustainability”

This is a conceptual paper defining sustainability and resilience, their importance and origins; how they are linked, their usefulness to business strategically and their implications. It includes an overview of the proposed approach to be developed in the research.
The second paper is intended to report on the results of the research carried out in the latter half of the EngD, and will be submitted early in 2014.

“Sustainability and Resilience- measuring strategic improvements” (provisional title)
This will be a research or case study paper, depending on which is deemed most suitable at the time. It will cover the action research conducted, including selected highlights of case studies used to develop the approach, and results from trialling it and associated metrics within the host company.

2 Context of the research
The project brief was developed by the Research Engineer with Ford and began with two organisational objectives. These were to develop metrics and methods to support decision makers when considering corporate, product or technology strategy options; and to inform future scenario analyses of their competitive environment. The overall aim is to improve the sustainability and resilience of the company. Deconstructing these objectives indicated the need to understand firstly the current state of sustainability and resilience theory as applied to business, and their relevance to the automotive sector; secondly the level of knowledge of these topics within the sector and any existing strategic decision-support approaches encompassing these; finally, a picture of current practices within Ford was required.

2.1 Sustainability theory and business
The mainstream definition of sustainability is often shown as overlapping circles— see Clift (1998)- summarised as “the continued wellbeing of the economy, society and natural resource base” (Walker et al., 2002, p.11). The most useful interpretation found for a manufacturing company is Turner’s “asset portfolio” approach to natural resource management, which uses four resource capital-types (manufactured, natural, human and ethical), and which Ross and Bissix developed into “exploitation paradigms”. These prioritise capitals according to their anthropocentric value, ranging from ultra-short-term, economic gains in the ‘Very Strong Exploitation’ paradigm, to restoration of damaged resources in the ‘Very Strong Sustainability’ (VSS) one (Ewert et al., 2005, pp.160-163). Individual businesses, like species within ecologies, transform resources from one kind to another, for human benefit (Ewert et al., 2005 p.160).

Rockström et al.’s recent assessment of the planetary-scale systems supporting human life indicates several are disrupted, needing restoration, and others are deteriorating
(Rockstrom et al., 2009). This suggests only the VSS paradigm is acceptable thermodynamically and ecologically for sustaining humanity long-term. Additionally, economic growth must rely on improved resource-efficiency and restoration of natural capitals (Jackson, 2009). Johnston et al.’s science-based ‘operational sustainability’ definition (2007) also talks of eliminating negative impacts such as pollution or over-extraction.

Competitive advantage can therefore only be maintained by considering natural and more traditional business resources (Hart, 1995), and internalised social and environmental goals are needed to overcome any associated limitations in these areas (Porter and Kramer, 2011). Sustainability has become a strategic issue due to stakeholder, legislative and cost changes, driven by these constraints (Haanaes et al., 2012).

A definition of organisational sustainability for use in this research has been developed therefore, based on these previous works:

*An organisation pursuing sustainability will seek to eliminate its negative impacts and improve its positive impacts from its activities, to restore natural capital whilst enhancing human and maintaining ethical capitals. It will do this by eliminating resource extraction and pollution, identifying unsustainability risks and opportunities, prioritising them on their net contribution to the capitals and mitigating such risks or exploiting opportunities, whilst maintaining sufficient economic capital to operate.*

2.2 Resilience theory and business

Organisations are complex systems; containing many interacting feedback loops, interacting with other systems, and producing non-linear, emergent behaviours (Senge, 1993). They are *adaptive*, changing without management interventions (Polacek et al., 2012) (Caldwell, 2012). They need resilience to co-evolve with their environment yet maintain their identity (Hadders, 2011).

Resilience describes a complex system’s ability to return to stability after disruption (Bhamra et al., 2011), its continued functionality during disruptions, and its adaptation to changes (Walker et al., 2002) (Burnard and Bhamra, 2011). Systems particularly need resilience to cope with turbulent environments (Bhamra et al., 2011). Developing resilient systems typically involves reducing uncertainty, risk (Burnard and Bhamra, 2011) and vulnerability (the degree to which events affect the system) (Bhamra et al., 2011). Undesirable system behaviours can also be resilient (Walker et al., 2002); so another goal is needed to discriminate between its wanted and unwanted forms (Walker et al., 2002).

Business resilience is important due to the increasingly unpredictable effects of globalisation (Taleb, 2008), economic turmoil, and changing social expectations of
companies (Porter and Kramer, 2006). A business aims for continued delivery of high quality benefits to its stakeholders and owners, whether profits or reputation. Ensuring a flourishing business and not just survival is therefore key. Resilience enables the delivery of these strategic goals, particularly the proactive generation of sustainable competitive advantage (Burnard and Bhamra, 2011). This is strategic resilience which favours diversification; operations resilience favours specialisation and optimisation, which only succeed in stable conditions. Both are needed (Hamel and Välikangas, 2003a) (Taleb et al., 2009).

Strategic resilience is “the ability to dynamically reinvent business models and strategies as circumstances change” (Hamel and Välikangas, 2003a, p.2). It allows firms to do this proactively, without traumatising themselves, enabling renewal without absorbing resources and capacities they need for maintaining competitive advantage. It matters when delivering long-term goals and efficiencies (Hamel and Välikangas, 2003b), e.g. product stewardship-based business models which may have lifecycles lasting decades. Walker et al. (2002) developed three measures of system resilience: how much change a system can withstand, without its controls or structure changing; how much it self-organises; and how much adaptive capacity it expresses. This last includes learning, experimenting with and adopting novel solutions, and developing generic responses to wide classes of challenges. This broadly matches business-oriented definitions identified by Bhamra et al. (2011).

Resilient companies use adaptive capacity to evolve; this is the mechanism for delivering resilience (Burnard and Bhamra, 2011). Many different company activities can improve resilience and their co-ordination is a strategic task (Parsons, 2010). A resilient business therefore should proactively manage its adaptive capacity, and exhibit proactive strategies which are efficient with resources, generate diversity, and based on realistic and accurate assessments of its capabilities and surroundings (Burnard and Bhamra, 2011), (Hamel and Välikangas, 2003a), (Bhamra et al., 2011) and (Hufschmidt, 2011).

2.3 The relationship between sustainability and resilience

Both concern the continuity of existence of a complex system. A system that works well is more sustainable generally and can operate for longer, which fits with resilience theory’s emphasis on high quality performance. Walker et al. (2002) propose sustainability as the goal which can steer the development of resilience. The resilience view looks at external effects on the system, thinking from the outside-in\(^1\), whereas sustainability starts from the system and thinks about impacts and feedback loops, thinking from the inside-out\(^1\). Unsustainability in the system’s outputs causes external (resilience) input-side issues via

\(^1\) Terms borrowed from Porter and Kramer (2006)
external feedback loops, yet lack of resilience can also lead to unwanted outputs and therefore unsustainability. This causal looping suggests that sustainability can also be part of the mechanism for delivering resilience.

In the context of better performance quality rather than survival, sustainability and resilience are also linked in their practical implications. As we extend our time horizons to allow for feedback loops lasting decades or longer on systems, and consider the long-term external changes a business has to deal with, both qualities are required to achieve this ‘flourishing’ state. Consider, for example, the difference between a company constantly on the brink of extinction and one which performs well despite disturbances. The first company will have little resource left over from crises, to cope with changes or exploit new opportunities. We would expect the second one to be more resilient by incorporating key social and environmental issues within its strategy. For the best performance these should be those issues with most impact upon it, and which it can most mitigate; and also be those with the most opportunity for competitive advantage (Porter and Kramer, 2011).

2.4 Sustainability, resilience and the automotive sector

Automotive vehicles account for a significant part of global greenhouse gas emissions (EC, 2010b). The industry is resource and capital intensive, exposed to other sustainability issues, and difficult to make consistent profits from (Wells, 2010). Executives within it recognise the key strategic nature of sustainability as a source of business challenges (KPMG, 2012). Markets are becoming globalised, urbanised (IGES, 2010), and younger consumers are decreasingly likely to own cars (KPMG, 2012). This leads to faster change within car markets, more uncertainty and increasing strategic issues for incumbent companies.

The theoretical failures of poor system designs are the same for businesses within both concepts: depleted resources, damaged (eco)systems, degraded societal license, disappearing markets, increased costs and unexpected changes which are beyond any capacity for adaption can take the company out of business suddenly or slowly. To be resilient long-term, an organisation must factor in sustainability in its goals. To be sustainable long-term it must build in resilience. If sustainability is the ultimate (and always moving) goal defining the direction of travel, then resilience is the ability not to be pushed off course and to adapt to that moving goal.

