

Analysis under Uncertainty for Decision-makers: What do Decision-makers want from the Analytical Community?

The Royal Geographical Society, 1 Kensington Gore
27 - 28 February 2018

Involving the following Collaborating Organisations:



Psychology

Lancaster
University



Department of
Management

E3G

energy futures lab
An institute of Imperial College London



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The previous Network Workshop – Decision Making Under Risk and Uncertainty held between 10 to 11th February 2016) has material related to the outputs in this report - see the following [link](#) to see material from that workshop.

1. Background

On 27th and 28th February 2018, a workshop was held at the Royal Geographical Society to discuss Analysis under Uncertainty for Decision-makers. The workshop attracted a broad set of audiences including defence, water, energy, forestry, engineering sector and academia - see Annex 2. Though over 95 attendees registered for first day and 75 for the second – due to inclement weather and subsequent travel problems actual attendees were lower than this with an estimate of 75 and 35 on respective days. This document represents a summary of discussions between participants and will form the basis of other outputs from the event.

The workshop was developed off the back of a workshop held between 10-11 February 2016, which involved industry, policy makers and academic participants. At this workshop, the following was found:

- There was a strong appetite to involve decision-makers at the heart of the value proposition;
- That an understanding of the process from an end-to-end perspective as well as the impacts of interventions at any one point and the repercussions upstream and downstream of decision-making value chain was essential;
- That multi-sectorial participation across sectors and domains was invaluable for capacity development to better understand the proliferation of tools available; and
- There is an appetite for capacity building and learning for best practice via engagements, summer schools, participation in research and the development of guidance and training documents.

With this in mind, it was decided to hold another workshop to develop a better understanding as to how to co-create experiences to:

- understand the type of information relevant to decision-makers and how to convey this effectively;
- use simulations and immersive processes to develop empathy as to the considerations of the issues that decision-makers have to contend with when making decisions; and
- allow analysis of process to understand the end-to-end perspective in decision-making.

2. Workshop Details

The workshop's intent and proposed outputs are summarised below.

2.1 Workshop Intent

- Provide an opportunity to discuss challenges faced by analysts in addressing decision-making under risk and uncertainty;
- Better understand the context(s) within which decision-makers have to make decisions and what they want from the analytical community;
- Assess the simulation process and how this can be used, improved and developed into a tool to develop understanding of what different decision-makers need to consider in different circumstances and over different timescales. A proto-framework to analyse the outputs from the simulations was also tested; and
- Understand what the Network wants from the community going forwards.

2.2 Workshop Outcomes

- Developed information sharing, networking, and cross-sectorial collaboration opportunities;
- Identify new capacity to support organisational decision-making needs across academia, industry and policy; and
- Calibrated an appetite for the type of value proposition that members of the network would like to continue collaborating with the network.

A workshop agenda is available in Annex 1. The workshop can be broken up into the following seven sessions:

- Attendees survey results presentation by Lucas Kruitwagen - section 3.1;
- A Key Note speech by Geoff Mulgan - section 3.2;
- Two 'Pop-Up Talk' Sessions involving 7 x 5 minute talks in total from participants discussing: (1) the problems that they have in their organisations; (2) what tools that they use to address risk and uncertainty; and (3) how they implement the outputs into strategy. This was followed by a single 20 minute Q&A session between the Pop-up Talkers and the delegates - see Section 4.
- A set of three simulations in three very different contexts and over 3 different timescales were conducted and the feedback from the simulations was undertaken - see Section 5.
- A decision-making panel was convened by Nick Mabey to assess what decision-makers want from the analytical community - see Section 6.

Finally, a feedback session was held between the workshop organisers and delegates to capture how to take the agenda forwards in the UK decision-making under uncertainty arena - see section 7.

3. Survey Results and Key Note Speech from Geoff Mulgan, CEO of NESTA

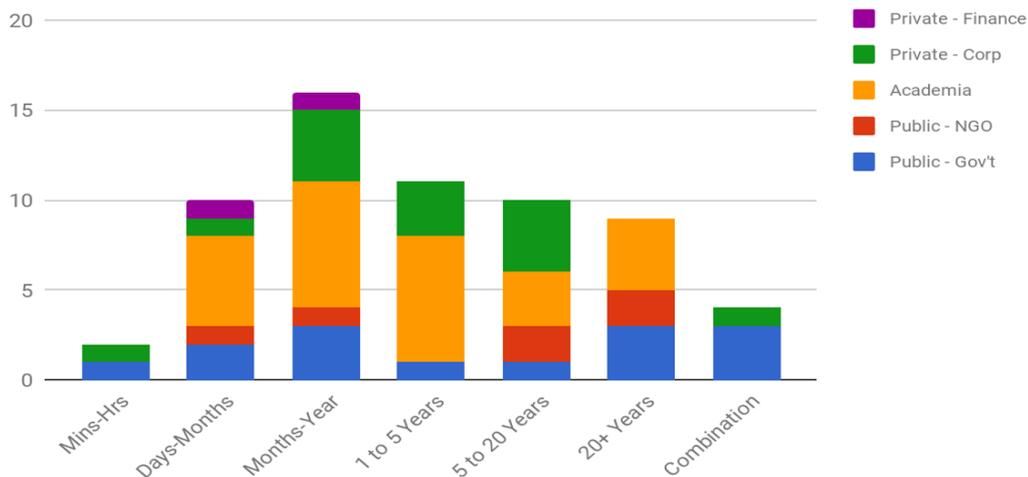
3.1 Workshop Attendee Survey Results

Of the 95 attendees who registered for the workshop 64 completed the online survey. The results were collated, analysed and presented by Lucas Kruitwagen.

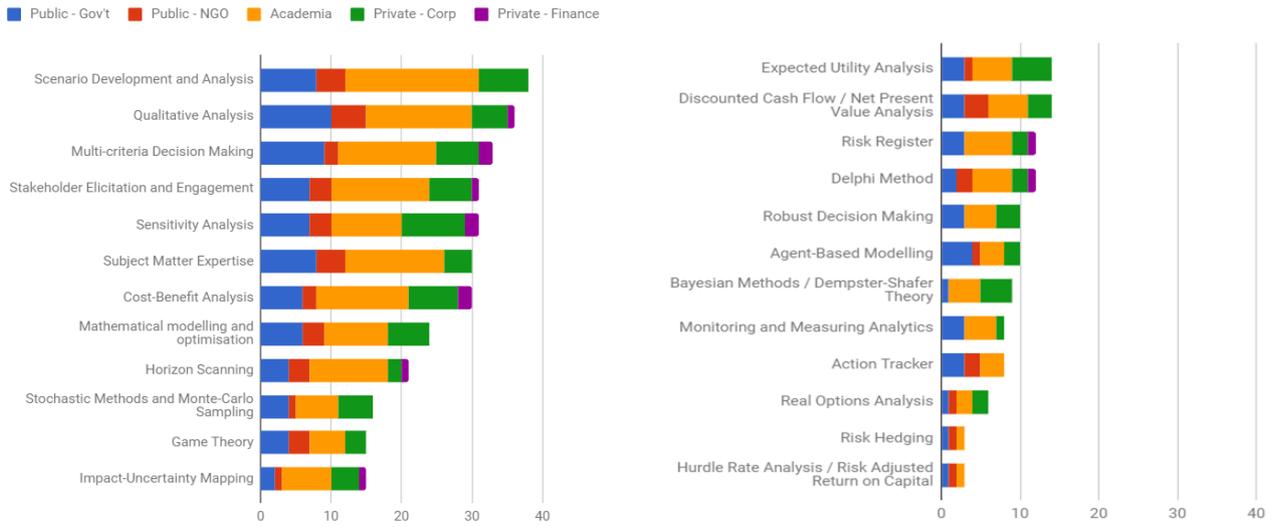
The summary of the results in presentation format are available [here](#).

