European Commission, Directorate General for Research and Innovation

Report to European Forum on Forward Looking Activities: Disruptive Emergencies.

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18th February 2013

Executive summary and recommendations

Introduction

This project was a high level review of the contribution that Forward Looking Activities (FLA) can make towards preparedness for and resilience to disruptive emergencies. Consideration was given to the following issues:

1. Role of FLA to anticipate disruptive emergencies
2. Role of FLA to reduce future risks from disruptive emergencies
3. The potential role of DG Research and Innovation in providing, within the EU, support on the preparedness for and resilience to disruptive emergencies.

For this project, disruptive emergencies are defined as unplanned and non-routine events that have a significant consequence or impact on people, property and infrastructure, or could seriously damage the security of the EU. The impacts include harm to people (including psychological impacts), short or long term economic damage, and physical damage to property and the environment. Disruptive emergencies have been classified as either:

Hazards - the results of nature or technical failure, including human error; or
Threats - the results of terrorist or criminal activity (including state sponsored)

Disruptive emergencies do not include everyday occurrences, such as street crime.
The scope of the project includes emergencies that occur either within the EU (or are covered by the EU Civil Protection mechanism, such as the forest fires in 2007), or events outside the EU, that have a major impact within the EU, such as the potential break down of the energy system due to the decision to close nuclear plants as a result of Fukushima.

In undertaking this project I drew on my experience of undertaking FLA in the UK government and as a consultant; and experience of work on the preparedness for and resilience towards disruptive emergencies. This includes work on disruptive emergencies as part of the UK National Security programme (CONTEST) and the associated National Risk Register. I conducted desk research and interviewed a number of experts on the subject. I also took account of comments made following a presentation to the EFFLA Committee at the commencement of the project.

This report neither covers the provision of humanitarian assistance by the EU after emergencies; nor an assessment of future risks or an audit of the capability of DG Research and Innovation to respond to them.

There is lot of activity by Member States and the European Commission directed towards the anticipation of, preparedness for, response to and recovering from disruptive emergencies. The recommendations cover areas where DG Research and Innovation can contribute to these activities.

Conclusions

The main conclusions of this review are as follows:

1. There is an important and increasing role for FLA to support the policy for and management of disruptive emergencies;
2. There are important areas of research that will lead to increased resilience across the EU. There is a role for DG Research and Innovation to support this research; and research collaboration and data sharing between Member States and more broadly.
3. DG Research and Innovation can provide additional support to the European Commission on disruptive emergencies, particularly on horizon scanning and access to scientific and technical advice.

Recommendations

Complexity science is an area that is currently not used to any significant extent to model disruptive emergencies. Advances in the understanding of complexity science could lead to it making an increasing contribution in the future.

Recommendation 1 – The funding of research on complexity science should take account of the potential benefits on predicting and managing disruptive emergencies.

The probabilistic forecasting of many types of disruptive emergencies (particularly hazards) relies on a good understanding of the science and large data sets. There is potential for significant advances in the accuracy of such forecasts.

Recommendation 2- DG Research and Innovation to encourage collaborative research and data sharing to support hazard forecasting.

The risks of disruptive emergencies (particularly threats) are often primarily based on current data and past trends. Given the high levels of uncertainty, in what is now a complex and interdependent world, it is important that FLA are also used to assess risks.

Recommendation 3- DG Research and Innovation should promote the use of FLA for anticipating risks

The disruptive emergencies that often cause the greatest problems and damage to organisations' reputation are those with a high impact and a low probability. It is difficult to justify large investments to reduce these risks; and in most cases there are not robust methods for assessing the likelihood of an even occurring.

Recommendation 4- DG Research and Innovation should encourage research on the assessment of low likelihood high impact events.

It is understood that DG Research and Innovation will be creating a Strategic Foresight Unit. Foresight, particularly horizon scanning, plays an important role in anticipating and planning for future disruptive emergencies.

Recommendation 5 – The remit of the proposed Strategic Foresight Unit should include foresight on future disruptive emergencies.

Research related to the management of disruptive emergencies is funded by DG Research and innovation. The potential very high social and economic cost of emergencies means that such research can result in large benefits.

Recommendation 6 – DG Research and Innovation should consider further encouraging application for research aimed at increasing the understanding of and ability to manage disruptive emergencies.

Responding to disruptive emergencies generally requires an assessment of a number of critical scientific and technical issues. The lack of good advice on these issues has been shown to significantly increase the impact of emergencies.

Recommendation 7 – DG Research and Innovation should explore with the EU Chief Scientific Advisor how best to support scientific and technical advice on the response to and recovery from disruptive emergencies.

Acknowledgments

I would like to acknowledge the helpful advice given by the EFFLA Committee and those I consulted while undertaking this project. However, all the comments and views expressed are my own and should not be seen as representing the policy of DG Research and innovation, EFFLA, or any of those individuals or organisations I consulted.

1. The role of FLA to anticipate disruptive emergencies

This section introduces the eight FLA discussed at the EFFLA meeting on 22 November 2012.