2.5 Resilient Sustainability: practical approaches

Companies cannot accommodate every future possibility into their strategy and solve all their unsustainability issues simultaneously, because the issues are too large and
An interconnected. A pragmatic framework is needed to sort through the issues and opportunities and identify the key interventions for managers, which is capable of working at different levels within, and beyond, individual firms. This is such a new area that almost no approaches exist. One developing practical framework however is Transition Engineering (Krumdieck, 2011b), which increases the resilience of systems when faced with constrictions in external resources supplies. Krumdieck suggests that we can already measure and therefore work away from unsustainability risks, similarly to dealing with unsafe designs; through a process of identification, prioritisation and mitigation. This approach was chosen as the basis for the approach to be developed, as it has been proven on strategic options in town-scale transport planning, and sufficient detail is published to allow reinterpretation for business. Whilst aimed primarily at engineers, it should work equally for business strategists; the same issue of limited organisational resources to be allocated to multiple opportunities and threats applies.

Transition Engineering (TE) uses a system engineering design approach. It suggests translating any resource-resilience issue into data and risks to help managers choose which levels of risk are acceptable, and prioritise amongst multiple options. Solutions are sought which reduce the system’s vulnerability and improve its adaptive capacity. This also improves the range of responses available for coping with change. Options are tested against future scenarios to identify their resilience across these, and the best combination of resilience, feasibility and project risk selected (Krumdieck, 2011b). This also allows the potential for a suite of solutions rather than one over-optimised one, to ensure the best resilience. In strategy terms this follows Hamel and Välikangas’ (2003a) advice to have many small strategic experiments in progress.

TE so far does only tackle one resource issue at a time, assessing multiple options against this; but this approach is a common and reliable one in engineering system robustness design and failure analyses. Otherwise the problems tend to become too complex to analyse at a conceptual stage. It is suggested that a combination of known sustainability issues such as Rockström et al.’s list (2009), competitive market data and resource issues already identified as material to the company, would form the starting point for selecting an issue to analyse.

TE also derives from urban transport planning and so its specialised and complex transport system models are not suitable here. A tool is needed for the business system analysis task therefore, and the initial selection is Robustness Engineering (RE), an extended design approach based on Failure Mode and Effects Analysis (FMEA) and focussing on system resilience (although this term is rarely used). It provides a parameter
diagram (P-diagram) of the system which records desirable and undesirable inputs, outputs, controls and transfer functions. Only the control factors and the transfer function are influenced by the company (see Figure 1). Ford have occasionally used this tool in local business process design. The selection of both the approach and this tool is based on their mutually compatible use of engineering paradigms familiar to Ford managers, their resilience focus and their historical success (less proven in the case of TE but developing).

![Diagram of the system which records desirable and undesirable inputs, outputs, controls and transfer functions. Only the control factors and the transfer function are influenced by the company.](image)

Figure 1 - Company P-diagram example

Improving resilience involves minimising undesirable outputs and optimising desirable outputs for given signal, noise and resource inputs. TE concentrates on risks to system function, but the same analysis could work for opportunities, if used as signals, or solution options; or, inaction to exploit an opportunity could be analysed as a risk. Unsustainability appears in this analysis in several guises, as a source of resource disruption, hazards (such as extreme weather), noise or market signals on the input side; and a measure of undesirable outputs. It can be used as the ideal goal of the resilience exercise and to prioritise options with similar resilience effects. Every company will have a unique resilience risk profile, dictated by differences in vulnerability, exposure, adaptive
capacity and sustainability. It will also have unique feasibility assessments of solutions, driven by its internal capabilities and resource availability.

3 The state of knowledge and practice in the sector

The industry publishes very few papers and little other information due to commercial sensitivity (Nieuwenhuis and Wells, 2003). Sustainability appears much better known within the sector than resilience. Most executives cite sustainability as a strategic issue (KPMG, 2012), whereas the number of companies failing during the 2008 recession (Wells, 2010) argues irrelevance in practice. Most global automotive firms publish annual sustainability reports on their operations impacts but it is not apparent whether sustainability or resilience approaches are used in internal decisions (Winnard et al., 2011). Almost all mention some form of eco-design, lifecycle management or FMEA-based tool which they use to assess product design sustainability (ibid.). This in theory helps them assess for example their choice of new technology to meet regulations, such as the new EU fleet average CO₂ vehicle emissions limits (EC, 2010a). This “tailpipe” type of CO₂ impact, and worries about overcapacity and economic sustainability, receive the majority of executive attention from the sector (KPMG, 2012).

A review of academic papers found a number of other design-related tools for sustainability such as D4S (UNEP and TUDelft, 2009) but none are useful for strategy support. Williams’ (2007) Design for Sustainability (D4S)-derived metrics for automotive Product Service System innovation however look at the larger systems surrounding the product and could prompt changes in strategic thinking. There is not much published recently on sustainable strategy in practice, beyond the papers cited earlier in the Context section; certainly not when combined with resilience. Research in both areas seems to focus on SMEs and is either data-intensive in a way which cannot work for a large complex firm such as a global carmaker (Tsai and Chou, 2009), or relies on self-assessment which is not checked independently (Stephenson et al., 2010). Hamel and Välikangas’ Quest for Resilience (2003a) remains the seminal paper, with Porter and Kramer’s socially-focussed Creating Shared Value (2011) the most holistic approach to sustainability thus far. However they are descriptive and any practitioner must develop their own methods to apply them. Krumdieck’s work with her team on Transition Engineering (2011a and 2011b) is the only practical application of resilience found so far, outside of natural hazard and disaster management.

Ford itself addresses sustainability at corporate strategy level by prioritising issues based on their importance to it and its stakeholders (FMC, 2012a) and integrates them into its strategic goals, reporting progress annually (FMC, 2012b). How issues are identified is
not clear. It publicly commits to supporting stabilisation of global CO$_2$ levels at 450ppm, for example, through operations and product emissions savings (FMC, 2011). For design purposes Ford’s in-house Product Sustainability Index (PSI) assessment tool combines best practice in the sector by including metrics on the product’s most significant environmental social and economic product impacts, based on simplified Life Cycle Analysis, Life Cycle Cost and Cost Of Ownership metrics (Schmidt and Taylor, 2006). There is a related proprietary Environmental FMEA tool (FMC, 2000). These are not however designed to assess strategy and the company was believed to lack a consistent way of embedding sustainability in strategic decisions, at the start of this project. Business resilience was a topic of interest from the start of the research as its overt focus aligns more closely with the company’s direct aims than does sustainability, and it might offer a more digestible way to interpret sustainability for companies. It is not mentioned externally by the company as such, but commercial strategy features strongly in press releases, interviews and annual reports; especially the ‘One Ford’ plan used since 2006 by the new CEO to drive turnaround from a weak and unprofitable position (Henry and Motavalli, 2011).

3.1 Establishing the nature of strategic decision processes at Ford

It was necessary to establish current practice, including how strategic decisions are made, and how sustainability and resilience are currently handled within them, by Ford. Data on this process has been collected using a grounded-theory approach (Mason, 2002, p.180). Semi-structured interviews were chosen due to the unavailability of decision process details within company documents or systems. These also capture views based on many years’ experience, and multiple roles, for each person (the questions currently in use are included in Appendix B). The interviewees were identified initially from the Research Engineer’s and Industrial Supervisors’ contact networks, for their contact with strategic processes and sustainability or business case discussions within those, and their accessibility. The interviews began at lower management levels, and each interviewee was asked to nominate another more senior manager to approach, or effect an introduction. To date 14 interviews have been conducted of which 4 are decision-makers who choose some strategies, the rest being proposal-makers and participants in the discussions.

Interviews were supported by 3 targeted meeting observations of strategy forums identified from the Industrial Supervisors’ diary. It was quickly found that due to the long duration of Ford decision processes, it was difficult to establish them from individual meetings without intensive longitudinal observations, as each meeting was only a small part of the process; so these observations were used mainly to cross-check on the findings from the interviews, which they confirmed.
The main finding is that the company uses its management and specialists' human "database" of expertise for decision making, and strategy arises both from top-down planning and bottom-up issue or opportunity discovery. The decision process is discursive, flexible, iterative, and moderately consensus-driven, whilst decision-power is concentrated towards the top of the organisation. The company does not use many formal methods to compare, rank (or generate) options and typically prefers to develop its own tools, so it may be difficult to "import" a new approach from elsewhere. Based on this, top-down support and co-operative work with internal "customers" will be needed to create a culturally acceptable solution, and increase the level of ownership and likely use of the research results.

In terms of indicators and their importance, these do not vary much between strategic and tactical level discussions or between interviewees unless their role is very specialist. Non-economic metrics other than "brand" related ones, especially for sustainability or resilience, are used less frequently than economic ones, including those from the Ford sustainability tools (PSI and E-FMEA). Use of PSI is established but neither global nor fully embedded within product development processes, whereas E-FMEA use has not progressed beyond a pilot case study. ‘Sustainability’ is additionally sometimes used to mean only tailpipe CO₂ emissions. Non-product design resilience was infrequently discussed, and only in terms of short-term crises or local issues.