The key messages from the presentation were as follows:

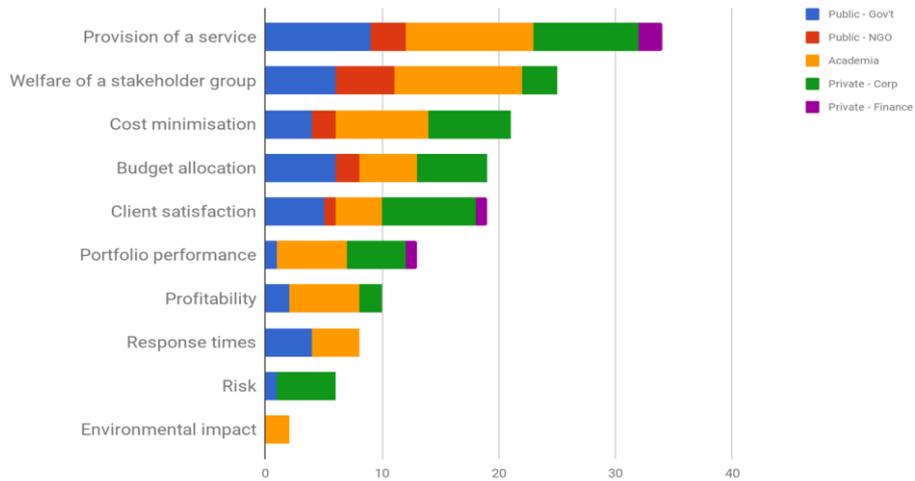
1. Time Horizon most relevant to the Analysts / Decision Makers Decision Making



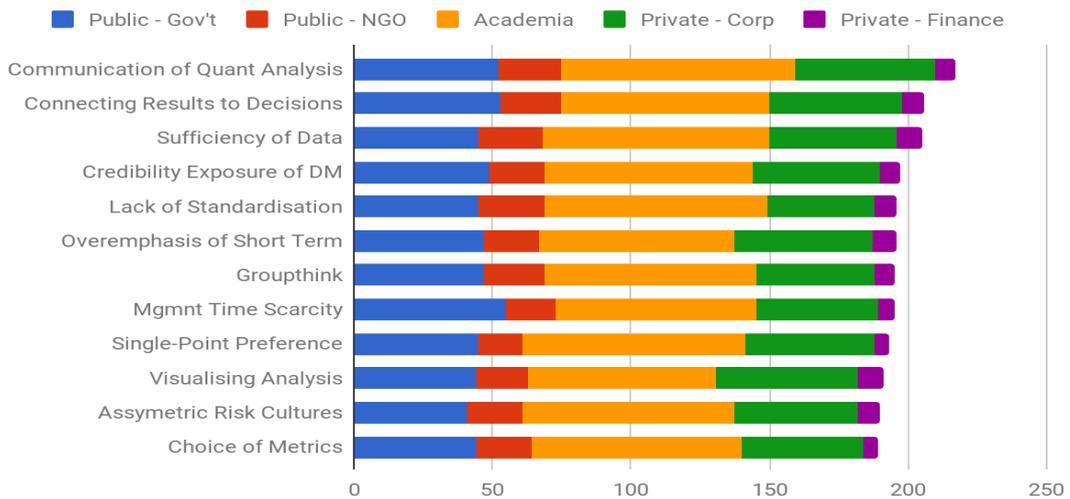
2. Types of Tools used by survey participants:



3. What do they seek to Optimise?



4. Barriers faced by Analysts and Decision Makers



We need to understand the following:

- Take stock of good examples such as Google Maps: assembling a system of intelligence in order to make something useful;
- Modelling uncertainty is the same as modelling complexity, and modelling uncertainty is actually not knowing how complex a problem is; and
- Key challenge will be to integrate AI: collective intelligence and individual intelligence = intelligence design.

4. Pop-Up Talk Sessions I to II

A summary of the issues covered relevant to workshop objectives for each presentation in the Pop-Up talk sessions by delegates as well as the themes developed in each Q&A session are summarised below.

Session I:

This session was comprised of the following participants:

- (1) Brian Efird, KAPSRAC;
- (2) Kris DeMeyer, Kings College London – Challenging current risk assessment approaches for better climate policy;
- (3) Jim Maltby, DTSL - Strategic decision-making under uncertainty in defence: Cognition and computation; and
- (4) Sunny Modhara, Network Rail - Uncertainties in decision-making at Network Rail.

The pop-up talks given in this session can be found in the following [here](#). A summary of the points raised and the themes developed in this session can be found below.

Brian Efird, KAPSRAC - Collective decision-making processes.

- Collective decision-making processes (CDMPs) emerge from politics and stakeholder interactions. Uncertainties around these pose fundamental challenges;
- Main CDMP uncertainties: Inclusion of new actors with different preferences and objectives. These generate complexity and opacity of processes;
- KAPSRAC Toolkit for Behavioral Analysis for CDMPs in use (open-source): rigorous, transparent and explicit modelling of decision-making processes; and
- Senior decision-makers have limited time and bandwidth, are inundated with information and require rapid decisions. Trust and clarity are key to successfully communicating uncertainty.

Kris DeMeyer, Kings College London - Challenging current risk assessment approaches for better climate policy.

Conducted risk and uncertainty workshop in w/c 19th February 2018:

- In Climate Risk Assessment Reports, need for co-production, specialized “knowledge brokers”: risk assessment specialists, co-production “midwives”;
- To foster culture of uncertainty one needs to manage risk culture differences, push for funding changes: reward impact to risk question, dedicated research for CCRAC, academic incentive changes; and
- Range of solutions show that responsibilities are fragmented.

Jim Maltby, DTSL - Strategic decision-making under uncertainty in defence: Cognition and computation.

- Iraq War Enquiry: human-centric miscalculation;
- Good enough decisions with feedback are required, as well as robust and adaptive strategies;
- Human-agent collective in how humans and machines interact;
- Iterative exploration, sense-making and rapid prototyping are needed in order to appropriately use models, which are merely imperfect and oversimplified mechanisms to enable decision-makers;
- Incentivisation of different reasoning methods should be encouraged in capacity building for decision-making under uncertainty.

Sunny Modhara, Network Rail - Uncertainties in decision-making at Network Rail.

- Various decision scales:
 1. Strategic at network level – up to 40-year time scale;
 2. Planning decisions at route level – up to seven years;
 3. Delivery decisions at sub-route level – up to three years; and
 4. Operational decisions at asset/component level – real-time to one month.
- At strategic levels, several sources of uncertainty exist: initial costs and timings of interventions, depreciation of assets, effectiveness of interventions, unknown unknowns.
- Planning needed to forecast asset lives (costs and volumes). Point estimates of costs are typical, but costs and other parameters are better expressed as distributions, to provide more realistic forecasts.

Session II:

This session was comprised of the following participants:

- (1) Leonard Smith, London School of Economics - Improving weather risk management in the energy sector;
- (2) Michael Petr, Forestry Commission – The future delivery of forest benefits, pressures from climate change, pests and diseases;
- (3) Martine Barons, Warwick University – Integrated decision support systems for food security.

The pop-up talks given in this session can be found in the following [here](#). A summary of the points raised and the themes developed in this session can be found below.

Leonard Smith- London School of Economics, Improving weather risk management in the energy sector.

- Risk managers and the law require that London Stock Exchange registered companies hold Reserves. The weather is one factor that can influence Reserve prices, but often not the main factor. Temperature forecasts thus influence price;
- Traders suffered from information overload when faced with trading decisions. A bespoke screen was created to enable traders to assess the importance of the weather on Reserve prices and thus their daily trades. The screen was color coded to create an easier decision-making environment;
- It is important for modelers to know when models are giving misinformation, and to highlight these cases to decision-makers. Unknown unknowns are not as bad as “neglected knowns” that are either known or unknown to not be in the model.

Michael Petr, Forestry Commission - The future delivery of forest benefits, pressures from climate change, pests and diseases.