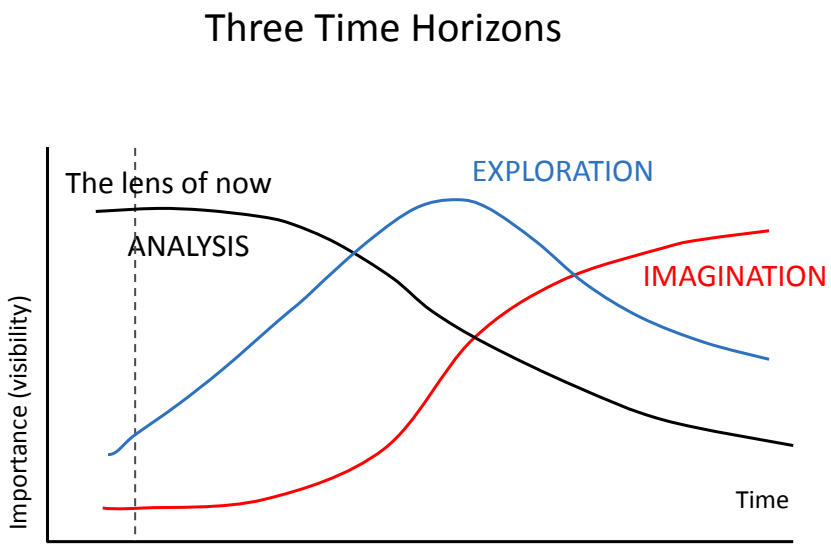
Horizon scanning

Horizon scanning is a structured evidence gathering process that forms a 'building block' for most FLA. For example, it provides input the drivers' analysis, producing roadmaps and scenario planning. However it is also a valuable tool on its own that has an important role in anticipating and planning for future disruptive emergencies. Robust horizon scanning is a critical component of achieving future resilience.

It is important to have an agree scope for the horizon scanning and a structure for the analysis and coding of the data. It is also important to look ahead beyond usual timescales; look across beyond usual sources; and look around and beyond usual cultures. This takes the research beyond a 'single expected future' to a 'range of possible futures.' The steps in a typical scanning exercise include:

1. Gaining an understanding of the 'audiences' requirements and perspectives
2. Compiling and reviewing existing scanning databases (of which there are many)
3. Undertaking supplementary scanning to get additional data and fill gaps
4. Review the data, often including a working or online consultation
5. Analyse and classify the results
6. Synthesis and reporting of the results.

A useful model for horizon scanning is the 'three horizons' as below:



The three horizons are:

1. The first horizon is the **current dominant model** (black) or 'business as usual'
2. The second horizon is the **emerging issues** (blue) that will dominate at some stage in the future. The distance into the future will be a function of the rate of change in the sector concerned.

3. The third horizon is the **weak signals** (red) that could become dominant is some possible time in the future. These are the most difficult to forecast, as out of a large number of weak signal it is often hard to judge which may become increasingly important.

An example of a transition from a weak signal to an important 'disruptive' influence is the work of Gene Sharpe[1]. This addresses how people can prevent and destroy dictatorships and became a 'manual' for the 'Arab Spring' as outlined in the following case study.

Gene Sharpe – From Dictatorship to Democracy

In 1993 Gene Sharpe wrote a guide to non violent revolution titled 'From Dictator to Democracy.' This was based on work he was doing in relation to Burma. At this time it would have been a very weak signal and would have been in the **imagination** category of scanning. In 2000 ideas from the book were used to help bring down Milosevic and Serbia, so it would have become **exploration** for scanning. For those looking for internal disruption with the potential to challenge leaders it would be something to keep a watch on. In 2009 it was used as evidence to prosecute protestors in the 'Green Uprising' in Iran. The prosecutors made references to 100 of the 198 methods in the book. At this point it had become part of the **analysis** phase of horizon scanning and any dictator should have been alert to the non violent tactic that could be used against them. So when the 'Centre for Applied Non Violence' was established and made contact with Egypt, the Government should have had warning of potential measures that may need to plan for. Other countries should also have been alerted to potential drivers of non violent revolution. In 2011 Arabic copies of the book were widely circulated in Egypt and it was used in Tahrir Square as a policy manual for the revolution. It had therefore gone from a weak signal in 1993 to one of the significant driver for revolution by 2011.

Horizon scanning is an important tool for assessing future disruptive emergencies. The above case study could have alerted the EU about the potential for an 'Arab Spring.' The following are some examples of how this could have been applied:

- Attacks on infrastructure by al Qaeda outside EU, signalled potential change in tactics within the EU
- The 'Stuxnet' computer worm was a warning of potential attacks on industrial systems. It is also suspected to have opened the door to State sponsored activity of this type
- The increasing links between organised crime and terrorist groups suggest new types of future threat
- Changing global supply chains as efficiency increases suggests reducing future resilience
- Concern around genetically modified crops can be extrapolated to other future technologies.

Horizon scanning should act as a radar system for future disruptive emergencies. It is therefore a key tool in anticipating and planning for future events so that they can be prevented or mitigated.

[1] From Dictatorship to Democracy- A conceptual framework for liberation, Gene Sharpe, Fourth U.S. Edition, The Albert Einstein Institute, May 2010

Drivers analysis

Drivers of change are major forces or trends that will shape the future environment for disruptive emergencies. They cover society, technology, economic, environmental and political forces. Horizon scanning is commonly part of undertaking drivers' analysis. Drivers can be used to identify future opportunities and challenges.

If drivers are being used to develop scenario (see below) it is the drivers that have the greatest impact and level of uncertainty (where there could be a range of significantly different outcomes) that are important. If drivers are being used to determine the future risks from disruptive emergencies it is those that have a high impact and likelihood of occurring that are important. It is therefore vital to be clear whether the objective of the drivers' analysis is to provide data for scenario planning or for risk analysis.

There are a wide range of databases and reports[2] that can be used as a starting point for a drivers' analysis. It is usually necessary to complement these data with further horizon scanning and possibly also interviews.

