

## Impact case study (REF3)

<b>Institution:</b> University of Warwick		
<b>Unit of Assessment:</b> B10 – Mathematical Sciences		
<b>Title of case study:</b> Guidance on decision analysis for mitigating risk: a multi-stakeholder perspective		
<b>Period when the underpinning research was undertaken:</b> 2012 – 2020		
<b>Details of staff conducting the underpinning research from the submitting unit:</b>		
<b>Name(s):</b>	<b>Role(s) (e.g. job title):</b>	<b>Period(s) employed by submitting HEI:</b>
Simon French	Professor	2011 – 2020
<b>Period when the claimed impact occurred:</b> 2014 – 2020		
<b>Is this case study continued from a case study submitted in 2014?</b> N		
<b>1. Summary of the impact</b> (indicative maximum 100 words)		
<p>French's research in decision analysis has international societal impacts through providing methods for decision-making with multiple stakeholders and perspectives and where significant, and sometimes deep, uncertainty is inherent to the context. It has changed the way UK government, business and industry and international bodies approach decision-making, including in crises such as a nuclear accident. His research has enabled users to look at uncertainties from different perspectives, and aided simple and effective communication between stakeholders, including those unfamiliar with probability concepts. French co-founded the <i>Analysis under Uncertainty for Decision-Makers (AU4DM)</i> network which disseminates his and related research. He wrote the AU4DM Catalogue of Decision Tools, has advised the International Atomic Energy Agency on decision-making on remediation and is currently contributing sections to the Sixth Intergovernmental Panel on Climate Change (IPCC) Report on climate change. His collaborations on the NERIS Platform and the CONFIDENCE project has supported the development of radiation protection cultures across Europe.</p>		
<b>2. Underpinning research</b> (indicative maximum 500 words)		
<p>Simon French of the Applied Statistics and Risk Unit of the Department of Statistics has a long, distinguished career in decision analysis, recognised by the award of the 2017 Ramsey Medal by the INFORMS Decision Analysis Society. Decision analysis uses systematic, robust, auditable techniques to develop and evaluate strategies and support decision-making. In applications in the public sector in contexts such as the environment, energy, food safety and the nuclear industry, it is particularly effective in engaging stakeholders in deliberations.</p> <p>Since joining Warwick a decade ago, his research has become more applied, looking at ways to support decision makers in the public and private sectors in preventing and mitigating risk. He draws on the perspectives of many stakeholders in his analyses, mindful of the need to temper mathematical models with the complex needs and behaviours of their human users.</p> <p>Specifically, his research has focused on:</p>		
<ol style="list-style-type: none"> <li>Using decision analysis to inform political processes in deciding on major societal issues in the presence of many analyses from different expert panels and stakeholder groups. Experts may offer different opinions and some stakeholders may possess quite antagonistic values, making agreement on a single analysis difficult if not impossible [3.2-3.5,3,8].</li> <li>Uncertainties permeate decisions and not all can be modelled probabilistically. Some may be deep, i.e. subject to substantial disagreements among experts and with little or no data to provide resolution. Uncertainty communication is also hard, for example, there is little</li> </ol>		

evidence on how to communicate spatial uncertainties, common in many important decisions [3.1,3.6-3.7,3.9].

3. The elicitation of judgements from experts, both numerical uncertainties and more qualitative judgements such as model choice and context setting. French is developing a broader perspective bringing together both types of elicitation. [3.1,3.5,3.8]

From 2017 to 2019, theoretical development on dealing with different types of uncertainty and scenario-focused analyses contributed to joint research in an EU H2020 CONFIDENCE project [3.9]. This focused on improving analysis and communication of uncertainty during nuclear emergencies; initial work on spatial-temporal uncertainty developed into a more general overview of different uncertainties and their categorisation in a manner informative to national regulators and emergency managers. It uncovered many uncertainties not addressed in standard nuclear emergency management procedures.