- Decision-making based on elements of long-term uncertainty- climate change, long-term horizons, ambiguity, types of forest management, political uncertainty. The Forestry Commission has developed web-based multi-criteria decision tools, allowing foresters to make informed decisions;
- As evidence providers, effective communication of up-to-date evidence and uncertainties to decision-makers is key to impactful decision-making. However, communicating uncertainty is difficult, especially when decision-makers want one key value or message, and when organizations require different information;
- By continuously engaging with customers, research and models are becoming better aligned with customers' work requirements, and customers' expectations are being managed.

Martine Barons, Warwick University - Integrated decision support systems for food security.

- The UK has seen a decrease in food security and a rise in hunger in recent years;
- Collaborating with experts from different fields provides scope for more robust decision-making, as estimates can provide insight to potential futures under different policy conditions;
- Uncertainty is propagated through law of total probability, resulting in an integrated decision support system, in which estimates are produced and visually communicated to support decision-making for policies.

Plenary discussion

- Institutional memory is deteriorating. Researching how to improve it is of paramount importance;
- Governance frameworks influence decision-makers (both in the private and public sector, but especially in the public sector) because different government structures make decisions based on different timelines. This leads to discrepancies in how different government structures value information;
- Questions surround the usefulness of information that is known to be wrong, and its impact on decision-making;
- When academics are working on an applied problem, and are incentivized to write a paper, there is a value disconnect between assumptions that will solve the problems, and actual objectivity in solving problems;
- In order to ensure that research is effectively applied it has to be inter-disciplinary.
- Individuals who have tacit knowledge about stakeholders, their agenda, their motivations and relationships are effective at helping analysts present their information to decision-makers.

5. Simulation Session Summary and Synthesis

There were three simulations run over a period of 2½ hours on the afternoon of 27th February - immersing participants in analysis and decision-making activities, which operated at three different timescales - as follows:

COBRA - Crisis response to a Major Incident. This session simulated the tactical/strategic response to a major emergency incident in a city centre location;

Brexit - Supply Chain Impacts of Brexit. The second simulation considered a company which is part of several supply chains with EU and other international partners beyond the UK; and

Oil & Gas - The 2 Degree Pathways Investment Simulation. This session made participants better understand the choices and trade-offs companies and investors face in the transition to a low carbon economy.

The types of uncertainties that sought to be identified are highlighted in Box 1, below.

Box 1: Categorise of the uncertainties.

- **Stochastic uncertainties** i.e. physical randomness e.g. weather
- **Epistemological uncertainties** i.e. lack of knowledge including:
 - What is happening?
 - What might happen?
 - What might others do?
 - How good is our understanding?
- **Analytical uncertainties** including:
 - Judgemental uncertainties - parameter values in models and codes;
 - Computational uncertainties - inaccurate calculations;
 - Model uncertainty - imperfect fit of the real world.
- **Ambiguities** i.e. ill-defined meaning
- **Endpoint uncertainties** i.e. required endpoint/impact/consequence is ill-defined.
- **Value uncertainties** i.e. partially formed preferences.
- **Ethical uncertainties** i.e. what is right.

More detailed analysis of the simulations will be available shortly from Nikki and Simon for those who attended the COBRA and Brexit simulation, respectively. A summary of the sessions are made in sections 5.1 to 5.3 for each simulation and preliminary analysis according to a proto analysis framework is made in section 5.4, below.

5.1 COBRA - Crisis response to a Major Incident

This session simulated the tactical/strategic response to a major emergency incident. This scenario involved an initial report of an explosion at the finishing line to a marathon. Participants were provided with the role of Police Commander, Fire Commander, Ambulance Commander, Major or Marathon Event Organiser. They were asked to work together at as a multi-agency team in order to coordinate the response from their respective agencies. They had to make decisions in response to a number of tasks delivered via audio feeds. For example, how to deal with criticism on social media? How to manage displaced runners? How to deal with limited specialist assets on scene? There was large amounts of uncertainty during this exercise, and players had to ensure that they worked together to reduce uncertainty, whilst being aware of their own, potentially conflicting, organisational goals and priorities.

Notes were made by a team of psychologists during the simulation, with feedback framed around the analysis framework provided by the organising team.

Framing - how might decision-making be framed in emergency contexts?

- One team began the simulation by framing their roles and responsibilities clearly. This team reflected that this helped them to identify who had more 'primacy' over each decision/task, whereas other teams felt less certain about who was ultimately responsible for decision-making.
- A suggestion during the debrief was that it might help to have secondary or shadow decision-makers in these meetings, who do not have responsibility for making a decision, but can provide reflection and question the decisions of the group. This might have pros in increasing confidence in the final decision, but could contribute to further deliberation and inertia if the shadow role of these individuals is not made clear (i.e., support role, not decision-making role).

Decision questions - what were the main sources of uncertainty during the scenario?

- A core issue for decision-makers was about accountability and governance. This related to decisions on whether to deviate from policy, wherein teams wanted clarity about how accountable they were for the decision and whether senior decision-makers had devolved responsibility fully or not.
- Personality clashes and disagreement were discussed between group members. It was hard for groups to reach a resolution on action when there was strong disagreement between team members. They struggled to identify how to overcome social issues like this in multi-team settings.
- Despite having no information about the cause of the explosion, teams were able to take action. Many adopted a 'risk averse' approach wherein they took the more cautious, satisficing actions to cope with uncertainty.

c. Simulations - what was good/bad about the simulation format?

- Participants reflected that the audio feeds made the scenario immersive and enjoyable. They also enjoyed being provided with a role to get them in the mind-set of the decision-maker.
- We collected data on each decision made by the group and also collected data on the individual reflections of team members during the simulation. These can be useful for comparing how different teams logged decision and helped to frame the debrief around comparing the different choices made by different teams who were given the same information.
- A possible way to improve the simulation would be to make it reactive (i.e., when log a decision there is a consequence to it). This is possible in other formats wherein teams are in separate rooms rather than working together as audio feeds can be tailored to the decisions made by the team.

d. Communications - how can risk and uncertainty be communicated during a major incident?

- One task the team had to deal with was communicating information about the major incident to the public. Teams decided to take a cautious approach and discussed their plans to provide enough information so that the public didn't feel they were being lied to, but not so much that working assumptions (that might later be disproved) were made available to the public.
- Due to the fast paced nature of a major emergency, there is often very little time to communicate information about risk from external parties. Team members were given additional information they could share if they wanted during the exercise (expert knowledge). This was most effectively used by the team who clarified their roles and responsibilities at the start of the exercise as they knew who had more expertise during different types of uncertain tasks.

5.2 Brexit - Supply Chain Impacts of Brexit.

Eleven participants, three observers and a facilitator took part in this simulation. More than half of the eleven participants came from academia and government. The objective of the simulation was to use a hypothetical scenario based around Brexit to stimulate discussion of the issues, events, behaviours, responses, etc. the participants perceive as being uncertain in the scenario and which of these would be significant in their decision-making. A rough outline of the simulation over the two sessions was:

February 27th (Afternoon):

- Discussion of the scenario;
- Identification of concerns, issues, uncertainties;
- What general and risk management strategies would the group consider?
- And, deciding on immediate actions.

Note: this is a pretty common agenda for most boards, management groups and task forces discussing an issue for the first time

February 28th (Morning)

- After an overnight break, what concerns, issues and uncertainties do the group felt that they missed or over/underemphasised?
- Reflecting on their discussions, could they have been structured or supported differently?
- Non-pejorative and constructive feedback from our observers

After the structure and objective of the session were outlined, the participants were presented with the scenario:

Watson and Fletcher Plc

You are a member of the Board of Watson and Fletcher Plc, a company that manufactures precision mounts for scientific, medical, photographic and similar instrumentation.