Gaps in methods or metrics identified by interviewees mostly concerned a lack of formal ways to incorporate non-product design risks, certain social or environmental concerns, or to include different future scenarios. The confirmed lack of metrics and methods for handling strategic sustainability and resilience established so far, indicates that this research should deliver useful results for the company. The work is ongoing to expand the number of decision-makers interviewed; early results indicate that their data generally supports that of the non-decision-makers. A table of specific metrics observed is included in Appendix C.

3.2 Communicating the research

When liaising with departments and individuals within Ford it was necessary to create a pack of information, usually to explain the research in some detail or deliver a quick management summary. A set of Powerpoint slides were developed, of a type called "Teachable Point of View" (TPoV) within Ford, designed to develop over time and be flexible so different ones could be selected to meet different needs. This also allowed communication and discussion of the developing research to academic supervisors, and was useful for action research, to raise awareness of the project and its findings within Ford.
Impacts of Current Business-As-Usual on Capitals

Capitals are affected by all activities. Currently other capitals are consumed and rearranged via human activity to create human benefits, and manufactured assets. Long term this is unsustainable, if other assets are exhausted & degraded by the impacts of this activity and their feedback loops. Impacts are cumulative.

Currently industry (inc. Ford) mainly depletes capitals to benefit wealth & wellbeing of some humans. Improvements are possible!

Figure 2- example Teachable Point of View slide
The pack consists of four main sections: the science of sustainability, its implications for business resilience, a business resilience framework, and finally how the research could help the audience’s department. The last section is tailored to each meeting. Individual slides were developed using recipient feedback during the work so far. It will continue to develop throughout the research. An example slide summarising some of the ideas underpinning the research is shown here in figure 2, and further samples are included within Appendix D. This slide shows current impacts of manufacturing companies on Turner’s capitals in a conceptual way, and how that generates feedback effects for the company. The slide content develops over time - for example this version shows current practice as to which resources are used from each of the capitals.

3.3 Working with initial case study teams

As the research concerns supporting strategic decisions, one of the best ways to develop the approach is to work with teams involved in real tasks to generate case studies. Whilst most of these will be set-up during the second half of the EngD, some interactions have already happened. The first of these was with an MBA researcher investigating social indicators for Ford products, commissioned by the same department as, and whose work will feed into, this research. The first two sections of the TPoV pack were used to brief the student on the background issues and science so that they could understand the department’s approach before starting their own work. There will be periodic interactions over the next few months during the MBA internship.

The second interaction was with a high level strategic study team looking at products and markets 10 to 20 years in the future. The initial contact was by audio and sharing a prototype of the TPoVs, then a face-to-face meeting with the team manager using the fully developed TPoV pack. The team’s initial study is now completed but, if it triggers more work in the next year, an opportunity was identified to use the research to provide information for future scenarios, and conversely test and develop indicators and approaches to assess different product-service options. Both of these connections are in their early stages so have yet to produce any results other than feedback on the TPoVs and any opportunities.

The third was triggered by the use of the TPoV pack with a senior manager interviewee. He was given it to read without a supporting presentation, and wanted to try out the approach to capture strategic risks for a geographic region, and assess different internal resource decisions for that region. The pack had been tailored guided by his feedback on missing approaches during the interview. The study was required for a short-notice sequence of meetings and resulted in both further developing the details of the approach, and in generating a blank generic parameter diagram and two analyses using it, for the
strategy team’s use. The team used these to generate their own future scenarios and assess different options for resilience. The blank P-diagram is based on figure 1 and includes instructions for users on what to include in each box. Feedback on this interaction is yet to be acquired. This work was a good opportunity to try to win managers to the approach, test some elements and spread awareness of the research.

3.4 Developing the approach framework and tools

Krumdieck et al.’s recent papers were analysed to build up a picture of the methods used. One summary covers the development of adaptive capacity measurement and covers in detail how resource (oil) supply restriction and transport activity risk was modelled (Krumdieck et al., 2010). An earlier paper lays out a generic and qualitative risk rating matrix (Dantas et al., 2007). The most recent summary creates the term Transition Engineering, goes into detail on assessing vulnerability via adaptive capacity, and how to assess options for improving this using an Opportunity Space grid, which last is generic enough to be useable in other analyses (Krumdieck, 2011b). The grid compares options against external scenarios, and allows them to be ranked in terms of resilience impact, feasibility and project risk. Finally her paper on the principles underlying the research gives useful insights into the process framework and the philosophy for assessing risks (Krumdieck, 2011a).

The detail in the papers is quantitative and detailed, but the approaches can be used qualitatively to analyse concepts, in the same way that SWOT for example can be used at many levels. The steps within TE can be summarised as:

- Convert resource issues into data where possible with risk assessments (this can be using trends and/or future scenarios)
- Define which system activity is affected and what drives its current adaptive capacity (is the activity degraded and how, do alternatives exist)
- Generate options which enhance adaptive capacity (by making the activity less vulnerable, reducing risks or adding extra alternatives)
- Assess the options’ effects against the future scenarios, and for feasibility and project risk to identify the best combination (a simple form of multi-criteria decision analysis)

(collated from Krumdieck(2011a) (2011b))
This was turned into an initial process flow chart for communicating to other teams, plus a generic blank Transition Analysis output grid based on Krumdieck’s Opportunity Space version was developed (included in Appendix E); both as a result of the third case study interaction. One additional finding from that interaction was that the P-diagram can be used to think about a system at the level above or outside the company (for example government policy). These elements will all develop further as the research progresses. The current process flow chart is shown in figure 3.

Meanwhile the first development of the Robustness Engineering tool was the adaptation of a parameter diagram to describe the business system or product service system, as in figure 1. A blank P-diagram with prompts was also developed for use by the third case study team. The second outcome has been the development of some simple qualitative risk metrics, using elements similar to those in FMEA although these have not been tested. These and other metrics will be needed for three types of levels within strategy formation. Figure 4 shows this process as a V shape, derived from the way Ford depicts its systems-development processes. In this strategy-development version the same type of process is planned, a top-down cascading of goals and targets and bottom-up delivery and checking; but the new levels are corporate, product-service system (PSS) and technology strategy.
Figure 3- Process flow chart for modified Transition Engineering approach
Figure 4- The Ford strategy development V process

This looks like a linear top-down Classical (analytically based, profit seeking) approach to strategy (Whittington, 1993), but is really a simplified view of the multiple loops and starting points of strategy development within Ford, which seems to be a mix of Classical with Systemic (socially oriented, multiple goals) and Processual (bargaining and learning, multiple goals) approaches (ibid.). It is already known from the interviews that Ford decision-making processes are discussion-driven and few formal methods are used to compare options, so it is likely that the approach developed by this research will be used to formulate options or generate data to support recommendations which are only then entered into the decision-making processes. This also means that the metrics developed may be inserted individually into existing formats, rather than presented in their original context, so they need to be easy to interpret and self-explanatory if possible. Future developments are described in the next section.
4 Research plan and objectives

The work so far supports in part all of the research aims identified earlier (shown below). All of these are influenced by the host’s needs, but the last two are the main outcomes for the company. To deliver them, the following research objectives have been identified. Each supports several of the aims simultaneously.

<table>
<thead>
<tr>
<th>Overall aim:</th>
<th>Show that resilience can be used to help deliver (product and organisational) sustainability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supporting aims: (approach)</td>
<td>Use internal tools familiar to the host as far as possible, to overcome cultural issues and potential resistance</td>
</tr>
<tr>
<td></td>
<td>Use other existing tools as far as possible</td>
</tr>
<tr>
<td></td>
<td>Develop new approaches where needed to handle concepts new to the host</td>
</tr>
<tr>
<td>Supporting aims: (proof)</td>
<td>Use case studies to demonstrate the benefits to strategy decisions, when supported by these sustainability and resilience approaches</td>
</tr>
<tr>
<td></td>
<td>Show that these approaches do one or more of: meet real world strategic needs, deliver significant change, deliver real results in the business world</td>
</tr>
</tbody>
</table>

Table 1- Research Aims

The research is concerned with how a resilience approach can be used to help support sustainable strategies, how it works within the context of real-world company decision-making (a contemporary and complex social process where the researcher has little control over events), and will be done as part of action research. All of these factors indicate case study as the most suitable research approach, (Yin, 2009 Introduction, p.3-23). As each study will be limited by the scope of the team involved, the project will use a multi-case approach.

4.1 Foundation objectives

This is a set of precursors feeding into other activity and so needs to be completed first. In order to benefit from the next annual strategy cycle at Ford starting in January 2013, these tasks will be completed before the end of 2012.