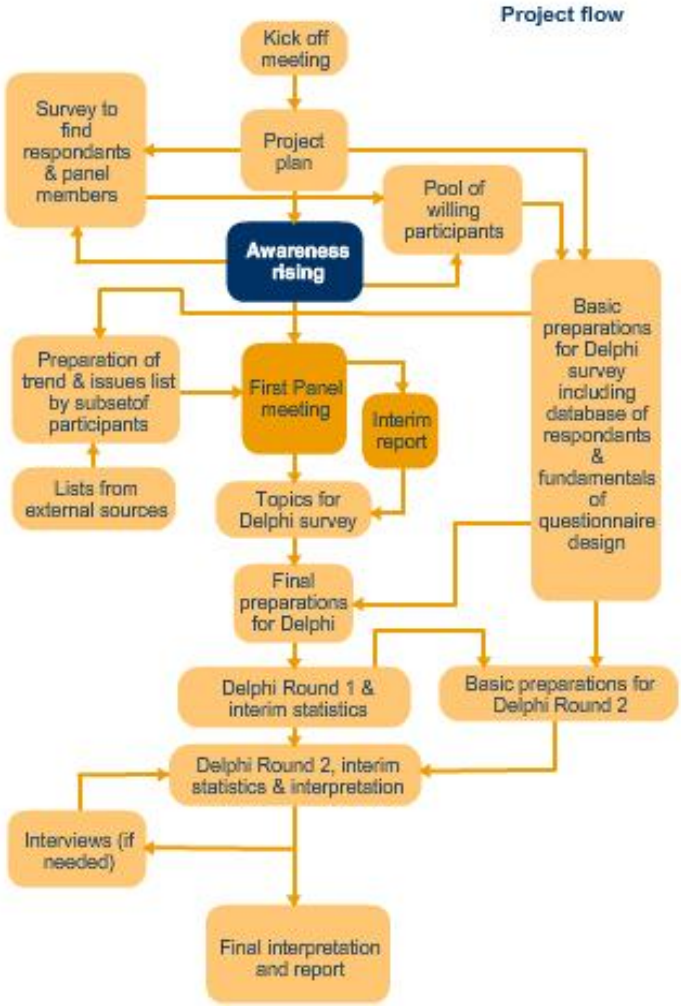
A process is required to assess the impacts and likelihoods of the drivers. The options for this include internal analysis, interview data, workshops and surveys (usually online). Some of the drivers that are likely to be important for disruptive emergencies in the EU are as follows:

Potential drivers of disruptive emergencies
Demographic and ageing populations
Wealth distribution and inequalities
Generational changes in values and identity
Increasing education levels
Lifestyle 'diseases' and pandemics
Urbanisation and migrant flows
Levels of dissent inside and outside EU
Fraud and organised crime
War, terrorism (including increasing links with organised crime) and insecurity
Climate change and more extremes of weather
Major natural hazards (volcanoes, earthquakes etc)
Competition for energy and resources
Accelerating changes in technology
Increasing complex and interconnected critical infrastructure
Pervasive computing and data
Cyber crime (including state sponsored)
International markets and supply chains
Global economic growth trends and financial stability
The BRICs and emerging powers
Space weather

[2] Foresight of new and emerging risks to occupational safety and Health associated with new technologies in green jobs by 2020, Phase 1 Key drivers of change, European Agency for Safety and Health at Work

Delphi

The Delphi method[3] was developed by RAND during the 1950s to assess technological capabilities during the Cold War. It is a consultation process involving a wide range of 'experts', who answer standard questions. An outline of a typical Delphi process is as follows[4]:



More recently the Delphi method has also been used to support strategic foresight on social issues. Studies have shown that caution is recommended when applying the Delphi technique, particularly outside the assessment of technology[5].

It is vital that the selection of respondents is carefully considered as many of the critical issues come at the boundaries of technology, which can open up a whole new range of potential vulnerabilities. For example, SCADA (supervisory control and data acquisition) systems have been widely applied to support process, including critical national infrastructure. This has created a wide range of new risks, which may not adequately appreciate by process engineer.

[3] The Delphi Method: Techniques and Application, Harold A Linstone and Murray Turoff (Free internet edition http://is.njit.edu/pubs/delphibook/)
[4] Professor Denis Loveridge, Manchester Institute of Innovation Research/Prest
[5] Delphi Assessment: Expert Opinion, Forecasting, and Group Process – A report for United States Air Force Project Rand, H Sackman 1974

The Delphi method also leads to a consensus view, whereas many risks are caused by the less likely consequences of a particular development or path of action.

The Delphi approach is valuable for considering how future scenario could evolve and may form part of a risk assessment. However, if it is used on its own, there is a significant danger that certain risks may be underestimated or missed.

Scenarios

Scenarios describe how 'the world' might look in the future and possible paths (timelines) from now to the future. They are based on an analysis of the drivers of change and should be engaging, compelling and credible. They must also have an internal logic and consistency, although caution is needed that scenarios are not discounted because they do not fit current assumptions of the future. These 'surprising' scenarios can often be the most important because of the insights that they bring. It is vital that a scenario is not treated as a prediction or forecast, as the future is likely to be formed from parts of different scenarios. If there are elements that are predictable these would form common elements across the scenarios.

Scenarios create an opportunity for a strategic conversation[6] and can create a shared understanding and language in an organisation. They help to identify and manage risks and plan responses. The events on the timeline can also act as early warning indicators and make it more likely that future events are anticipated.

It is likely that there will be significant difference in the nature and impacts of disruptive emergencies between scenarios. There is widespread use of scenarios for planning humanitarian assistance in less developed countries; but there is scope for greater use of scenarios for disruptive emergencies in developed countries.

Over twenty different methods exist for generating scenarios[7]. Each has strengths and drawbacks, depending upon topic, participants, and audience[8]. One of the most commonly used approaches in management and policy strategy for scenario planning has the following stages:

1. Defining the scope of the scenarios (focal question) and setting up the project;
2. identification and analysis of drivers;
3. identification of predictable elements and critical uncertainties;
4. construction of the scenario axis or space;
5. selection of the scenarios;
6. creation of the scenario narratives; and
7. communicating the scenarios.

[6] Scenarios: The Art of Strategic Conversation, Kees van der Heijden, John Wiley and Sons, 10 March 2011
[7] The current state of scenario development: an overview of techniques, Peter Bishop, Andy Hines and Terry Collins, Foresight Vol. 9 No. 1 2007
[8] Scenario Planning, Gill Ringland ,Wiley

A powerful way of communicating the difference between scenarios is though the use of 'stories.' The following example is from a series of scenarios on the English natural environment out to 2060[9].