In the late 19th century, Benjamin Watson set up a company to manufacture high precision brass fittings in Wolverhampton. The company prospered in the early 20th century, but by the late 1970s it was in difficulties and would have failed but for two events. Firstly, Benjamin's great grandson, David, took over the reins of what was still a family firm. David was a dynamic and shrewd businessman and quickly targeted high value, high precision markets. Secondly, his chief engineer, a Peter Fletcher, developed a mechanism that allowed the very precise movements in scientific instrumentation, Moreover, it was a mechanism that could be miniaturised. David made Peter a partner in the business, and the company took out a number of patents. It was these patents that allowed it to take a world lead in the manufacture of the mounts and joints needed in many scientific, medical, photographic and similar instruments. By 2000 the company had developed markets across Europe, the US and Asia-Pacific. For a few high volume products, it licensed other companies to produce specific versions of the mounts and joints; however, in the main it manufactured the components that its customers needed for its instruments, which were generally very high value, but low volume products. Thus, the company sat and still sits in a number of supply chains, taking in high quality materials and sending out components that its customers will build into their products. Logistics are outsourced to a global company, meaning that Watson and Fletcher can satisfy orders worldwide. Composites are increasingly replacing metals in its products. During the 1990s, the company gained many clients in the satellite and aerospace

industries. In 1998, David and Peter successfully took their company to market, making Watson and Fletcher a Plc and themselves very tidy fortunes. They both retired from the company in the 2000s.

Last financial year Watson and Fletcher Plc made profits before tax of £28 million on a turnover of £291 million. Since 2001, it has maintained a research function, which has helped it develop components (and patents!) that has kept it 'the company to go to' for mounts and joints needed in high precision instruments. Its major markets with percentages indicating the contribution by sales to gross profit before tax are currently the UK (12%), the US (12%), Germany (10%), the Netherlands (9%), Norway (9%), Switzerland (8%), South Korea (8%), the rest of Europe (6%), India (6%) and Singapore (3%), and the rest of the world (17%). Its suppliers of the high quality metals and composites are distributed mainly across the UK and Europe. Watson and Fletcher Plc is still headquartered in Wolverhampton and manufactures its products in two factories nearby,

The Board is meeting today to begin to consider its strategy in relation to Brexit. There is no intention to formulate and adopt a final strategy today but it does want to consider the issues, consider contingencies and identify the key questions that need answering in the coming months.

The participants were also told that they could assume that any knowledge they had of Brexit issues along with the details in the scenario.

Before any discussion began, the participants were asked to complete a brief mental map questionnaire, noting down what they thought were the key issues, uncertainties and concerns they would have as members of the board.

Discussion began with the facilitator asking members to state their thoughts briefly. He noted key points on post-its, which were later organised to give a summary of the discussion. Once each member had presented his or her initial thoughts, general discussion ensued with the facilitator noting down new points on further post-its. As the discussion progressed, the post-it were organised under four headings: uncertainties, objectives, actions and assumptions. See Table, below.

Uncertainties	Objectives	Actions	Assumptions
<ul style="list-style-type: none"> • £ vs \$ vs Euro as Brexit progresses • Impact of changes in Tariffs, both with EU and rest of World • How might the UK market be impacted - our customers' markets • Will UK remain in some EU trade area or customs union in some way? • Potential delays and cost changes across supply chain • Stock market perception of us • Competitors' strategies 	<ul style="list-style-type: none"> • Expansion (growth for resilience) • Shareholders • Other stakeholders 	<p>Set up working group to investigate:</p> <ul style="list-style-type: none"> • Analysis under different Brexit scenarios • Set up manufacturing in Europe • Change location of HQ • Partnerships? • License patents more • 'Be nice to' customers and suppliers • Larger inventories if logistics delays likely 	<ul style="list-style-type: none"> • Current competitors located in Germany, US and South Korea <p>Also we would know the following</p> <ul style="list-style-type: none"> • All details of current strategy, including marketing • Our competitive advantage(s) • Manufacturing costs (broadly fixed and relatively small) • Value of skills, patents etc. • Nationalities of staff, particularly R&D • Lead times in supply chain • Tariffs and logistics of supply chain

Uncertainties	Objectives	Actions	Assumptions
<ul style="list-style-type: none"> • Might a competitor buy us out • Lose technical, R&D staff • Additional costs • ISO, EU, BS standards issues • Access to EU research programmes 			<ul style="list-style-type: none"> • Precise location of raw material suppliers • Market trends

At the end of the afternoon session, the each member was asked to complete a second questionnaire, noting what they had learnt and how their thinking had changed during the discussions.

The following morning the group reconvened and reopened the discussion, noting that there had been no real discussion of some issues, including:

- the short and long term and the possibility of hedging against short term exchange rate volatility;
- any potential for disruptive innovation and consequent entry of new competitors with lower costs.

The discussion moved onto whether the discussion and process followed the day before could have been better or more productively organised. Many felt that they want a longer description of the scenario with more details on the current strategy, markets, costs and profits, competitors, etc. Nonetheless, there was a feeling that generally the process had been effective and that they had made a lot of progress towards a framework and model in a relatively short time.

Finally, the three observers gave their feedback, reflecting on behavioural, business especially supply change and decision-making issues. Broadly conclusions of the simulation were:

- The scenario was thought to realistic and stimulated discussion well. It was presented too tersely, perhaps, with too few details. A balance had needed to be drawn between the time needed to read and absorb the scenario and the information needed for constructive discussion (e.g. current strategy, more on the costs and their distribution, location and scale of competitors and customers, nationality of workforce). On reflection, however, this balance should have favoured a longer description, maybe twice as long. It might also have been improved if each participant were given a formal role and the information in their scenario tailored to that role.
- The group included a high proportion of academic and government participants, and as a result they maybe did not see the opportunities that Brexit could bring business and industry.
- The process had been broadly effective and had paid considerable attention to group dynamics, although at one point the facilitator had lost full control and so could have managed time better. However, a number of positive points were noted.
 - Inviting each member to give their first thoughts in turn had got created a positive, effective discussion.
 - Using post-its was an effective way of structuring the conversation and led quickly to a framework in which to take things forward.

- The value of an overnight break for reflection when discussing strategic issues had been demonstrated as the morning's reflections came up with new issues. [N.B. there is a lot of empirical, behavioural evidence to support this observation.]
- There was a feeling that, had the session been a full day, the group would have got a strategy together well. However, with the time available, it was noted that a reasoned discussion of the company's objectives had yet to occur.
- The observers introduced several valuable models in their reflections:
 - Gary Klein's and Karl Weick's thinking on sense-making and (recognition-primed) decision-making.
 - Cynefin. A model to categorise uncertainty and knowledge in a way that relates to decision-making and the choice of actions and strategy.
 - Models of decision processes including Spetzler's Decision Quality model and the DMP Framework;
 - Stakeholder power and influence.

A longer, more detailed analysis of the simulation, including comparison of the participants' initial thoughts with their reflections after the discussion.

5.3 Oil & Gas - The 2 Degree Pathways Investment Simulation.

This session sought to allow participants to act as both decision-maker and analyst to better understand the choices and trade-offs companies and investors face in the transition to a low carbon economy. New technologies, changing energy services, rising efficiency, competitive resource landscapes, and policy and regulatory changes all have potential to disrupt energy industry business models, strand assets, and destroy shareholder value. Participants role-played company and investor decision-making through the energy transition. See <http://www.2degreepathways.com/> for details.

The processes and heuristics used by participants in managing uncertainty in their decision-making were observed by a Decision Scientist. The developers of 2 Degree Pathways are also considering pathways for future research - including psychological and behavioural economic studies. The simulation was run on laptops.

These notes were generated in the discussion session following the simulation on the morning of 28th February.

- What Strategies were developed by the different teams? There were a number: Oil Strategy? Gas strategy? Green strategy? Dividend strategy?
- Influence of the news headline feeds during the simulations on decision-making:
 - Responses ranged from using the headlines but found the process of internalising them more like gambling to quite the opposite - others found that the headlines weren't strong enough. Some teams just followed the narrative and were quite convinced on priorities.
 - Teams were aware of substantial Cognitive Bias. Those who had the strategy already tended to pick the bits of news that reinforced that - they used the news to test their strategy rather than using news to adapt their strategy.
 - Some teams considered that their wasn't enough time to read/use the headlines and that they were already cognitively overloaded: There was just too much information.