### 3. References to the research (indicative maximum of six references)

**Warwick = Bold**

[3.1] **French, S.** (2013) *Cynefin, statistics and decision analysis*. Journal of the Operational Research Society, 64 (4). pp. 547-561. doi:[10.1057/jors.2012.23](https://doi.org/10.1057/jors.2012.23)

[3.2] Papamichail, K. N. and **French, S.** (2013) *25 Years of MCDA in nuclear emergency management*. IMA Journal of Management Mathematics, 24 (4). pp. 481-503. doi:[10.1093/imaman/dps028](https://doi.org/10.1093/imaman/dps028)

[3.3] Argyris, N. and **French, S.** (2017) *Nuclear emergency decision support: A behavioural OR perspective*. European Journal of Operational Research, 262 (1). pp. 180-193.

doi:[10.1016/j.ejor.2017.03.059](https://doi.org/10.1016/j.ejor.2017.03.059) [Need to confirm this is correct, title provided was "Behavioural Issues and Impacts in Nuclear Emergency Decision Support" but other details are the same]

[3.4] **French, S.** and Argyris, N. (2018) *Decision Analysis and Political Processes*. Decision Analysis, 15 (4). pp. 208-222. doi: [10.1287/deca.2018.0374](https://doi.org/10.1287/deca.2018.0374)

[3.5] **French, S.** (2012) *Expert Judgment, Meta-analysis, and Participatory Risk Analysis*. Decision Analysis, 9 (2). pp. 119-127. doi:[10.1287/deca.1120.0234](https://doi.org/10.1287/deca.1120.0234)

[3.6] **French, S.**, Argyris, N., Haywood, S. M., Hort, M. C. and **Smith, J. Q.** (2019) *Communicating Geographical Risks in Crisis Management: The Need for Research*. Risk Analysis, 39 (1). pp. 9-16. doi:[10.1111/risa.12904](https://doi.org/10.1111/risa.12904)

[3.7] **French, S.** (2019) *Axiomatising the Bayesian paradigm in parallel small worlds*. Operations Research (published online).

[3.8] **Hartley, D.** and **French, S.** (2018) *Elicitation and Calibration: A Bayesian Perspective*. In: Dias, Luis C., Morton, Alec and Quigley, John, (ed.) *Elicitation: The Science and Art of Structuring Judgement*. Springer International Publishing, pp. 119-140. ISBN: 978-3-319-65052-4

[3.9] **French, S.**, Haywood, S., Oughton, D. H. and Turcanu, C. (2020) *Different types of uncertainty in nuclear emergency management*. Radioprotection, 55. pp. S175-S180, doi: [10.1051/radiopro/2020029](https://doi.org/10.1051/radiopro/2020029). In: 'Coping with uncertainties for improved modelling and decision making in nuclear emergencies. Key results of the CONFIDENCE European research project', Special Issue.

### 4. Details of the impact (indicative maximum 750 words)

French's emphasis on multi-disciplinary and participatory approaches to solving real problems and the innovative use of technology in supporting decision-making has helped politicians and policymakers, business leaders, public health officials, local authority and community representatives, and emergency planning officers in the UK and internationally.

COST (European Cooperation in Science and Technology) Action IS1304, 2013-19: French served on the management team of this EU-wide multidisciplinary network of scientists and policy makers to promote structured expert judgement (SEJ) to quantify uncertainty for evidence-based decisions, and improve the use of scientific expertise by policy makers. He led the development of training courses, co-ordinated two workshops and the final conference: around 50 ESRs were exposed to SEJ methods, and training materials are widely available through the Action's website. Knowledge of SEJ methods was transferred to intermediary organisations, e.g., TNO ([www.tno.nl](http://www.tno.nl)) in the Netherlands and VTT ([www.vttresearch.com](http://www.vttresearch.com)) in Finland. The action was judged in the highest category of success. [5.1]