William Campbell, London, aged 75 (born 1985)

"Working in London at the turn of the century, we were driven by money, just as we are today. Private companies had taken over most services by the time I was a teenager so, for me, the world has always revolved around wealth. Personally, it's meant I've had a happy life, with everything I need."

"We've benefitted from progress. Back in 2010, people were still sceptical about robots but now they staff coal mines, factories and hospitals; they produce food and generally keep things going. They also weren't keen on the idea of chips to boost brainpower, but I've had treatment to increase my memory and pass on knowledge. I think everyone should get enhanced - it helps drive the country's economy."

"What's shocked me most over the years are the big unpredicted events, both natural and man-made, that really changed the world. I remember the September 11 attacks in 2001, the Indian Ocean tsunami in 2004, and the Credit Crunch in 2008. But the heat-wave of 2020, and the widespread drought it caused, was on a completely different scale. Food supplies shrank very quickly, but our country was fortunate as we could buy food from abroad to deal with shortages."
"In 2025, a few years after the drought, we invested heavily in biotechnology to mass-produce food that could tolerate little water. Things seemed to be going well, but when oil prices reached $300 a barrel that year we finally realised energy wasn't always going to be on tap. Lots of cars were converted to run on electricity and we had to build 20 nuclear power stations in just a few years. By 2040, electricity from nuclear power was cabled to the UK from countries including Turkey and Slovakia."

"Manufacturing was advancing dramatically, and in 2042, the International University won several Nobel prizes for developing nanotechnology to improve food, medicine and energy. More businesses adopted this new way of making things, particularly as it merged with developments in brain science, computers and biology."

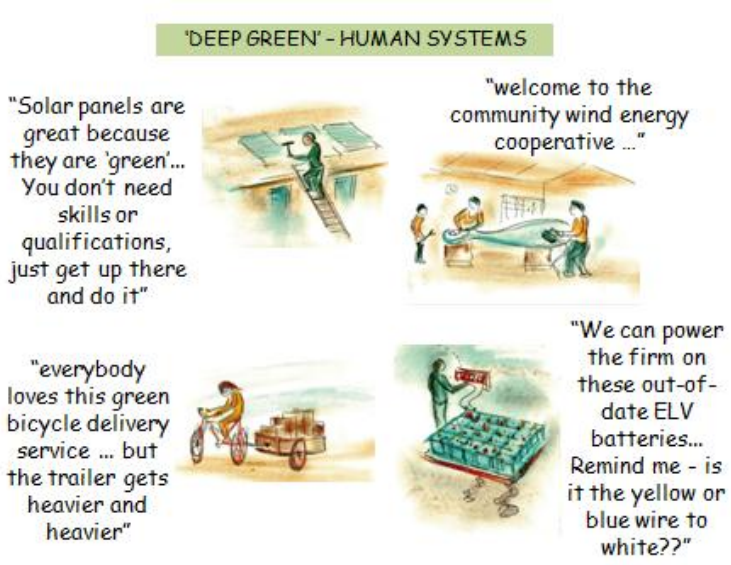
"In 2050, the London and east coast floods shocked everyone. I was still working in the City and joined a consortium to build up the sea defences along the North Sea. As a nation, we celebrated our progress at the 2051 Festival of Britain. This opened up our heritage and landscape to the world through high definition virtual reality which attracted 6 billion visitors from across the globe."

"Our sense of achievement suffered a blow last year when some of Britain's poorer areas needed famine relief after the sea began to die in parts of Europe, and food-production units ran out of raw materials. Food supplies were badly affected again. We were lucky that countries with a lot of resources, like Russia, bailed us out and we avoided starvation, but this really brought home how the world is changing. We'll have to pay back the Russians soon, though, or our gas supplies will be cut off."

[9] Creedy, J.B., Doran, H., Duffield, S.J., George, N.J., and Kass, G.S. 2009. England's natural environment in 2060 - issues, implications and scenarios. *Natural England Research Reports, Number 031*.

"We've always done well as a nation, but I'm worried we won't be able to feed ourselves over the next 50 years as the population continues to grow, particularly through immigration. Many problems have been sorted out, like cheap energy, but things could get a lot worse very quickly."
©Natural England

Imagery can also be a powerful communication tool[10].



Roadmaps

Roadmaps show developments into the future usually including trends and the associated applications and action plans. They are most commonly used for studying longer-term developments in science and technology.

A road mapping exercise often starts with a scoping exercise that will explore the areas to be investigated and the time horizon. Following this the drivers of change need to be considered, usually through a combination of desk research and consultation or workshops. The drivers would then be prioritised to identify those that are critical to the direct of the roadmap.

At the heart of a roadmap is a timeline, often based around the cycles and developments of technology. This also needs to include the key actors, or events, that are required for the timeline. Action plans and the associated resource requirements would then be added to complete the roadmap. Caution is needed on the timing of events in the roadmap, as this is generally to most difficult element to predict.

The Delphi process discussed earlier can be a useful part of roadmap development, particularly for those related to technology developments.

[10] Foresight of new and emerging risks to occupational safety and Health associated with new technologies in green jobs by 2020, European Agency for Safety and Health at Work

Caution is needed to avoid a roadmap being seen as a forecast of the future. There are often drivers or events that will result in a roadmap diverting onto a different path. In some cases a roadmap could also be halted by changes to demand or regulatory impacts. A common approach is to build a set of roadmaps for a range of developing scenarios. The value of this is that it helps to explore the potential range of future developments. For disruptive emergencies it also helps to identify the potential worst case scenario, the potential paths towards these and the points were actions can be taken to reduce the future risks.