- Teams found that the headlines about coal were quite confusing and it took them some time to figure out you couldn't interact with the coal market.
- Influence of other Actors / Teams?
 - Some teams had made assumptions about the idealism of other players with a view to trying to flush out everyone else in the room – but never really nailed the dynamics.
 - There was not enough time to strategize against other players. On occasion teams looked at the asset base of other companies.
 - Others were not too worried about where they were in the rankings and being competitive was a choice.
 - Some teams found it difficult to follow what the right prices were and that there was much difficulty in understanding how and what the dividend strategy should be.
 - There was a lack of time to try the different levers to play the game and understand how to implement strategies.
- What were teams trying to optimise? Profit and how did they interpret the Companies Act? There were a range of issues which team sought to optimise – these included:
 - Satisficing - being in a comfortable position;
 - Ranking on market valuation;
 - Not going bankrupt;
 - Some had fixed policies others continually adjusted their policy;
 - Some considered 'ethics'.
- Teams found it difficult to implement their chosen strategy and struggled to get feedback to know they were meeting the obligations of the Companies Act?
 - Equity markets vs non-equity markets/longer term;
 - Culture of companies;
 - Nature of the shareholders, bounding company behaviour e.g. John Brown;
 - Culture in context (internalisation, etc.);
 - Brands/brand values as relates to the Companies Act;
 - Specialisation of technologies, R&D / learning rates, static R&D with betting house;
 - Adding carbon markets - carbon budget more real; and
 - Assumed all the participating teams would be moral - in the end no team was.
- How did teams optimise risk/uncertainty? If not, why not?
 - Those that did used diversification and hedging;
 - Those that did not could not as the simulation was too fast!
 - Suggested larger teams – to allow more specialised e.g. gas market, oil market, info, HQ, trading desk;
 - Teams simplified to act and were more comfortable to be optimistic and ignorant.
- How was decision-making made on respective teams? Did you teams reach consensus? What information was important? What info wasn't? What was the team dynamic like? Who did what? And was there expertise on your team? (Domain knowledge or otherwise)? There were a wide range of answer to these questions as follows:
 - Specialisations developed endogenously;
 - Experts were able to drive decision-making;
 - Took a while;

- Team work flow developed endogenously;
 - Strategy dictated the work flow, but whether it was appropriate was rarely discussed?
 - Some teams identified missing specialisations (aka. Unknown, unknowns);
 - If it was BP, you want the BP team roles in the right place;
 - It would have been good to develop an opportunity to discover each-others' roles.
- It was notes that if you were an *actual* CEO of an O&G company it would not have been easy to flip strategies so easily.
- How does this simulation compare to your actual work environment? How does risk/uncertainty impact your own work environment? Any other feedback/thoughts?
 - What about the regulator? E.g. utilities heavily regulated
 - What is the purpose of the simulation? Needed to be clear about this.
 - It was felt that the mechanics of the game got in the way of the learning and that there was a need to play the simulation multiple times to be able to develop the appropriate strategies.
 - Team liked the game – but it was noted that by playing Monopoly doesn't necessarily tell me how the Real Estate Sector Works. Therefore questioning the role of games in developing insights into decision-making behaviour?
 - Teams felt that there was a need to address aspects where game deviates too much from reality such as dividend swings and irreversibility's. That said it was recommended that a shock and disaster would have been interesting.
 - It might be useful to undertake a strategy session before the simulation starts during which teams could: (1) Set constraints to how much you can change things; and (2) Discover robust/dominant strategies.
 - Insights on feedback session might have included:
 - Industry gaming policy makers, policy makers as a player - setting carbon tax?
 - Include climate performance criteria;
 - Visualisation – of outcomes could have been more sophisticated; and
 - There could have been Theatre/Drama - storytelling to elicit response.

5.4. Insights from Simulations: Needs of Decision-makers at Different Time-Scales and Contexts

The AU4DM Network has developed the following proto-framework of analysis to assess how decision-making was undertaken – this is articulated in Box 2, below. This was used to assess the simulation outputs.

Box 2: The AU4DM Network proto- analysis framework to assess decision-making.

a. Framing

Framework of Analysis for Simulations to Address / The intended outputs from the workshop simulations will be:

- Understand the way that problems were framed, the reactions and reasons for participants taking a particular line of thinking and the impacts that had on the final decision;
- Identify and categorise what uncertainties concerned decision-makers and different actors in the simulations; and
- Develop insights as to how better framing might have improved decision-making.

b. Decision questions

- The other factors that DMs need to take into account which Analysts need to consider when undertaking their analysis and communicating it.
- How develop capacity in DMs to understand better what the analysts are developing in their analysis.
- The role of institutional configurations within which decisions are made and the incentives decision-makers have when making their decisions which might result in group think or unconscious bias.

c. Simulations

- How the simulation helped to inform the decision-making process
- What could have been done to improve the simulation process
- Whether simulations (which could include modelling, games and role-play) could be used in your setting

d. Communications

- What information do decision-makers need and what do they not require.
- How should analysts present information to decision-makings, including about uncertainties
- How can complex analyses and related decisions be presented to third parties

During the Plenary feedback session for all three simulations the following was found from across the simulations using the proto-analysis framework within respective categories - Box 2:

a. Framing

- Simulations enhance understanding about the way decision-makers think about problems, and what influences this thinking;
- Different frames allow for different categorizations and identifications of uncertainty;
- Simulations offer insights into the human decision-making process, as opposed to analytical decision-making. Identifying roles and responsibilities within teams leads to better framing of decision-making;
- Challenges arise when there is a range of expertise in a team, and members are interpreting frameworks in different ways;
- Interacting with web applications during simulations drives the scenarios response to decisions, allowing for real-time challenges to arise;
- A large processing burden arises when people try to be the analyst and the decision-maker. Those two functions should be separated out and then integrated to ensure that better decisions are made; and
- Narratives and stories provide rich illustrations, so presents decisions in these terms make decision-makers more comfortable and confident. This reduces the probability of reactive decision-making when volatile, dynamic information is presented. It is noteworthy though that stories are very powerful and are used to drive decisions they can do so in ways which may not be widely beneficial, e.g. decisions that are driven by specific political motives.

b. Decision questions

- Developing capacity in decision-makers themselves is an area that needs vast improvement. Research into institutional architectures, decision processes and decision contexts are necessary to improve capacity development;
- Different frames for information foster different levels of negotiation and cooperation within teams when making decisions;
- Information rich environments provide rich decision-making environments and the potential to explore different possible outcomes; and
- There is potential for training and tool development to improve team dynamics for decision-makers.

c. Simulation exercises

- Simulations work as a way to explore real life situations. However, when designing a simulation exercise, clarity surrounding what the simulation should achieve, who the audience is, what the goals are and what is being explored (behaviors, external factors, real life events) is vital. Simulation design will influence which decision processes are teased out;
- Longer sessions provide the potential for more in-depth exploration and learning; and
- Simulations must mirror real life and not be oversimplified, so strategies to deal with complexities can be discussed.

d. Communication

- Considerations must be made surrounding the type of information decision-makers require, and how specific representations of uncertainty are communicated; and
- The ability for models to be adaptable depends on the aims and derivation of the model. Models should be in line with aims of the scenario- is it being used directly to make decisions, or to encourage wider thinking.

6. Decision-maker Panel: What do Decision-makers Really Want?

A decision-maker panel was held at the end of the first day chaired by Nick Mabey. The Panel consisted of:

- Ruth Denyer, Head of Risk, ITV (left early due to a prior commitment);
- Laura Sandys, CEO Challenging Ideas and former MP;
- Phillip New, CEO Energy Systems Catapult and formerly head of BP Biofuels;
- Geoff Mulgan, CEO NESTA and former director of Prime Ministers Strategy Unit;
- David Fisk, Professor at Imperial College London and former Chief Scientific Advisor for Office of Deputy Prime Minister.