4.1.1 Development of candidate metrics

Whilst the approach method has developed significantly the metrics have not. In order to inform the collection of data in case studies and the selection of final indicators a set of candidate ones is needed, based on the approach method developed so far, and sustainability and resilience theories. Case studies will typically each occupy only one level within the strategy process and need appropriate metrics for their level and topic, but some metrics will be common and there will be generic types needed. For example, desirable and undesirable outcomes on the P-diagram are intended to be expressed as impacts on either
resources or the four capitals, so will need social and environmental impact metrics or alternatively ones for human, natural and ethical impacts to supplement existing economic ones. There may also be metrics useful for prompting improved product design or business models; and as many of the analyses will be conceptual, many are expected to be qualitative rather than quantitative.

Some potential indicators have already been found, such as those from Spangenberg et al.’s (2010) deconstruction of consumption efficiency, and Williams’ (2007) sustainable innovation metrics for automotive PSSs. Some others have been generated for initial discussions with other teams (such as PSS and company-level resilience and sustainability metrics contained in the current TPoV slide pack); more are needed to complete the classes required and the selection needs to be refined.

**Risks and contingency:** this task will use the theory and available tools to generate possible metrics. The main risk is that a smaller selection cannot be made in advance of the case studies; in this case it will be made once the context (purpose, topic and level) of each case study is understood. The selection may also be adjusted as practice within the company changes.

4.1.2 **Completing analysis of Ford current practice**

A number of people at Ford who support proposals and participate in discussions have been interviewed, but not many decision-makers. The sample in this group needs to be enlarged to confirm the practice and gaps identified so far. It is planned to interview another 4 senior managers, in the period to the end of November 2012 and to observe another 3 strategy meetings. The need for further interviews and observations will be reviewed as results are analysed.

The information from this will complete the base-lining interview process. The comparison of current Ford practice with the proposed approach can then be finalised in a gap analysis, identifying points of intervention where it could be applied effectively, which elements are needed, and which teams to engage with to conduct case studies.

**Risks and contingency:** This task relies on access to busy senior managers, and to senior level strategy meetings towards the end of the annual cycle. If the strategy cycle meetings have finished or managers are not accessible, there will be enough information from the completed interviews and observations to begin the further research. If the extra interviews are delayed this will only matter if conflicting trends are discovered in their findings; in which case the direction of the research will be reviewed. Supplemental shortened interviews can be done with participating managers and observations made at the start of or during the first case studies. A cut-off date of Easter 2013 is planned for any
extension of this task to avoid late changes. The task would be completed later but not delay the research overall. General lack of access to high-level strategy forums and decision-makers, conversely, requires a scope review; this is handled via supervisory meetings on an ongoing basis. Finally it is expected that practice will naturally change during the project time-period, and this will have to be captured also in the data.

4.1.3 Setting the test criteria for success of the objectives

The research aims (see table 1) are supported by the theoretical work conducted thus far but have not yet been proven in practice. The last two aims in particular define generic ways to test for overall success. Firstly evidence can be sought of improved strategy decisions when using the approach or its outputs. This has two main elements, improvements in the quality of the process itself, and in the choices resulting from it. Secondly there is the requirement to prove that the approach meets real world strategic needs, delivers significant change, or delivers real results in the business world. These all require robust criteria for measurement.

Although the approach has been designed to fill identified strategic gaps its efficacy in this respect has not been tested. The significant change it produces could affect practice within the firm (the processes and results) but also the culture within it. This requires a different set of tests and a way to prove whether changes observed are significant or not (plus a definition of “significant” in this context). These criteria will inform the design of the case studies and other data collection exercises so must be selected first.

**Risks and contingency:** Success criteria must be practical so that it is feasible to collect data. Whilst the Research Engineer is the main resource required, this also requires access to company systems and staff to collect data. If any prove impossible the currently accessible sources of data will be reviewed to establish whether they are sufficient, or the research design needs to be adjusted. See also the next task.

4.1.4 Research method design

The delivery phase of the research must be carried out according to best-practice in action research and particularly case study design. The details have yet to be established but interviews and observations are expected to form a major part of the approach. This task also requires the information from previous foundation ones to formulate the hypotheses to be tested, and how the data will be linked to them; set the requirements for robust and high-quality data generation, collection and analysis; and guide the choice of case studies and any other approaches used to test the research. It defines which kinds of data are needed so
drives the choice of sources, and sets the parameters for the subsequent delivery and confirmation phases.

**Risks and contingency:** Additional detailed research design may be needed as the case studies are identified and begun, for example establishing which elements of the design each study can satisfy and therefore how it should be done. Time is planned for this within each study. Short-notice study opportunities (such as the initial interactions) will rely on the general design and retrospective analysis.

### 4.1.5 Identifying sources of data

This interacts with the other foundation tasks. It seems unlikely as Ford has long product development and strategy cycles, that the research will affect any existing corporate indicators at global level within the next two years. Those are based on recent production and sales activity and mostly short-term strategic goals, whereas the research concerns internal strategic options developed against future scenarios. Therefore success criteria will rely on more local measures of process and result quality, arising from within the case study teams and the decision-makers they support. The one major exception is that the project might affect the strategic direction information which is reported externally, for example in press releases. In terms of significant change, suitable sources of data already under consideration are included in Table 2 below:

<table>
<thead>
<tr>
<th>Evidence that decision practice has changed (people adopting techniques/metrics)</th>
<th>Presence of the approach tools/metrics in decision packs or meetings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approach influence on outcomes- Discussion about new criteria and their balancing in meetings?</td>
<td></td>
</tr>
<tr>
<td>Demand for training/briefing in the approach</td>
<td></td>
</tr>
<tr>
<td>Demand for Research Engineer involvement in strategic studies, decisions</td>
<td></td>
</tr>
<tr>
<td>Actual product or service changes resulting from its use</td>
<td></td>
</tr>
<tr>
<td>Strategy changes seen internally, or in press releases, and new strategic ventures</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Evidence of culture change (awareness of, and thinking about, resilience and full spectrum sustainability)</th>
<th>Increased presence of approach tools/metrics/keywords in meeting related documents, presentations, minutes; verbal discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased presence of them in other communications- email, internal web file storage/sites, external communications</td>
<td></td>
</tr>
</tbody>
</table>

**Table 2- Possible sources of data for identifying significant change**

External assessments by other bodies will be used if relevant. Existing internal assessments of products using the PSI tool or E-FMEA may provide supporting data for new
conventional products or technology strategy analysis; in-house capability for new LCA analysis is limited so these levels of analysis may well use qualitative data such as expert opinion. Qualitative assessments of proposals is an established engineering and business practice for Ford (within concept FMEAs or SWOT analyses for example) and valid for use with the research; it is likely to form the main source of data.

Judging by the findings so far business resilience is unfamiliar as a term and concept to Ford (besides being a relatively new field) so is not reported as such. Some of the existing internal information however is likely to reflect indicators identified in resilience theory. Some local business-process design teams have for example used P-diagrams previously. Historical data exist in annual and sustainability reports, press releases, share prices, a few external opinion papers or books, and external media articles, but internal details on strategy are not similarly available. Some current data may be obtainable inside the firm; but these and future assessments for both resilience and sustainability will mostly have to be obtained from case study teams and by approaching internal functions, or generated within pilot exercises; again the data is likely to be more qualitative than quantitative.

A sequence of data sourcing tasks have also been identified, shown below:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Identify if, how, where and when each of the chosen metric and success criteria data are collected within the company</td>
</tr>
<tr>
<td>2</td>
<td>Investigate whether they are accessible to the research</td>
</tr>
<tr>
<td>3</td>
<td>Establish whether they might be changed by the research within its reporting timescale (depends on the choice of case study teams and the success criteria)</td>
</tr>
<tr>
<td>4</td>
<td>Check which data are missing versus those required by the theory (part of the gap analysis)</td>
</tr>
<tr>
<td>5</td>
<td>Identify any available surrogate internal or external sources of these</td>
</tr>
<tr>
<td>6</td>
<td>Once collected, check quality and consistency of collected data before use</td>
</tr>
</tbody>
</table>

Table 3- Data sourcing tasks

**Risks and contingency**: As Ford is not informationally transparent, and access to sensitive strategic information is tightly controlled, searching and permission-seeking within the company will be required to access any additional internal data sources. Where these cannot be accessed or do not exist, external and surrogate sources will be investigated such as industry analysis papers, or data on other companies. Two further options are direct collection of data by the Research Engineer if feasible, or access to internal resources to create the data. If none of these is feasible dummy information must be used to test the
approach; this or anonymised data will be needed in any case if analyses from the approach are to be published. Data sources are expected to change alongside practice and personnel changes during the project, meaning they must be reviewed regularly and new sources found if required. Different case studies which are set up throughout the project may also require different sources. It is planned to design access to specific data sources as required in the studies.