An example of where roadmaps have played an important role is assessing future risk is in telecommunications. The modernisation, including 'next generation networks, has resulted in a major change in the nature and scope of the networks. The improvements in performance and efficiency have resulted in less redundancy and diversity in the networks. The consequence of this is less resilience. This trend is likely to continue until see properly functioning markets where a value is placed on resilience.

History

When undertaking strategic foresight it is generally good practice to look back about twice as far as the project is looking forward. It is vital to understand the starting position and what led to it before considering possible future scenarios. Looking back will also gives an indication of the potential levels of change, most of which will be increasingly rapid in the future.

Looking at the history can also be useful in an organisation. For example, when I established the Future Unit in the Department of Trade and Industry (DTI) in 1998, one of the initial acts was to get a historian to review the past[11], including a wide literature review and interviews with the past Secretaries of State and Permanent Secretaries. The report highlighted the scale of change since 1970 and what had been handled well and what less so well.

On disruptive emergencies there are important lessons to be learnt from past events. These include undertaking robust lessons learnt reviews after all incidents. There are important lessons to be learnt from even the best managed emergencies. However, it is equally important to recognise what has changed.

Case study: Foot and Mouth disease

The 2001 foot and mouth disease (FMD) epidemic was one of the largest in history, costing the UK economy at least £8 billion[12].

Careful account was taken of the lessons learnt from the 1968 Northumberland Report on the 1967-68 epidemic. Some of these lessons were still relevant but there had been changes to farming practice that were not fully recognised. In particular, the nature and extent of sheep movements was fundamentally different. This contributed to the wide dispersal of the disease before its identification. The relationship between agriculture and other sectors of the rural economy were

[11] From Ships to Silicon: A Recent History of DTI, Report completed for: The Future Unit Department of Trade and Industry, 28 March 2000, Dr Janet Saunders

[12] Foot and Mouth Disease 2001: Lessons to be Leant Inquiry Report, London, The Stationary Office, 22 July 2002

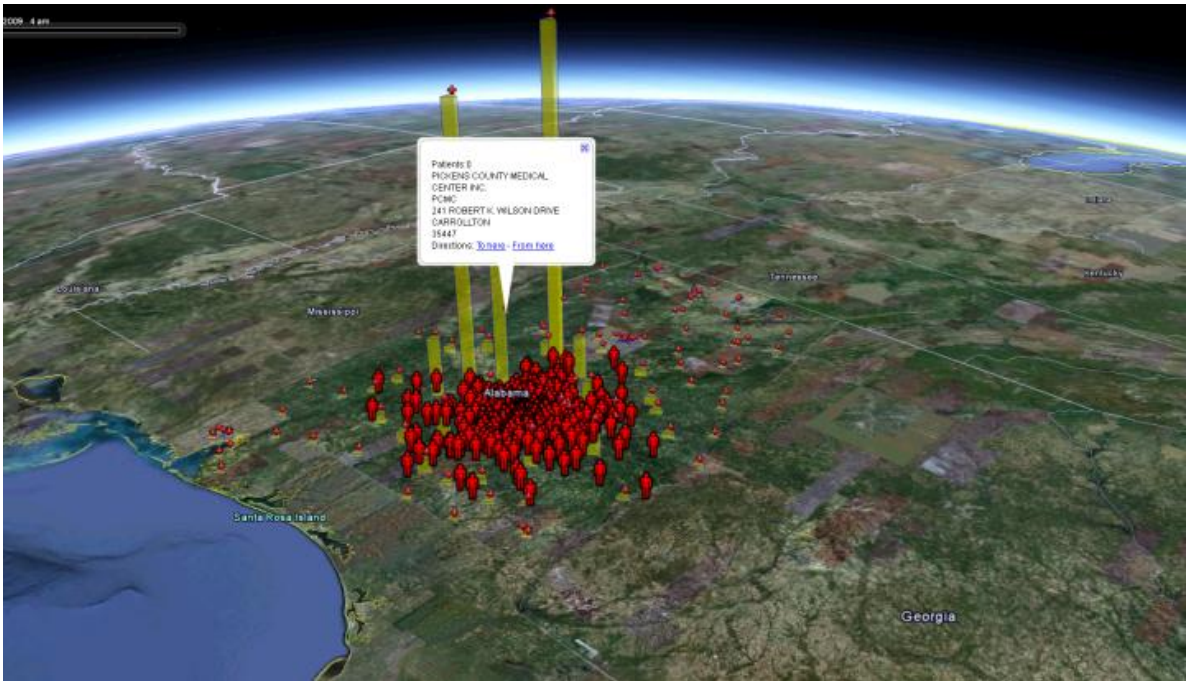
also not fully recognised.

This case demonstrates that in addition to understanding past events it is vital to have a full understanding of ongoing changes. It is also important to understand what is driving changes and the interactions with other sectors of the economy.

Modelling and systems thinking

System dynamic models were originally developed in the 1950's. They are now increasingly used, as a result of advances in computing power and developments in modelling software. However, it is still an area that relies significantly on specialist modelling skills.

Models are used to simulate future disruptive emergences, to assess the potential impacts and to manage events. They can also be a powerful tool for reviewing options, particularly if appropriate visualisation methodology is applied. The example below[13] shows a model of a flu pandemic.



Before commencing modelling, a clear understanding is needed of the required scope of the model and how it is to be used. It is then important to determine the components that need to be included in the model and the relationships between them. Key to developing robust models is effective engagement with experts and the data collection and analysis. If looking into the future, it is also important to ensure that the underlying assumption will remain valid and there are no 'tipping points.'

One of the issues on using models is that the 'customers' for the results may place too high dependence on them, beyond the prudent bounds of their reliability. It is my common experience is that the outputs of models are seen as the 'truth,' as they are based on a

[13] Business Laboratory, www.business-laboratory.com

mathematical foundation; whereas, other foresight methods such as horizon scanning as seen as 'imagination' and therefore thought of as less valid in assessing future situations. In reality they are complementary tools and models should equally be used with caution.