The following points were raised during the Panel Session:

Opening remarks included the following: Decision-making and analysis is not a case of supply and demand with analysis supporting decision-makers or decision-makers making demands of analysts to assist in making a decision regarding a problem. It is about developing an ecosystem that allows reflective argument and public debate about decisions and that these are made with the evidence that is appropriate to derive those decisions. There is a need for institutional memory to develop wisdom and avoid the 're-inventing of the wheel' on both sides of the community.

Speaking truth to power and decision support relationships in terms of trust, legitimacy and empathy is fundamental.

When a request is made to the panel by the chair to identify where best to invest time/effort and resources to make better decisions the following was discussed.

One of the panel members responded by stating that when managing and planning for risk in 2-5 year timeframe, dealing with crisis and Business Continuity Management as well as interacting with the board who need to balance long term and short term needs to ITV. The following is relevant: (1) The board need clarity to make decisions by the provision of information that empathises with their mind set and provides meaning to them as decision-makers; and most importantly (2) the board needs to understand the issues in a 2 page summary note.

Another commented that, in a parliamentary democracy, there is a need to frame issues around public policy and ensure that there is a broad breadth of decision-makers involved. In some cases, there is policy with politics and others politics with policy. The biggest issue is the need to translate and shape analysis so as to match other people's mind-set. Where the other person's mind-set is accommodated to allow the material to be conveyed in a context that they understand. Work in the Food Standards Agency places social science and science at the heart of evidence and the politics provides the context. The Oscar Wilde quote of writing a long letter having not had time to write a short letter very much resonates in the way that analysts get information across to decision-makers.

One of the panel members experience in Big Oil - of the Macondo Deep Water Horizon Crisis, BPs strategic positioning away from green agenda and the collapse of the oil price in 2008. Presently at the energy systems catapult working with policy makers, investors and SMEs to make choices so as to navigate the legacy of past energy policy towards a new policy driven future which is highly uncertain.

- Based on the former experience, no matter how much one spends on analysis and the possession of a 'too big to fail' mind-set you still get knocked sideways by unforeseen issues. At a tactical level, emotional arguments took on scientific data and the emotional arguments won e.g. the biofuels and Indirect Land Use Change discourse.
- At the Energy Systems Catapult, it is extremely difficult to get consensus due to disparate nature of actors in the UK energy system. Decisions have to be made despite the political situation one might find oneself in and choices for actors should be provided as best as is possible. As a function of this, we very much advocate the dedication of developing experiential platforms to test hypothesis and developing a shared understanding of complex issues in real world and allow evidence to be better validated.

Another panel member explained that he sits on 40 advisory boards, having a £450 M annual budget allocation and 220 staff – the key consideration that the organisation has to consider is to address projects which are 'Okay but not good enough'.

To develop better decision-making the following might be relevant: (1) Combining datasets; (2) Web scraping and its presentation in different visual formats; (3) Better intelligence design; and (4) experiments - NESTA are

undertaking public policy experiments in 20 countries on economics, behaviour and education and developing a culture of *'Learning Through Actions'* which is extremely powerful.

As a guide as to what analysts and decision-makers might want from each other - the following might be useful:

- In the Robert McNamara documentary *'Fog of War'*, it was his lack of empathy which made him controversial;
- Good analysis allows speaking truth to power but power always speaks to truth;
- No fact without a story. No story without a fact;
- We complicate to understand and we simplify to act (and make decisions);
- There is the need to build in *'Act and Learn'* capability to understand the way that we think and be different (2nd and 3rd Learning Loops); and
- Analysis needs to be better embedded in the decision-making process.

The chair emphasised that there is a board support for prototyping. This needs to be developed in the context of 30 year strategies to allow to former to provide the latter with guidance. When planning for the long term, there is also the need to address a mind-set which some decision-makers have which that is being ambitious is fine as long as it is not on their watch.

In their role as former CSA to office of Deputy Prime Minister and being on the board of Ofgem one panel member suggested that the following points are relevant regarding decision-makers interaction with analysts:

- The quote from Obama's valedictory is poignant: *'For history tells us that while these truths **may be self-evident**, they have never been self-executing.'*
- The Decision is only that part of the process that you cannot take back.
- Game Theory stipulates that you only manage risk that you cannot shift.
- It was bemusing to get reports from analysts with figures to 9 significant figures about possible uncertain futures.
- To be presented data from *'Black box models'* which were opaque and in turn provoked the generation of further work by the need to cross-reference outputs from other black box models was unhelpful.
- Do scenarios help? How do they influence decision processes?
- The employment of probabilities by adding weightings to aspects of considered options is far from scientific.
- We find it hard to write a collective memory of what happened in history, even recent history e.g. there is difficulty in recalling what the electricity sector was like prior to liberalisation in the UK.
- It is clear that more analysis doesn't provide you with any more real options.

In the Q&A session the following was discussed:

Are those in positions of decision-making good at making decisions and how much practice is needed to get decision-makers to make better decisions?

- A panel member explained that MPs, as opposed to Ministers, are actually only able to make small decisions and are not always for them. They need a breadth of knowledge and judgement for which they are not trained.
- Another stated that though it is difficult to train politicians scenarios are good for preparation and training. One could break down the constituent members of parliament to assess the individual members' propensity to work according to values based judgements and those who work to analysis based judgements as well as the degree of democratic engagement in the decisions made.

How can you develop a collective intelligence for decision-makers and the analytical community?

- It was explained that there is a Chinese Political Decision Training Academy where knowledge and mind-sets are taught. In this respect China is light years ahead. UK ministers have no training at all.
- It was stated that there is very much a case of government by amateur in the UK in an increasingly complex world. In the UK there is a tendency to develop capability or strategic reviews with decisions and legitimacy being based on instinct.
- Professional practice is important and some decision-makers have made careers out of avoiding making decisions. There is a need to develop organisational cultures to encourage appropriate risk taking
- The shortening timeframe of CEO's and MPs tenures is getting shorter which hinders the ability to develop collective intelligence.

The potential role of the network in seeking to address these issues were covered as follows:

- The scientific community don't understand priorities and politicians need to be more receptive to scientific outputs;
- In area of energy - so complex that there is a need for an Energy Agency to take the technical decisions away from politicians. Politicians have role in reflecting societal values;
- There is a need to understand optimal policies;
- Important to make distinction between a great decision poorly executed and poor decision well executed;
- Limitation of models - modelling for different independent actions in system and their utilisation in an exploratory role is useful decision support. As a tenet of policy design they are dangerous;
- In the 1980's and 90's there was a separation of Policy and Analysis functions. There is a need for the development of the case for the re-integration of these functions as well as the development of operational experience within the analytical community;
- On the point of black box models this might be addressed by an analogous code of practice in Artificial Intelligence where any algorithm has to be open to scrutiny;
- Develop better-structured arguments that generate more insights than unitary formalisation analysis; and
- The Network is a great idea. The challenge that it needs to fulfil is the: (1) Need to be robust; and (2) Address the way that people think about problems. The community needs to substantially strengthen to do this!

The chair summarised the following take-aways for the Network to potentially advance:

- Decision-makers and Analysts need to work together better;
- The need for a stronger community to develop empathy, iterate and experiment more. To develop capacity to understand:
 - (1) The limitation of models and tools;
 - (2) Have a minimum time in tenure;
 - (3) How to train people to be more adaptive;
 - (4) The interconnected nature of series of decisions;
 - (5) The tendency to technological assessments rather than ones based on operational management;
 - (6) The role of debate; and
 - (7) Understanding the uncertainty that surrounds decision-making.

- How to motivate more investment in immersive, experimental expertise development for decision support; and
- Culture of decision-makers and analysis for decision support with a view to learning lessons of what works.