4.2 Delivery objectives
These research tasks form the majority of the work to test and further develop the approach; and depend on the foundation tasks.

4.2.1 Develop missing approach elements
Based on the work so far, particularly interviews and initial case study contacts, it is expected that the following new elements will need to be developed; simplified risk assessment, simplified scenario generation, assessment of uncertainty within these, and simple resilience assessment. An informal variety of multi-criteria decision (MCD) support may also be needed, although typically Ford handles MCD via discussion in meetings. It is planned to develop and test these elements as required within the case studies.

Risks and contingency: There is a risk that elements required will be missed. This will be partly addressed by the initial gap analysis, by reviewing the choice of case studies against the approach and the success criteria periodically, and finally by information collected from participants. If any elements are still missing at the end of the project these will be analysed within the limitations and further research discussion sections of the final thesis and any journal papers.

4.2.2 Use case studies to demonstrate the benefits of the approach
This is planned to be the main way in which information is gathered and the approach developed and will take the majority of the researcher's time. Potential teams will be identified from the Researcher's and Industrial Supervisor’s contacts plus new ones created during the previous research interactions. There are three main ways identified so far of interacting with case studies. These are described in table 4: in practice some studies may be a mixture of these.
### Table 4- Types of case study

The detailed research plan for each study will add relevant methods for collecting data; although action research involving coaching, participation in or leading of analyses, meeting and analysis observation, and interviewing are expected to be the main approaches. Both the team’s processes and the content of those processes may change during the study. The generic steps planned for each case study are shown in table 5.

Each case study is expected to last between 1 and 6 months, typical durations for Ford strategic tasks. Some may be intermittently active. This objective will thus be made up from a mosaic of overlapping short studies of different types designed to cover the research design data requirements in total.

**Risks and contingency:** Certain planned strategy activities take place in a yearly cycle so it is possible to miss a key activity in early 2013 by late identification or access permission. In this case there will be another opportunity to engage with the top-down formal cycle in early 2014. There is also the option to use other strategy studies which arise throughout the year bottom-up within the company; this is already part of the existing plan but will need to be extended.
<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>identify study requirements from the general research design</td>
</tr>
<tr>
<td>2</td>
<td>check suitability of teams or projects against these</td>
</tr>
<tr>
<td>3</td>
<td>discuss and negotiate the requirements with potential teams</td>
</tr>
<tr>
<td>4</td>
<td>check which data and criteria will be covered</td>
</tr>
<tr>
<td>5</td>
<td>record what their current practice was before starting</td>
</tr>
<tr>
<td>6</td>
<td>record the data and decisions within the process of the study</td>
</tr>
<tr>
<td>7</td>
<td>record any other observations during the study, for example the quality of the process in use, practitioner issues and acceptance</td>
</tr>
<tr>
<td>8</td>
<td>check what has changed directly (for offline and parallel studies where comparisons should be available) or indirectly (for in-line studies where comparisons can only be historical)</td>
</tr>
<tr>
<td>9</td>
<td>check which data and criteria were covered from the research design</td>
</tr>
<tr>
<td>10</td>
<td>analyse and interpret the results for the study</td>
</tr>
<tr>
<td>11</td>
<td>identify whether further case study or other methods are needed</td>
</tr>
</tbody>
</table>

Table 5- Generic steps for case studies

As measuring the effects of the research at corporate level is part of the objectives, studies need to be found at a suitably senior level, or the scope of the research objectives must be adjusted. The technology level on the other hand is the most optional as some sustainability and resilience methods are already available for this and product design purposes. These could be removed from the scope if necessary; however some technology level data is likely to emerge anyway from product-level studies.

Experience indicates that 2 or 3 studies will be the maximum capacity of the research engineer at any one time. As the tasks involved in each study become clear, it will be possible to assess the associated workload, so that the selection of studies can be reduced for resource reasons (by removing the least effective ones), or expanded (to fill objective or research design gaps).

Lastly, as the majority of case studies have yet to be found and rely on acceptance of the research by, and permitted access to, “real” teams it is possible that some of the required testing and data collection will not be available through this approach. In this case the research design and data sources must be revisited to establish whether other approaches within the company can provide sufficient evidence to test the success criteria.
This is likely to delay the research and reduce the scope of any testing. External data might allow the partial testing of some elements of the approach; otherwise only a solely theoretical development will be possible. This should become apparent in the first half of 2013, and the research design and scope will be adjusted accordingly.

4.3 Confirmation objectives

As the research must be interpreted and written up the delivery tasks are intended to be complete by April 2014 to allow up to six months for this third group of activities. Several tasks have been identified.

4.3.1 Analysis of case studies and other research

Although some analysis of results and summarising will take place during each case study and the body of evidence will build up as the project progresses, the final analysis can only be done on completion of the case study phase. The initial task will be checking the quality and consistency of the data. Following this the coverage of the success criteria must be established then checked to test for success including evidence for significant change in practice or culture. There will also be separate tests for the effectiveness of the approach in itself. These will draw on best practice in case study research.

Risks and contingency: This task must include identifying if possible which changes can be attributed directly and solely to the research activity, and where other causes may also be present, to try to separate correlation and cause. However this may not be fully possible –especially if the main methods of data collection are qualitative, for example ethnographic methods such as interviewing which provide subjective experiential information. This risk must be addressed as far as possible within the research design, reviewed during the case study or other work. Any remaining ambiguities shall be discussed as part of the analysis of the general project and specific studies within the final thesis.

4.3.2 Interpretation of the body of work

This task will assemble the arguments for whether each of the research objectives have been achieved, and how. Like the preceding task this will draw on best practice examples for comparison and on any recent publications. It is likely that two parallel sets of interpretation will be created, one addressing the company's need at the time of finishing (which may change over time) and the other the original academic research objectives. For example sample evidence for benefits from the approach will be interpreted to allow its use on the TPoV slides or other company communications, whereas part of the academic task will be to confirm the nature of the contribution to knowledge. Interpretation may overlap with the analysis task.
Risks and contingency: Again this task relies on preceding ones for content, but its execution is reliant on the Research Engineer. If the scope of the research, particularly testing via case studies, has been reduced then this will become a more theoretical task.

4.3.3 Reporting the results

There are three main parts to this task: writing (and defending) the thesis, selecting material for and writing another journal paper, and producing information suitable for the company to use, for example via the TPoV communication pack. There is also likely to be the need to write a manual for the company for future use or adaptation of the research outputs, namely the resilient sustainability strategy approach and its metrics. Additional opportunities to publish papers or develop company documents and presentations may also arise during the project.

Risks and contingency: although the majority of this task will be carried out by the Research Engineer it requires editing and approvals from various stakeholders such as the supervisors, and company Public Affairs for any publications. Internal documents may require other buy-in such as from management, but this forms part of any subsequent company roll-out of the resulting approach or communication of the results and is not, strictly speaking, part of the research itself.

4.4 Timing plan

Figure 5 shows a Gantt chart showing the task relationships, resources and timings. This plan gives the overview of the work described here to plan, deliver and analyse the research to meet the research objectives.

Acknowledgements

The author wishes to acknowledge and thank both the Engineering and Physical Sciences Research Council and Ford of Britain for their assistance and support in funding, the University of Surrey's Centre for Environmental Strategy for all their support on the EngD course and project, and Ford of Britain for hosting this project. Additionally thanks are due to all those Ford colleagues who have participated in the research.

9722 words excluding references
### Figure 5: Outline research plan for years 3 and 4

<table>
<thead>
<tr>
<th>Task</th>
<th>Main Resources</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Develop metrics</td>
<td>Research Engineer</td>
</tr>
<tr>
<td>2</td>
<td>Analysis of current practice</td>
<td>Research Engineer; senior managers for interviews; strategy meeting access</td>
</tr>
<tr>
<td>3</td>
<td>Set success criteria</td>
<td>Research Engineer</td>
</tr>
<tr>
<td>4</td>
<td>Research method design</td>
<td>Research Engineer</td>
</tr>
<tr>
<td>5</td>
<td>Identify data sources</td>
<td>Research Engineer; company staff; company systems (maybe)</td>
</tr>
<tr>
<td>6</td>
<td>Develop missing elements</td>
<td>Research Engineer; case study teams</td>
</tr>
<tr>
<td>7</td>
<td>Case studies</td>
<td>Research Engineer; case study teams</td>
</tr>
<tr>
<td>8</td>
<td>Analysis of results</td>
<td>Research Engineer</td>
</tr>
<tr>
<td>9</td>
<td>Interpretation of results</td>
<td>Research Engineer</td>
</tr>
<tr>
<td>10</td>
<td>Reporting of results</td>
<td>Research Engineer</td>
</tr>
</tbody>
</table>

**Foundation tasks**
- Development of metrics
- Analysis of current practice
- Setting success criteria
- Research method design
- Identification of data sources

**Delivery tasks**
- Development of missing elements
- Case studies

**Confirmation tasks**
- Analysis of results
- Interpretation of results
- Reporting of results

**Date**
- Oct, Nov, Dec
- Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep

**Main Resources**
- Research Engineer
- Senior managers
- Strategy meeting access
- Case study teams
- Other studies
- Research Engineer; subjects

**Year 3**
- 2012

**Year 4**
- 2013
- 2014
References


Delft University of Technology.