If developing models or being presented with results from them it is recommended that the following questions are asked:

1. Is it possible to define how a system works, both now and in the future?
2. Is the theory underpinning the model sound?
3. Will the underlying assumptions remain valid?
4. Is the system modelled subject to unintended consequences?
5. Are there 'tipping points' that will fundamentally change the underlying assumptions?
6. Does the model accurately represent the starting conditions?
7. Does the model accurately model the past (hind-casting)?
8. Can the model be tested through short term forecasts?

There is likely to be accelerating increases in our scientific understanding, quality and quantities of data, computation power and developments of modelling tools. This will lead to increasing applications of system dynamic modelling for the anticipation, response and recovery from disruptive emergencies level of data. This will allow more accurate probabilistic forecasts to be generated.

Complexity science

Complexity science is not a single theory and is highly interdisciplinary. Rather than focusing on the component of a system it focuses on the interconnections between them. It can be used to aid the understanding of mechanisms through which unpredictable, unknowable and emergent changes may happen. It also recognises that with complex systems the best course of action may be highly context dependant.

Most analysis of the risks from disruptive emergencies focuses on an individual event, such as a large scale flood, and looks at the likelihood of this occurring and the wide range of potential impacts. In many cases system dynamic modelling will be used as described above. However, disruptive emergencies can be caused by a wide range of interconnected element and random events, with outcomes that cannot be predicted.

There is increasing understanding of the underpinning theories of complexity science and the potential applications to real world problems. It is likely that as the science progresses it will have an increasing role to play on anticipating and managing disruptive emergencies.

The differences between systems thinking and complexity science are summarised in the following table:

Systems thinking	Complexity science
Dominant rules and potential equilibrium	Tends to defy calculated equilibrium
'Control system' that guides and shapes	Possibility of self organisation
Elements of system can be understood	Elements interdependent and change with context
Rational process and predictable results	Dynamic processes defies prediction
Changes with rules based learning	Perpetual change, so learning is a constant factor

One on the current relative weaknesses in the analysis of the risks from hazards is the ability to analyse the complex web of interdependences associated with many risks, particularly those involving critical national infrastructure. The causes and networks associated with threats are also increasing in complexity, including growing links between terrorist and criminal activities. Complexity science could play a role in addressing these interdependences as the science progresses.

Recommendation 1 – The funding of research on complexity science should take account of the potential benefits on predicting and managing disruptive emergencies.

Selection of FLA tools

The choice of the most appropriate FLA tools and techniques to use for anticipating disruptive emergencies needs to take account of the particular requirements of the analysis, the data available and the nature of the emergency being considered. There may also be factors such as resource availability and data security that will impact the selection of tools.

Looking at the overall requirements for anticipating disruptive emergencies the following table summarises the potential level of application of the tools described in the above sections. However, these ranking should only be seen as indicative and the selection should be informed by an understanding of the tools and the specific requirements of the case.

FLA tool	Likelihood	Impact	Planning	Response
Horizon scanning	High	Medium	Medium	Low
Drivers analysis	High	Medium	Medium	Medium
Delphi	Low	Medium	Medium	Low
Scenarios	Medium	High	High	Medium
Roadmaps	High	High	High	Medium
History	Medium	Medium	Medium	Low
Modelling	High	High	High	High
Complexity science	Low	Low	Low	Low

2. The role of FLA to reduce future risks from disruptive emergencies

The risks from disruptive emergencies are a result of a combination of the **likelihood** of the emergency occurring and the potential **impacts.** There is a relationship between these, as for most emergencies the likelihood of high impact events is less than for corresponding low impact events. For undertaking an assessment of risks from disruptive emergencies the most common approach is to assess the likelihood of a **reasonable worst case**, which represents a challenging emergency, after highly implausible emergencies have been excluded.

There are many possible kinds of emergency and the risks the EU faces are continually evolving, along with the measures needed to respond to them. There are also significant variations in many of the risks, both within and between Member States.

Likelihood

The likelihood of a disruptive emergency occurring is determined for a period into the future that varies according to the nature of the event and the purpose for which the risk is being assessed. Where governments look at a broad range of hazards and threats the next five years is a typical period. However, if business or government is reviewing a major long term investment, longer periods may be appropriate. In both cases, the likelihood may vary over the period and FLA will be an important part of analysing any such trends.

An analytical approach can be used to assess the likelihood of many naturally and accidently occurring hazards, although there can be limits for new and emerging risks due to limited data. Progress in data analysis and advances in technology will lead to increasing capability to make probabilistic forecasts. The figure below shows the relative ability to give probabilistic forecast for a range of hazards both now and in 2040[14]

[14] Foresight Reducing Risks of Future Disasters: Priorities for Decision Makers (2012). Final Project Report. The Government Office for Science, London

	Ability to produce reliable forecasts					
	Now			2040		
	Spatial	Magnitude	Temporal	Spatial	Magnitude	Temporal
Geophysical hazards						
Earthquakes	2	1	1	3	2	1
Volcanoes	3	2	2	5	3	3
Landslides	2	2	1	3	3	2
Tsunamis	2	2	1	3	3	2
Hydrometeorological hazards	6 days ahead					
Storms	3	3	4	5	5	5
Floods	3	3	4	5	5	5
Droughts	5	5	5	5	5	5
Hydrometeorological hazards	6 months ahead					
Storms	2	2	2	3	3	3
Floods	2	2	2	4	4	4
Droughts	2	2	2	4	4	4
Infectious disease epidemics						
Known Pathogens	2	5	2	4	5	4
Recently emerged pathogens	1	4	1	2	4	2
Pathogens detected in animal reservoirs	1	1	1	2	3	2

Low ability 1 2 Medium ability 3 4 High ability 5

Improving hazard forecasting will require significant research and the collect of large volumes of data.