7. What Next and Concluding Remarks

7.1 What do people want from the network?

The following requests were made from the attendees of the workshop regarding what they wanted from the network. They are grouped according to the categories that were developed in the previous workshop on 10-11th February 2016 along with the more generic strategic needs of the Network:

Strategic Requirements

- Would like to see clarity and definition regarding the network: what it is trying to achieve, interests and outputs for different domains; differentiators from other networks, and what do people actually get?
- Develop a Twitter handle for the conference and associated workshops.

Putting Decision-makers at the Centre of Network Development

- Need to identify which set of decision-makers: former holders of public office (e.g., former MPs) or senior positions (e.g., presidents of societies, advisors, etc.), suppliers of selective decisions or design engineers etc. should be included in the network.
- Using the requirements and practices of decision-makers to explore useful frameworks and tools for decision making, and identifying useful evidence and analytical practices
- Rather than testing decision-makers, offer the tools and approaches being developed by the community with a view to trialling the processes when involving decision-makers to assess whether the tools lead to better outcomes and to generating narratives around what works and how decisions are made.
- Explore cultural and visual aspects in decision support such as utilising an information design set of outputs.
- Develop events and networking opportunities for different types of decision-makers.
- Still not happy that we know what do decision-makers want? Is it (1) Range of options; (2) Which risks do they want to better understand; (3) Do they understand the trade-offs when making one decision over another; and (4) How does uncertainty play into decision making?
- What does it take to be a good analyst / decision-maker?

A1. Capacity Building, Knowledge Exchange and Sharing of Best Practice Along the decision-making process value chain of: (1) **Framing**; (2) **Tools**: Game Theory; Robust Decision-making; Scenario Analysis; Agent Based Modelling; Systems Dynamics; Multi-criteria decision-making; Integrated Assessment Modelling; Adaptation Pathways; Real Options; Hybrid methods (Note that this list is not exhaustive); (3) **Dialectic Processes and Behaviour** - management of the process and interaction between analysts and decision-makers; and (4) **Communication issues**.

- Understanding how decision-makers treat uncertainty when making decisions
- Communicating uncertainty effectively and appropriately (based on the understanding developed above)
- Have detailed examples of tools and processes for practitioners, analysts and decision-makers to better understand them.

- People generally are not that good at making decisions under uncertainty. Could the network seek out some advocates whom think they can develop (e.g., young officers in British Army)?
- Make summaries of new thinking accessible.
- Examine the availability of interventions and examine what is known effective decision-making.
- Would it be useful to have a clearer definition of what we mean by uncertainty? The workshop never parameterised this.
- Propose a formal expectation on analysts to communicate uncertainty in their outputs but this could be problematic to understand as to what this means in the eyes of decision-makers?
- Develop a set of responsibilities for analysts, responsibilities for DMs, development of some 'principles'. E.g. Rainbow book which is a collection of catalogues which are issued by HM Treasury and formalises approvals process for programs and projects.

B1. Produce a set of publications that have a policy and industry audience

- Catalogue corporate and organisational knowledge of what has gone before; curating this knowledge and the ability for the network to assist in keeping that knowledge visible and regularly updated.

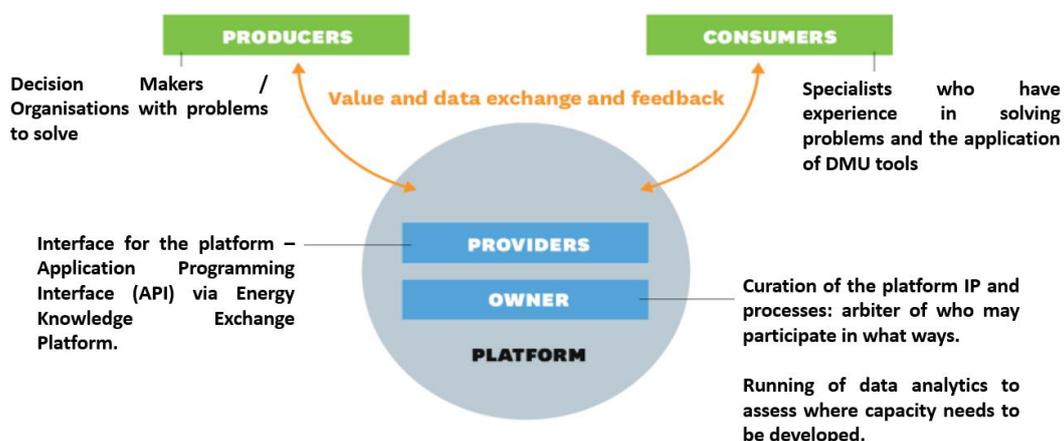
B2. Development of a Summer School to develop capacity

- Content needs to be identified for appropriate engagement with relevant target audiences
- Winter school for 3 days (e.g., European Environment Agency)?
- Summer school - 2 weeks probably too long! - But maybe not for analysts? Potentially combined with a shorter session for decision makers to allow analysts and decision makers to interact.

B3. Real work engagements and prototyping to allow learning by doing – Knowledge Exchange

- Provide opportunities for decision makers and analysts to examine decision processes together;
- Survey more examples and case studies; and
- Three days to have a problem to work on and a case study – adaptive management, monitor and change: 60% content to act

Wild Card – possibility of the development of a 2-Sided Network with producers (Decision-Makers / Problem Owners) on one side and consumers (Analysts and Specialists) on the other? See figure below.



- Could the network lead research agendas by advancing impact and engagement? Participants want to know what is the latest thing that is `known' (don't necessarily want the unknown); problem based forum - 'can you help me with this problem?'; taking network forward - identifying specific communities of DMs
- Making better Analysts to support better decision-making - brokering engagements
- "Pipelines, platforms, and the new rules of strategy"

7.2 Summing up – by Gary Kass and Charles Featherston

Gary Kass - aired his personal reflections of the workshop as follows:

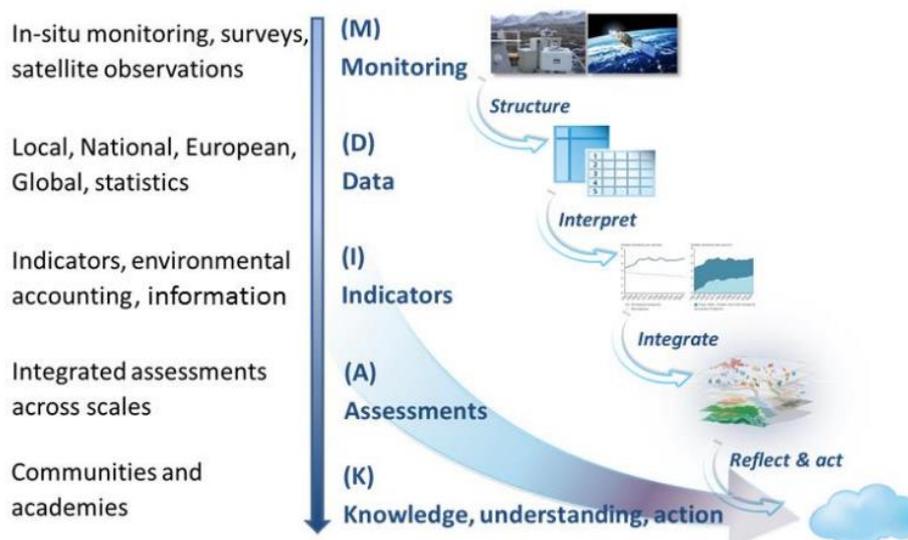
- A step forward from the previous workshop of 10-11th February 2016. The network needs to develop a value proposition with some meat to identify what the business idea is?
 - What's the decision making under uncertainty space lacking and seeking to address?
 - What is distinctive about the Network to address that market failure?
 - How can we apply those distinctions to different constituents in the `market'?

To do this we need to develop a reputation based on a sound mission / belief statement detailing the above with:

- (1) Clarity on objectives set against clarity of the meaning of the evidence;
- (2) Details of the knowledge asymmetries that are being addressed;
- (3) Use of different forms of Knowledge Management Frameworks e.g. MDIAK – see figure 1, below;
- (4) Identification of roles in decision-making; should these be specified or should they evolve?
- (5) Role of Simulations - what role developing decision-making capacity?
- (6) Accountability - for and to whom?
- (7) Taking account of biases; using narratives to collapse uncertainty?