Appendix A  Final draft of first journal paper

Surviving or flourishing? Integrating business resilience and sustainability
(Julie Winnard, Andy Adcroft, Chris France, Jaqi Lee and David Skipp)

Is it less resilient to be a bamboo-dependent panda than an omnivorous brown bear? The panda became a herbivorous specialist long ago; a great adaptation when enough bamboo species were available but which came at a cost as people progressively affected habitat and numbers. On the other hand, brown bears, whilst affected by the actions of people, have added suburban bin-raiding to their repertoire of behaviours, allowing more range and energy. An environment which is affected by change more rapidly than adaptation normally takes place requires resilient resources and behaviours for survival. This paper explores this idea in a business setting through examining the links between sustainability and resilience and starts with the a priori assumption that it is no use being good at something which is irrelevant or unsustainable.

Sustainability is increasingly a strategic issue for firms seeking competitive advantage. It has been driven by stakeholder, legislative and cost changes, including natural resource constraints (Haanaes et al., 2012). Business resilience has been of greater interest recently due to the unpredictable effects of globalisation and economic turbulence (Taleb, 2008) and also in response to social limitations on, and expectations of, companies (Porter and Kramer, 2006). Usually, however, resilience and sustainability have been examined as separate issues; this paper brings them together using a multidisciplinary approach bound together by complex systems theory.

Senge (1993) described organisations as complex systems because they contain many interacting feedback loops between their elements, interact with other complex systems, and produce non-linear, emergent behaviours. Thus complex systems are frequently compared to living organisms which change and learn. Others have debated which system elements were key to delivering change, whether change is identical with learning and whether active management is required to cause them (Caldwell, 2012). The concept has developed that organisations are complex adaptive systems, as change and learning happen within them even without deliberate top-down intervention (Polacek et al., 2012, Caldwell, 2012).

More recently, writers on organisational sustainability have classified organisations as complex adaptive social systems, and emphasised their need for effectiveness and adaptability in the face of increasingly complex and changing business contexts. Both
qualities are needed to provide sufficient resilience for them to co-evolve with their environment whilst maintaining their unique identity (Hadders, 2011). They are also sometimes called complex evolving systems, reflecting the idea that their identity might also change (Mitleton-Kelly, 2003). The central argument of this paper is that for complex systems to continue into the longest term, they must have the dual characteristics of resilience and sustainability rather than one or the other and that these two characteristics must exist in a symbiotic state.

The paper first explores the concepts of resilience and sustainability in a business setting through the use of a range of literature. It then explores the relationship between resilience and sustainability and explains why both are required for organisations to flourish rather than just survive. The paper concludes with a discussion of the practical implications of combining them and demonstrates how engineering concepts can be used to offer practical solutions to complex business system problems.

**Resilience**

Resilience has many definitions but common across most of them (for example of ecosystems, businesses, or human societies) is that it is a system quality. The conceptual basis, derived mainly from ecology, is the ability of a complex system to return to stability after disruption (Bhamra et al., 2011). There are additional refinements requiring both the system’s continued functionality during disruptions, and its adaptation to environmental changes, whether innate or deliberate (Walker et al., 2002), (Burnard and Bhamra, 2011). Resilience is needed by systems (and also individual system elements) to cope with turbulent external environments ranging from high impact events or disasters, to accelerating change, to smaller uncertainties, risks or perturbations (Bhamra et al., 2011).

Human approaches to developing system resilience have focused on the needs to reduce uncertainty (by improving the ability to forecast the likelihood of, or type of, disturbances), to reduce risk (by reducing the likelihood of specific events) (Burnard and Bhamra, 2011) and to reduce vulnerability (mitigating the effect that disturbances have on the system by lowering its exposure to them, reducing its sensitivity to them, and/or increasing the system’s range of available responses) (Bhamra et al., 2011). Whilst most literature implies the desirability of resilience, it is important to note that undesirable system behaviours can also be resilient (Walker et al., 2002). Some form of goal is needed for discrimination between wanted and unwanted forms of resilience (Walker et al., 2002).

If the raison d’être for any business is the continued delivery of high quality benefits to its stakeholders (whether profits, status or reputation) then the ability to ensure not just
survival, but a business quality of life is key. In this sense resilience is a system quality which enables the delivery of goals. For business it has much the same definition as for other types of system with the proactive generation of sustainable competitive advantage as a particular goal (Burnard and Bhamra, 2011). This we would define as strategic resilience which tends to favour diversification. Operational resilience, on the other hand, works well whilst conditions are unchanging and favours extremes of specialisation and optimisation. Whilst both strategic and operational resilience are needed, theory and practice have tended to focus more on operations resilience (Hamel and Välikangas, 2003a), (Taleb et al., 2009); in contrast this paper concentrates on strategic resilience.

Strategic resilience has been defined as “the ability to dynamically reinvent business models and strategies as circumstances change” (Hamel and Välikangas, 2003a, p.2). It is the capacity for firms do this continuously in anticipation of and not just in response to events, without causing themselves excessive disruption. Resilience ideally enables strategic renewal with “zero trauma” to the company, avoiding the consumption of precious resources and capacities that? ultimately undermine competitive advantage. Strategic resilience also matters for the delivery of long-term goals and development of corporate efficiencies which require time to evolve (Hamel and Välikangas, 2003b). For example business models based on product stewardship such as service-based leasing may have cycles lasting decades for long-life assets.

Walker et al. (2002) developed three defining characteristics of general system resilience: first, how much change a system can withstand, without its functional control or structure changing; second, how much a system self-organises; finally, how much capacity for learning and adaptation it expresses. Adaptive capacity can be further broken down into learning, flexibility to experiment and adopt novel solutions, and development of generalised responses to broad classes of challenges; this broadly matches the business-oriented definitions of (Bhamra et al., 2011; ).

What fundamentally differentiates a resilient system from an irresilient one is its adaptive capacity. The ability to evolve new capacities and resources, and even new equilibria, can be viewed as the mechanism by which resilience is delivered (Burnard and Bhamra, 2011). This is the sense used in this paper; resilience can be improved by many different activities within a company and the co-ordination of these is a strategic task (Parsons, 2010). A resilient business therefore should proactively manage this adaptive capacity, and is likely to exhibit strategies which are also proactive, efficient with resources of all kinds, generate diversity, and are based on realistic and accurate assessments of its
capabilities and surroundings (Burnard and Bhamra, 2011), (Hamel and Välikangas, 2003a), (Bhamra et al., 2011) and (Hufschmidt, 2011).

Those assessments are also efforts to reduce uncertainty, risk, and identify vulnerability. Reducing uncertainty is advisable but limited in possibility; whilst data can be gathered, hazards will change and there will always be unpredictable high-impact low-probability events to contend with: “Black Swan events don’t have precedents” (Taleb et al., 2009, p.79). Whilst we can usefully concentrate on the consequences of disruption instead of outright causes because robust systems design can remove unnecessary risks and reduce system vulnerability, some events and even solutions will always lie outside a company’s control or capacities (Burnard and Bhamra, 2011), (Taleb et al., 2009) and (Hufschmidt, 2011).

Whilst there is disagreement in the literature as to exactly how vulnerability, resilience and adaptive capacity are conceptually related to each other, and whether each is tangible (Bhamra et al., 2011), there is agreement on the main processes which develop and deploy the adaptive capacity of any organisation. These are preparation including the awareness of risks, planning and adapting in advance, mitigation through reacting to and overcoming an event in progress, and recovery by restoring efficacy and adapting after changes (Burnard and Bhamra, 2011), (Hufschmidt, 2011) and (Bhamra et al., 2011).

Resilience is, however, not an easy characteristic to measure from the outside. Organisational survival and sustainability may be the ultimate proof of its presence but this is retrospective and, therefore, of limited help to the creation of business strategy. It is easier to assess current or future resilience from within a company, where the components of adaptive capacity-building, preparation for multiple eventualities and other strategies are more visible and it is likely that this is the resilience of most interest and use to a company’s strategy-makers.