Recommendation 2- DG Research and Innovation to encourage collaborative research and data sharing to support hazard forecasting.

For determining the likelihood of most types of threat, an approach based on data on both the intent and capability of planning and executing the proposed event is generally required. Account also needs to be taken of the vulnerability of the intended targets. A significant part of the risk assessment will be based on 'intelligence' but it is also vital to undertake FLA to determine how the treat may change in the future. However, it is difficult to determine the relative weightings to give to 'intelligence' and FLA.

Case Study: al-Qaeda threat to critical national infrastructure in the UK

In early 2005 when the National Risk Assessment (NRA) was being prepared the intelligence supported the risk of attacks from al-Qaeda on crowded places (including transport.) The intent was to cause loss of life, or serious injury, to large numbers of people; and a number of such events formed part of the NRA.

Horizon scanning suggested that al-Qaeda may also wish to engage in attacks on critical national infrastructure (CNI) in the future. However, at that time, there was no evidence to support the intent

to carry out any such attacks in the UK. The view was that their intent would continue to be directed towards causing death and injury, rather than economic disruption. It was argued that a risk for which there was no supporting intelligence should not be included in the NRA. However, there was also a counter argument that the NRA needed to anticipate future risks and changes to al-Qaeda's intent, given that they had the potential capability. This caused significant debate on how to handling the results of FLA for which there was no supporting intelligence.

It was concluded that attacks on CNI should be included in the NRA and appropriate measures taken to manage them. A potentially successful attach was subsequently detected, which would have caused major disruptions and economic impacts over a number of months.

This incident highlighted the requirement to include FLA in risk assessment and to take careful account of the results, even where there is no supporting intelligence. However, this does not weaken in any way the requirement for the assessment of intelligence material.

FLA contributes toward anticipating, rather than simply responding to, emerging risks.

Recommendation 3- DG Research and Innovation should promote the use of FLA for anticipating risks

Impacts

The impacts of disruptive emergencies are generally based on a reasonable worst case scenario. These scenarios are then used to inform the resilience planning assumptions. The nature of the impacts will vary according to the type of emergency but it recommended that the following are considered[15]:

Fatalities – that are a directly attributed to the emergency;
Illness or injury – caused to people over the period following the onset of the emergency;
Social Disruption – this can take different forms including the inability to gain access to healthcare or schools, interruptions to essential services such as food, water and fuel and the need for evacuation of individuals;
Economic harm – the effects on the overall economy, excluding the cost of repairs. It is also important to ensure that it is only lost, rather than displaced, economic activity that is included; and
Psychological impacts – including widespread anxiety, loss of confidence or outrage that communities may experience.

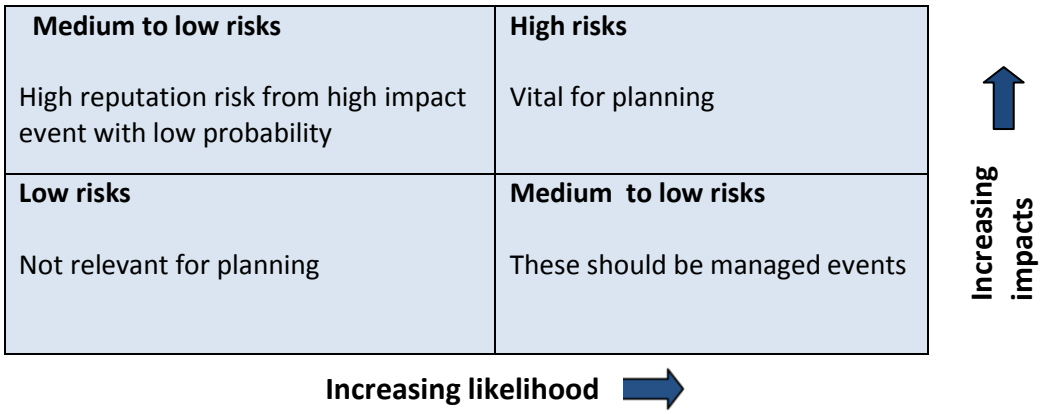
These impacts can arise from event outside the EU, such as disruption to essential supplies, or changes to policy as a result of external emergencies. They can also be emergencies that originate outside the EU but then have a direct effect with the EU, such as a health pandemic.

It is possible to put a monetary value to all the impacts, except for elements of the psychological ones. Most emergences will have a range of different impacts, so it is important to give careful consideration to the respective weightings.

[15] National Risk Register of Civil Emergencies, 2012 Edition, Cabinet Office, London Ref:408697/0212

Managing the Risks

The risk is a combination of the likelihood and impacts of a given emergency. It is often helpful to combine the risks into a graphical representation, such as below:



The high risk events are the critical events for the risk management. The first stage in managing these is to draw up the **resilience planning assumptions** based on a reasonable worst case scenario. This should provide the details of the emergency, including the impacts, warning times, potential concurrency across EU member states and regional variations. The resilience planning assumptions should then be considered by those that have a direct or indirect role in managing the emergency. Together they should assess what plans and resources need to be in place to effectively manage the emergency. This should include external international support or military assistance. The required plans and resources should then be compared with those that are available and assessments made on the capability to respond. Decisions can then be made on the priorities for responding to any gaps in capability or measures to increase resilience.

For major disruptive emergencies it is also important to undertake exercises. However good the planning, there will invariably be important lessons learnt from exercises. They are also vital training for those that will be engaged in managing future emergencies.

The medium risk emergencies with a high impact but a lower relative likelihood cause particular management problems. The case for investment to reduce the risk or increase resilience is weaker than for the high risk events despite the level of the impacts being similar. They therefore present high reputation risks for both governments and business. Society sees it as the role of government to safeguards us all against such events; and major events, such as the Deepwater Horizon oil spill, can cause major economic and reputation damage to business. In many cases it is also very difficult to make an assessment of the likelihood of such events, as often there is limited data and in some cases the event may not have previously occurred. There has been some research on the relationship between more likely low impact event and high impact events but often the judgement of experts has to be relied on. This is an area where greater understanding is required.