#### UK Government's Uncertainty Toolkit for Analysts

UK government departments, including the Food Standards Agency, the Medicines and Healthcare Products Regulatory Agency (MHRA), Department for Business, Energy & Industrial Strategy (BEIS), the Defence Science and Technology Laboratory (Dstl), the *Nuclear Decommissioning Authority* (NDA), OFGEM, Public Health England (PHE) and the Met Office have benefited from French's research and expertise. His work across many areas has *"provided real insight across government... and has resulted in several successful studies for government and industry which are informing policy and future direction,"* says Professor Veronica Bowman, senior principal statistician at Dstl. [5.3] The basic tenets of his ideas [3.1,3.4,3.7] form part of a cross-government Uncertainty Toolkit for Analysts (published in early 2020, aimed at analysts across all departments and agencies) which sets out *"good, not best, practice, as analysis and communication must always be tailored to the audience and decision being made"* [5.4]. Antony Bexon, head of radiation assessments at PHE, says that the toolkit *"fits well with a growing move across Government to acknowledge and address uncertainty more formally."* [5.5].

#### The AU4DM Network

In 2015, jointly with Mark Workman (Imperial College London), French co-founded *Analysis under Uncertainty for Decision-Makers* (AU4DM), a community of academics, policy makers and industry representatives seeking to develop best practice around analysis for decision-making under uncertainty. Through workshops and meetings, and novel tools such as the Visualisation of Uncertainty catalogue as well as other online resources, AU4DM has become a national leader in this field: organisations testifying to the practical value of the network include Anglian Water, *"The network differs from other initiatives that seek to promote better uncertainty handling in decision making in that it listens to user needs instead of simply explaining academic modelling tools... AU4DM organises two or three excellent professional development events based around the exploration of realistic scenarios annually"* [5.9]; Network Rail, *"The events hosted by AU4DM ran a number of training simulations using very realistic and probing scenarios to catalyse discussions about uncertainty. Short pop-up style presentations... allowed examples of complex decision-making under uncertainty and potential solutions to be shared between attendees representing a wide range of decision contexts"* [5.10]; and Dstl, *"the Decision Tools catalogue that he edited from input across the network has been incredibly successful in guiding users to research and tools and the visualisation catalogue he co-edited has provided similar benefits."* [5.3]. The visualisation catalogue is now going in to its second edition.

AU4DM has also had an international impact: Sunny Modhara (Network Rail), *"The adoption of these ideas has attracted interest from a large number of other international railways, in particular their incorporation into industry guidance on decision making."* [5.10] The Decision Tools catalogue has helped shape Chapter 17 *Decision Making Options for Managing Risk* in

the next IPCC Report (due 2021). French is a contributing author to section 17.3 and a peer reviewer of the entire Chapter. Professor David Viner, a director at Macquarie Capital and a coordinating lead author for Chapter 17, who met French through AU4DM, says: *"He has provided many insights and recognises political sensitivities that arise from suggestions about how communities, regions and governments should think about risks and decisions... IPCC reports are influential across governments in facing up to the impacts of climate change. His contributions will help the next report continue to be so."* [5.11]

#### Uncertainty handling in nuclear accidents

Funded by the UK's Atmospheric Dispersion Modelling Liaison Committee (ADMLC), in 2014 French led a project with the Met Office and PHE to improve the presentation and treatment of uncertainties during a nuclear accident to the UK's Scientific Advisory Group for Emergencies (SAGE). To SAGE's general approach which considers a single reasonable worst-case prediction of the course of the accident, he added a 'novel' second approach [3.3,3.6,3.7] which used several scenarios including one or more reasonable worst cases as well as ones with lesser impacts [5.5]. Matthew Hort, ADMLC Chair, says that the project *"facilitated in building an improved, shared understanding and realistic expectations between decision-makers, scientists and communicators of what will be known in the early phase of a radiological emergency and how this knowledge... will evolve."* The project led to discussions with Robin Grimes, the FCO's Chief Scientific Adviser, on how this work can be used to *"inform and improve the current practices of presenting uncertain information in radiological emergencies, and thus improve the provision of health protection advice."* [5.6].