**Sustainability**

The generic and ecology-based environmentally-specific definitions of sustainability are useful as they are often implied in others. The OED definitions are:

\[
\begin{align*}
\text{a. The quality of being sustainable at a certain rate or level.} \\
\text{b. The property of being environmentally sustainable; the degree to which a process or enterprise is able to be maintained or continued while avoiding the long-term depletion of natural resources} \quad \text{(Online Oxford English Dictionary, 2012)}
\end{align*}
\]
The mainstream definition of sustainability is the triple bottom line aim of balancing different and sometime conflicting goals and is most often shown as three overlapping circles with sustainability at the triple overlap (see for example Clift (1998) or Hart (1997)). Walker et al. (2002) summarise this as “the continued wellbeing of the economy, society and natural resource base” (Walker et al., 2002, p.11).

Sustainability theorists have developed these ideas further (Johnston et al., 2007) and most useful for practical purposes is Turner’s asset portfolio approach to natural resource management which uses the four resource capitals types: manufactured, natural, human and ethical. Ross and Bissix build on this with their exploitation paradigms which prioritise the generation of the capitals according to how they are valued. These range from the ultra-short-term, non-maintainable utility and economic gains of the Very Strong Exploitation paradigm to the prioritisation of restoring damaged global natural resources and ecosystems in the Very Strong Sustainability paradigm (as summarised in Ewert et al., 2005, pp.160-163).

Hart (1995) added natural resources to the existing resource-based theory of the firm and argued that competitive advantage could only be maintained by considering natural resources as being as vital to success as more traditional resources (for example unique organisational capabilities such as innovative design or brand differentiation). Pollution prevention, product stewardship and sustainable development strategies are needed as increasingly full embodiments of proactive natural resource-management. This would offer proactive opportunities rather than just reactive solutions to existing problems (Hart, 1997). A similar position is taken by Porter and Kramer (2011) who suggest the internalisation and strategic importance of both social and environmental goals to both overcome unsustainability-driven issues which limit companies and to find new sources of competitive advantage.

From this perspective, businesses are elements within an economic ecosystem which operates within the larger system of human society, which is in turn contained within the planetary environment; all businesses interact with systems within which they are nested. Each business impacts upon, and is impacted by, issues differently depending on how it uses or wastes or pollutes resources such as materials, energy, people or money. It is also impacted by the surrounding system of other organisations and individuals which form its supply chain, markets and stakeholders.

Rockström et al.’s (2009) assessment of the status of the planetary-scale environmental systems required for humanity to exist, indicates that several of these have been disrupted already and require restoration whilst others will soon reach their limits. This
suggests that only the 'Very Strong Sustainability' paradigm is now scientifically acceptable in terms of sustaining human activity beyond the short-term, as simply maintaining the natural capitals will not be enough. This has important implications for businesses due to increasing supply-side shortages of resources, combined with accelerating activity-restricting legislation imposed to limit negative impacts, and their corollary resource limits to economic growth.

Jackson (2009) suggest that this limit might only be overcome by being more efficient with the resources available and by rebuilding natural capitals. Individual businesses behave like species within ecologies by transforming resources from one kind to another for human benefit (Ewert et al., 2005 p.160). It is not possible for one business to have a net positive effect on all capitals so other elements are needed to create a system that recycles and transforms resources as efficiently as possible in other ways to operate as sustainably as possible. However a clear definition of sustainability for businesses is still lacking.

Johnston et al. (2007) and Fuller (2012) both set out to define sustainability and develop a set of principles for sustainable development. Fuller’s separation of sustainability as the goal of a system from the process of actually doing it is useful; but he is concerned with clarity of meaning for design-related education, not organisations. Johnston et al. use the science-based principles of The Natural Step approach (TNS) to derive their own definition of operational sustainability for organisations, based on eliminating their contribution to ecological and social ills. The TNS approach also informs Krumdieck’s (2011a) risk-led thinking and fits well with the natural resource-based view of the firm.

There is, however, still debate about how to define and measure sustainability, how much change is needed and what is to be done and by whom. Krumdieck (2011a) acknowledges this and identifies a pragmatic solution; treat the problem as you would safety. It is almost impossible to both define and deliver a completely safe system but we do know what unsafe systems look like and how they can be improved. Under UK Health and Safety law, for example, organisations are required to take all reasonable and practicable measures to remove, reduce or mitigate risks to individual’s health, safety and welfare (HSC, 1996 p.11). Krumdieck suggests that we can already measure and therefore work away from unsustainability risks similarly, through a process of identification, prioritisation and mitigation. Both safety and sustainability assessments vary with location and context, and require prioritisation between different kinds of risks. Whilst Krumdieck’s suggestion is aimed primarily at engineers, it should also work equally well for business strategists, as the same issue of limited resources available to deal with only a subset of multiple opportunities and threats exists.
For the purposes of this paper, the following general definition is used:

*A firm pursuing sustainability will seek to eliminate the negative impacts and improve the positive impacts from its activities, to restore natural capital whilst enhancing human and maintaining ethical capitals. It will do this by eliminating resource extraction and pollution, identifying unsustainability risks and opportunities, prioritising them on their net contribution to the capitals and mitigating such risks or exploiting opportunities, whilst maintaining sufficient economic capital to operate.*

Furthermore the process of moving towards the ideal state of being sustainable is enacted in a complex and dynamic set of systems requiring constant adjustment and change of boundaries, goals and functions. Therefore the ultimate goal is always shifting and a continuous process will be needed.

**The link between sustainability and resilience: Surviving or flourishing?**

Resilience and sustainability have origins in ecology and social sciences and, fundamentally, consider the continuity of existence of an active system. Sustainability, with its survival or extinction ethos, is perhaps more conceptually binary than resilience, yet a system that works well should be more sustainable because it can operate for longer. This fits well with resilience theory’s emphasis on high quality performance. Walker et al. (2002) propose sustainability as the goal which can be applied to evaluate and steer the development of resilience. The resilience view looks at external effects on the system, thinking from the outside-in, whereas sustainability starts from the system and thinks about impacts and feedback loops, thinking mostly from the inside-out (terms borrowed from Porter and Kramer, (2006)). Unsustainability causes external (resilience) input-side issues for organisations but lack of resilience can lead to unwanted outputs and therefore eventual unsustainability (see figure 1). This logical looping also suggests that sustainability is part of the mechanism for delivering resilience.

In the context of adaption for better performance quality rather than just survival, sustainability and resilience are clearly tied together in their practical implications. As we extend our time horizons to allow for the effect of impact feedback loops lasting decades or longer on systems and consider the external changes and threats that a business has to deal with long-term, both qualities are required to achieve this flourishing state. Consider, for example, the difference between a company barely surviving (and therefore constantly on the brink of extinction) and one which performs well despite disturbances (that is,
flourishing). The first company will have little or no resource left over from dealing with crises, to react to extra changes or exploit new opportunities. We would expect it to eventually fail or to have to improve. We would expect the second one to be more resilient to sudden surprises through the incorporation of at least some social and environmental issues in its strategy. For the best performance these would be those issues and opportunities with most impact for it and which it can most mitigate or exploit by its actions (Porter and Kramer, 2011).

What is likely to happen if a firm develops only sustainability or resilience? It could be award-winningly sustainable yet go out of business suddenly if business conditions change or a key resource becomes interrupted. An example of this one-sidedness was the demise in early 2012 in the UK of small solar-PV panel installation companies, due to the early Government halving of feed-in-tariffs upon which their business models had relied. Conversely a firm could be economically resilient (short or even medium term) yet its activities have impacts that degrade its own feedstock, or damage its customers and eventually mean that it runs out of one capital or another and cannot operate; hazards due to unsustainability. An example of this is the drastic decline in the productivity of the UK fishing industry, and its general collapse in size over the last century, due to overexploitation of fish stocks (Thurstan et al., 2010). Another expected example only beginning to play out is the eventual depletion of finite fossil oil reserves by petrochemical companies. This may be arrested well before its end-point by legislation to address climate change through direct (extraction or emissions caps) and indirect (demand reduction) effects; it will be a race between resource depletion, feedback from environmental damage and the social unacceptability of these impacts which brings this about.

The forms which create the crisis for poor system design are essentially the same for both concepts: depleted resources, damaged (eco)systems, degraded societal license, disappearing markets, increased costs and unexpected changes which are beyond any capacity for adaption can take the company out of business suddenly or slowly. To be resilient long-term, an organisation must factor in sustainability in its goals. To be sustainable long-term it must build in resilience. If sustainability is the ultimate (and always moving) system goal and the direction of travel, then resilience is the ability not to be pushed off course along the way and to adapt to that moving goal.

**Resilient sustainability in practice**

As the two concepts have historically been developed separately, there is a lack of an holistic approach that integrates the two. Theoretically this implies that companies must
accommodate everything that could possibly happen into their strategic thinking and solve all their unsustainability issues at the same time. Clearly, this is a strategic impossibility because the issues are so large and interconnected. A pragmatic framework is needed to sort through the issues and opportunities in order that managers can identify the key interventions. This requires a system model, and a method for effecting change. The approach also needs to be capable of working at different levels within and beyond individual firms. One practical framework and change method to deal with this is Transition Engineering (Krumdieck, 2011b) which increases the resilience of systems when faced with constrictions in resources.