An example of one such successful initiative is the government Office for Science Foresight Toolkit which has been driven by and framed around meeting user's needs

Figure 1: MDIAK Knowledge Management Framework for the European Environment Agency



Charles Featherston - aired the following personal-professional reflections of the Network and the Workshop:

- The cross-disciplinary nature of the network has advantages but also leads to divergence. The next challenge will be to converge around a set of manageable themes, tools, and research agenda.
- On the Pop-up Talks
 - Impressive range of situations;
 - All covered a variety of uncertainty, complexity and the decision-making practices;
 - Information, analysis, decision-making processes and reviewing; and
 - As many tools and approaches as there are situations.
- On the Simulations:
 - Really interesting experiments that varied on: (1) Response & long term consequences; (2) Longer-term action; and (3) Choosing direction.
 - On the Simulation for the manufacturing firm under Brexit: in particular international supply chain the interest came from: (1) Information and processes; and (2) Really valuable feedback from observers
- What will I do differently based on the outputs from the workshop:
 - The way we engage with experts;
 - Futures and foresight: (1) The way we collect and analyse evidence; and (2) Toolkit training sessions today and tomorrow; and (3) how to tie insights from these exercises back to the decisions that are being made; and
 - The way that we senior decision makers.

All this comes at a good time when new curricular is being developed for Civil Service learning and development

- In terms of the *Call to action*:
 - What problems can all the practitioners together provide that can help reveal new insights when studied; and
 - What is missing from our research individually that we can answer together?
- The challenge for the research programme workshop attendees appear to suggest the following approach:
 - (1) Can we start with what is useful for decisions;
 - (2) Work backwards to what decision-makers need to be communicated;
 - (3) Identify approaches and useful tools;
 - (4) Then frame an inter-disciplinary view of how we view uncertainty; and
 - (5) Look at how to define usefully what uncertainty we are addressing.

Annex 1: Agenda

TUESDAY 27th FEBRUARY 2018

09:00	Refreshments and Registration	Main Hall
09:30	Welcome and Introduction	Education Centre
09:50	Session I: Pop-up Talks - Chair: Mark Burgman Structured 5-minute risk and uncertainty problem 'pitches' with Q&A. <ul style="list-style-type: none"> • Brian Efird - KAPSARC • Kris DeMeyer - Kings College London • Jim Maltby - DSTL • Sunny Modhara - Network Rail 	Education Centre
10:50	Key Note Speech from Geoff Mulgan, CEO NESTA <i>Decision-making in the Modern World</i>	Education Centre
11:30	Break	Main Hall
12:00	Session II: Pop-up Talks - Chair: Emma Soane Structured 5-minute risk and uncertainty problem 'pitches' with Q&A. <ul style="list-style-type: none"> • Lenny Smith - London School of Economics • Michal Petr - Forestry Commission • Martine Barons - Warwick University • Zulandi Van der Westhuizen - World Energy Council 	Education Centre
13:00	Lunch	Main Hall
13:45	Simulation 1: Emergency management decision-making COBRA-style meeting	Sunley Room
	Simulation 2: Supply chain management under policy uncertainty Supply chain management under Brexit	Drayson Room
	Simulation 3: Investment decision-making using scenario tools Oil and Gas capital planning	Education Centre
16:15	Break	Main Hall
16:30	Panel Session: What do decision-makers really want? Chair: Nick Mabey, E3G	Education Centre
17:45	Networking Buffer Supper and Drinks	58 Princes Gate

WEDNESDAY 28th FEBRUARY 2018

09:00	Refreshments and Light Breakfast	Main Hall
09:30	Reflection on the Simulations	Sunley Room, Drayson Room, Education Centre

11:00	Break	Main Hall
11:30	Plenary Discussion – Development of an Analytical Framework. Chair: Geoff Darch	Education Centre
12:00	Plenary Discussion and Break-out Session - What next for the Community? Chair: Mark Workman	Education Centre
12:45	Wrap-up and Concluding Remarks. Gary Kass and Charles Featherston	Education Centre
1300	Close	

Annex 2: Participants list

Name	Organisation	Name	Organisation
Salvador Acha	Imperial College London	Julie Gore	Bath University
David Addison	Virgin Earth Challenge	Meyrick Gough	Southern Water
Prue Addison	Oxford University	Michael Green	Wood Plc
Anthony Alexander	Sussex University	Michael Hobson	Smith Institute
Lisa Aufegger	Imperial College London	Candice Howarth	Surrey University
Peter Bance	Energy Systems Catapult	Ruth Hughes	NERC
Martine Barons	University of Warwick	Nasir Hussain	Bloomberg Intelligence
Peter Bedwell	PHE	Kalyani Inampundi	Imperial College London
Sayara Beg	Datanut Scientists Ltd	Matthew Ives	University of Oxford
Andrea Borrego	E3G	Annette Jezierska	The Future Fox
Laura Boulton	Lancaster University	Abdool Kara	National Audit Office
Patrick Brandl	Imperial College London	Sanjoy Kumar Khataniar	Schlumberger Software Integrated Solutions
Olivia Brown	Lancaster University	Oksana Koltsova	Legion
Mark Burgman	Imperial College London	Lucas Kruitwagen	Smith School, Oxford University
Celia Carling	Imperial College London	Jenny Kwok	Thames Water Utility Ltd.
Geoff Darch	Anglian Water	Charilaos Latinopoulos	Imperial College London
Kris De Meyer	Kings College London	Deborah Lee	Met Office
Jane Dennett-Thorpe	Onawi	Polina Levontin	Imperial College London
Ruth Denyer	ITV	Sarah Livermore	Committee on Climate Change
James Derbyshire	Middlesex University	Rick Lupton	Cambridge University
Brian Efird	Kapsarc	Kirk Luther	Lancaster University
Tohid Erfani	UCL	Nick Mabey	E3G
Ruth Falconer	Abertay University	Chris Malins	Cerology
Charles Featherstone	Government Office for Science	James F Maltby	DSTI
Lisa Fischer	E3G	Robert McKibbin	Navigant
David Fisk	Imperial College London	Ana Mijic	Imperial College London
Simon French	Warwick University	Sunny Modhara	Network Rail
Bruce Garvey	Imperial College London	Gilberto Montibelier	Loughborough University
Gary Glennon-Alty	Defence Science & Technology Laboratory	Nick Moody	Met Office

Name	Organisation	Name	Organisation
Philip New	Energy Systems Catapult	Geoff Mulgan	NESTA
Murtaza Okera	Kings College London	Alex Murray	UCL
Ronan Palmer	OFWAT	Gareth Conway	DSTL
Paul Ormerod	Limetools	Rob Evans	Tripos Consulting
Nadia Papamichail	Manchester University	Lama Yaseen	KAPSARC
Edoardo Patelli	University of Liverpool		
Rachel Phillipson	MottMacdonald		
Michal Petr	Forest Research		
Nicola Power	Lancaster University		
Steve Pye	UCL		
Laura Sandys	Challenging Ideas		
Karl Schultz	The Higher Ground Foundation		
Margarita Skarkou	Barclays		
Eleni Skaliotis	Ministry of Justice		
Emma Soane	LSE		
Leonard Smith	CATS, LSE		
Mike Steel	Environment Agency		
Graeme Sweeney	Chairman of ZEP		
Roger Street	UKCIP, Oxford University		
Erica Thompson	CATS, LSE		
Shane Tomlinson	E3G		
Ans Vercammen	Imperial College London		
David Viner	Mott Macdonald		
Alexander Wanitschke	Reiner Lemoine Institute		
Ed Wheatcroft	CATS, LSE		
Nick Winser	Energy Systems Catapult		
Mark Workman	Imperial College London		
Charles Zogheib	Imperial College London		