French's work on the EU-funded CONFIDENCE project [3.9] on categorising and presenting uncertainty has helped *"shape the understanding of the international community regarding the level of confidence that might be gained through the application of process-based models in assessment of human exposure to radiation, and in particular, their possible use in communicating risk and gaining trust of the public and other stakeholders following a nuclear or radiological emergency."* [5.7] The Slovak Republic project member, Tatiana Duranova, who was trained by French in workshop facilitation, says: *"Simon's contributions in decision analysis and uncertainty handling influenced the process of the development of radiation protection culture in Slovakia and so made it possible for stakeholders to be knowledgeable, active, open and democratic and better prepared for decision making in case of possible nuclear accident when uncertainty handling is a key issue."* [5.8]. Less tangibly but possibly more effectively, the work is shaping thinking and practice within NERIS, a European network of agencies, communities around nuclear sites, regulators and research institutes that promote emergency preparedness and share good practice. Public Health England's Bexon says: *"Our thinking on uncertainties and the use of scenarios to convey complex and deep uncertainties has a route to wider application than just the UK."* [5.5]

#### Decision analysis in remediation of radiation-contaminated sites

French was invited to join the International Atomic Energy Agency's (IAEA) programmes on Modelling and Data for Radiological Impact Assessments (MODARIA I and II, 2012-2019) in the working group on site remediation. With the NDA's permission, he contributed a 2011 report on the Geological Disposal Facility (GDF) for high-level radioactive waste in the UK, along with many other inputs from the perspective of decision analysis. The output was finalised in December 2019. These reports *"will provide important information and tools for use by Member States in the development of pragmatic remediation strategies, and the subsequent planning and implementation of remediation... (to) ultimately ensure and demonstrate protection and safety of people and the environment to the benefit of current and future generations."* [5.7].

#### Probability of Black Start

In 2017, French suggested to the UK's Acting Chief Scientist, Professor Chris Whitty, that SEJ methods [3.8] could assess the risk of a complete failure (Black Start) of the National Grid, which would result in significant disruption to businesses and households. To minimise the impact of this risk, BEIS considered the development of a legal obligation on electricity companies setting a timeframe within which restoration should be achieved. BEIS required a

robust likelihood assessment of total electricity failure; French was a leader of the project in 2019, and "(t)he output from this SEJ has fed into the cost-benefit analysis that underpins the proposed legal obligation." [5.12].

**5. Sources to corroborate the impact** (indicative maximum of 10 references)

**5.1]** COST Action Final Assessment Review: 'IS1304: Expert Judgment Network: Bridging the Gap Between Scientific Uncertainty and Evidence-Based Decision Making' by T. Meyer, EPFL, Switzerland, 2018.

**[5.2]** <http://au4dmnetworks.co.uk/>

**[5.3]** Statement (17/12/19) from Prof Veronica Bowman of DSTL.

**[5.4]** Uncertainty Toolkit for Analysts in Government whole website PDF (<https://analystsuncertaintytoolkit.github.io/UncertaintyWeb/index.html>)

**[5.5]** Statement (10/07/20) from Antony Bexon, PHE

**[5.6]** Statement (25/4/27) from Chair of ADMLC relating to Presenting Uncertain Information in Radiological Emergencies Project.

**[5.7]** Statement (11/09/19) from Tamara Yankovich of the Division of Radiation, Transport and Waste Safety of the IAEA.

**[5.8]** Email (17/6/20) from Dr Tatiana Duranova, Nuclear Safety Division, VUJE Inc, Slovakia

**[5.9]** Statement (17/06/20) from Dr Geoff Darch, Anglian Water

**[5.10]** Statement (28/05/20) from Sunny Modhara, Whole Lifecycle Costing Manager, Network Rail

**[5.11]** Email (13/05/20) from Prof David Viner, a Co-ordinating Lead Author of the next Intergovernmental Panel on Climate Change Report.

**[5.12]** Email (17/7/20) from Herpreet Bhamra, Department for Business, Energy and Industrial Strategy, UK Government