Transition Engineering offers the prospect of translating a more general resilience issue into assessments of risks and solutions in a subtle and nuanced manner which could help managers prioritise between different options. Solutions are sought which reduce system vulnerability and improve its adaptive capacity. This aims to both improve the system design and also the range of strategies and approaches it has to coping with change. Options can be tested against a set of future scenarios, to identify the one with the broadest resilience across all outcomes, and the best combination of project feasibility and risk (Krumdieck, 2011b). This combination of strategic analysis and engineering thinking is novel and allows the selection of a suite of solutions rather than just one over-optimised one to ensure the best resilience. In strategy terms this follows Hamel and Välikangas’ (2003a) advice to have many small strategic experiments in progress.

To analyse the system design and generate a system model another tool is needed, and Robustness Engineering (an engineering design approach based on Failure Mode Effect Analysis) can supply this. It provides a parameter diagram of the system which records desirable and undesirable inputs, outputs, controls and transfer functions. Only the control factors and the transfer function are influenced by the company. Figure 1 offers an example drawn for a manufacturing company. This is the starting point when thinking about resilience; minimising undesirable outputs arising from both noises and signals and optimising desirable outputs for given signal and resource inputs. Krumdieck’s approach concentrates on risks to system function and the same analysis can be applied to opportunities which can be inserted as signals, as solution options, or the failure to exploit or respond to them can be analysed as a risk.
Unsustainability appears in this analysis in several guises, for example as a source of resource disruption, hazards (such as extreme weather), noise or market signals on the input side. It is also a measure of the undesirable outputs of the system, which are mainly driven by both inefficiency and resource-intensity. Improved sustainability can, therefore, be used as the ideal goal of the resilience exercise to drive the choice of strategies which enhance both. Resilience is the optimisation of output benefits from the combination of input capitals and company resources, despite disturbances affecting either these or market demand; the outcome of the review process.

**Next Steps**

Every company will have its own individual risk profile which is dictated by differences in vulnerability, exposure, adaptive capacity and sustainability. It will also have its own feasibility profile driven by internal capabilities and resource availability. Prioritising the intersection of the highest priority issues with those which the company can most influence (Hamel and Välikangas, 2003a) allows the selection of Krumdieck’s (2011a) biggest strides away from unsustainability. As with all conceptual developments, however, further research is needed to establish whether this combined approach is useful for analysing and improving
the sustainability and resilience of organisations. The relationship between resilience and sustainability is theoretically robust and, we would argue, this is likely to be empirically robust and practically useful.

References


Appendix B  Question set used for semi-structured interviewing

General scene setting & background questions:
Q0  What degree background do you have?
Q1  How long have you been working in the automotive industry?
Q2  Which other sectors have you worked in as well?
Q3  How long have you worked for Ford?
Q3  And how long in this kind of job?

Easing into the specific questions:
Q4  What is your experience of how the company generally makes decisions?
Q4b What do you understand to be the decision-making process?
Q4c What is your general role within decision-making?
Q5  Are there differences in your view between how Ford makes daily/detailed (tactical) decisions and high level/longer range (strategic) ones?
Q6  How are you involved in strategic decision-making? (Proposer, participant, decision owner etc.)
Q7  How do the high-level / longer range decisions relate to daily and short-range ones?
Q10c How do strategies get made, and adjusted or discarded within Ford?
Q8  Are you aware of any company definition for what constitutes a 'strategic decision'? 
Q8b How would you define a strategic decision, and are there significant differences between your definition and what you believe the company’s definition to be?

If they believe they are involved in strategic decision-making:

Metrics/Information focus:
Q9  What sort of factors do you consider when making more strategic decisions?
Q9b Which factors is it most useful to consider? (Why?)
Q9c Is there anything included which is unhelpful? (Why?)
Q9d Is there any missing information which you think would be useful? (Why?)
Q9e How far ahead in time is considered?

Methods focus:
Q10  What standard approaches, if any, are used in decision-making?
(to arrange information, analyse it, compare options, present recommendations etc)
Q10b What approaches do you feel might be appropriate but which are not currently used?)
Focus questions (only used if sustainability, resilience and risk don’t come up specifically earlier):

Q11  How do you come across sustainability- in the wider meaning of environmental impact- within these decisions?
Q11b And sustainability- in terms of social impact?
Q11c And sustainability– in terms of economic sustainability ?
Q11d What about organisational resilience? (The capacity to absorb shocks, keep functioning and adapt).

Q12  Is there anything else important that you’d like to include about decision-making at Ford?
### Appendix C  Ford metrics used in decision-making

<table>
<thead>
<tr>
<th>Economic metrics</th>
<th>Social metrics</th>
<th>Environment metrics</th>
<th>Ethical/moral metrics</th>
<th>Resilience metrics</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Very high importance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proposal total cost; Revenue effect; Cost per unit; Investment cost; Available budget this year;</td>
<td>Brand impact; Key market trends;</td>
<td>Company compliance with own strategic targets to support global CO2 targets;</td>
<td>Which internal functions are stakeholders? Is there really a problem to fix? Does this proposal give us a business benefit?</td>
<td>Can I delay the decision? Who owns the decision? Do they support the proposal? Strategic benefit of proposal;</td>
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<tr>
<td><strong>High importance</strong></td>
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<tr>
<td>Volume effects; Profit effect; Formal finance metrics; Is the net effect positive? Growth %;</td>
<td>Brand position; Brand differentiation; External opinion of brand; Product portfolio perception (customers); Media % coverage;</td>
<td>Effect on (green) reputation;</td>
<td>Brand reputation; Company reputation; Integrity of brand;</td>
<td>Time needed vs. available; Resource need vs. available; What is the strategy? Strategic fit of proposal; Plant utilisation targets;</td>
<td>Size of risks; Size of opportunities; Time horizon; Which option is recommended? Relevance of information; Competitor intelligence;</td>
</tr>
<tr>
<td><strong>General (examples only)</strong></td>
<td></td>
<td></td>
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<tr>
<td>Spend vs. plan; Cost of ownership; Cost vs. performance tradeoff; Progress vs. target;</td>
<td>Local social impacts e.g. Jobs; Stakeholder consensus (internal); Credibility of company; Customer satisfaction;</td>
<td>Specific legislation; Tailpipe emissions incl.CO2; Noise; Fuel Economy; External corporate (e.g. GRI);</td>
<td></td>
<td>Which options to consider; Growth constraints; Crisis needing response (e.g. in supply chain);</td>
<td>Impact on strategy; Impacts on plan; Specific product performance benefits;</td>
</tr>
</tbody>
</table>
Appendix D  Examples of Teachable Point of View (TPoV) slides

6 Paradigms of Sustainability- Values

The extended sustainability types. (Adapted from Ross & Bissix overview in Ewert et al., 2005)

- **VSS** very strong sustainable
  (natural capital must be improved to restore the ecosystem)

- **SS** strong sustainable
  (natural capital must be maintained)

- **WE** weak exploitation
  (human and natural capitals can be traded-off)

- **SE** strong exploitation
  (human economic benefit more important)

- **WS** weak sustainable
  (capitals managed for humans with some limits)

- **VSE** very strong exploitation
  (very short term economic focus only)

Sustainability is only represented by SS & VSS paradigms
Choice between these two depends on ecosystem status

Why do Sustainability and Resilience both matter?

- **Current State**
- **Event Horizon**: Stay above to survive

1) Business as usual is unsustainable and leads to extinction
2) Resilience widens range of survivable operating conditions in short term, but does not avoid extinction
3) Survival requires improvements in both Sustainability and Resilience

Organisations are “buffeted” by signals and noise.
Direction of travel or buffeting can push them into extinction.

David Skipp, 2012
### Appendix E  Blank analysis output form

**Transition Analysis Output Form**

Total resilience rating is based on both vulnerability (does the scenario affect the system) and adaptive capacity (can the system adapt)

<table>
<thead>
<tr>
<th>Scenario 1 (most likely)</th>
<th>Scenario 2 (best)</th>
<th>Scenario 3 (worst)</th>
<th>Scenario 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Option 1 (preferred)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feasibility: low/med/high</td>
<td>Level of uncertainty</td>
<td>Level of uncertainty</td>
<td>Level of uncertainty</td>
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<tr>
<td><strong>Option 2</strong></td>
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<tr>
<td>Feasibility: low/med/high</td>
<td>Level of uncertainty</td>
<td>Level of uncertainty</td>
<td>Level of uncertainty</td>
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<td></td>
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<tr>
<td><strong>Option 3</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Feasibility: low/med/high</td>
<td>Level of uncertainty</td>
<td>Level of uncertainty</td>
<td>Level of uncertainty</td>
</tr>
</tbody>
</table>