Recommendation 4- DG Research and Innovation should encourage research on the assessment of low likelihood high impact events.

The medium risk emergencies with a high likelihood but lower relative impacts should be routinely managed by both governments and business. However, they are still important as they can form part of a cascade of events leading to a major emergency.
Particular measures are required to counter the risks from terrorism. The UK has a programme to address both the immediate threats and the longer term factors that enable terrorist groups to grow and flourish. This counter-terrorism strategy (CONTEST)[16] has four work steams:

Pursue: to stop terrorist attacks;
Prevent: to stop people becoming terrorists or supporting terrorism;
Protect: to strengthen our protection against a terrorist attack; and
Prepare: to mitigate the impact of a terrorist attack.

It is important to recognise that disruptive emergencies rarely occur in isolation. There is a high level of interdependence between emergencies with national infrastructure often having the most complex networks of dependence. For example, the loss of an electricity transmission system will rapidly result in major impacts on most aspects of society. This vulnerability has increased with the development of more advanced and interconnected economies.

There are also important interconnectivity issues for business in Member States. Lean business models, operational consolidation and extended supply chain networks across the globe have become the norm for many companies. Such companies often source parts from low cost overseas markets in Asia, where the risks of natural disasters are higher. However, if resilience is part of the planning, global supply chains can help to manage these risks.

High risk disruptive emergencies

This project has not included an assessment of the potential risks facing the EU. However, based on literature reviews the following are suggested as areas to be included in EU risk assessments:

Hazards	**Threats**
Human disease (pandemic) Flooding (coastal and inland) Major fire (urban and forest) Volcanic eruptions Severe space weather Animal disease (Zoonotic and non-zoonotic) Major industrial accidents Major transport accidents Disruptive industrial action Public disorder	Malicious attacks on crowded places Attacks on infrastructure Attacks on transport systems Unconventional attacks (chemical, biological, radiological or nuclear) Cyber security (included 'state sponsored' activities)

[16] CONTEST – The United Kingdom's Strategy for Countering Terrorism, Presented to Parliament July 2011, Cm 8123

Many of the above risks, such as human disease pandemics, could apply across all EU member states; while others, such as volcanic eruptions, are location based although the impacts could be far reaching due to large number of displaced people, or airborne pollution.

For individual member states some of the highest risks are likely to vary due to regional variations. It is important to have data on specific levels of risk, such a detailed flood risk models. It is also important to identify critical points (such as part of infrastructure) so that measure can be taken to increase their protection and resilience.

3. The potential role of DG Research and Innovation on the preparedness for and resilience to disruptive emergencies

Background

The European Commission has a long record of initiatives to support the preparedness for and resilience to disruptive emergencies caused by both threats and hazards. This section provides a brief overview of some of the key elements and suggests potential roles for DG Research and Innovation.

On **threats** the work is now led by the Vice-President, High Representative of the Union for Foreign Affairs and Security Policy (Catherine Ashton). The aim of the EU internal security policy is to protect people and the values of freedom and democracy, so that everyone can enjoy their daily lives without fear.[17] The Lisbon Treaty[18] created the Standing Committee on Operational Cooperation on Internal Security (COSI), which considers threat assessments and priorities. It manages overseas cooperation between the EU agencies and bodies involved in internal security, including Europol, Frontex, Eurojust, Cepol and Sitcen. These activities seek to build on those undertaken by EU member states.

Hazards are covered by the Community Civil Protection Mechanism (CCPM) which heightens Community cooperation in cases of national emergency and in situations where there is an imminent threat of a major emergency. It was first established in 2001 and provides support to Member States; and any other country in the world affected by a disaster can also ask for the support of the CCPM. In February 2009, the European Commission adopted a Communication on a Community approach to the prevention of natural and man-made disasters[19] setting out an overall disaster prevention framework and proposing measures to minimize the impacts of disasters. In December 2011, the European Commission proposed legislation to strengthen European co-operation in civil protection to provide a more efficient, effective and rapid response to disasters as well as enhanced prevention and preparedness actions. These proposals established the capability for pre-planned assistance on disruptive emergencies and laid the foundations of a comprehensive disaster management policy for the EU. It also established a 24/7 Emergency Response Centre[20] (ERC) within DG Humanitarian Aid and Civil Protection (ECHO.)

There are also a number of sector specific activities, such as the European Risk Observatory (within the European Agency for Safety and Health at work) which undertakes FLA to identify new and emerging risks to workers.

[17] Draft Internal Security Strategy for the European Union: "Towards a European Security Model," Council of the European Union, Brussels, 23 February, 2010, 5842/2/10 REV2

[18] Treaty of Lisbon amending the Treaty on European Union and the Treaty establishing the European Community, signed at Lisbon, 13 December 2007

[19] Communication on the internal security strategy addressed the need for an integrated approach between security and other policies. COM(2009)82 final of 23.2.2009

[20] Decision of the European Parliament and of the Council, on a Union Civil Protection Mechanism, Brussels, 20.12.2011 COM(2011) 934 final

Possible roles for DG Research and Innovation

Strategic foresight

In order to implement the measures required to provide the required levels of resilience and protection against disruptive emergencies it is important to anticipate, as far as possible, the changing nature of both threats and hazards.

These are a wide range of drivers of change that will influence future disruptive emergencies. For example, the internet has transformed many business activities but at the same time created new opportunities for organised crime. There are also balances between competing trends, such as on weather forecasting where robust observation data, increasing computing power and advances in the science have increased to ability to produce more detailed and accurate forecasts; but this is countered by the increasing range of variation in the weather, as a result of climate change.

The EFFLA Policy Brief No1 proposes that a dedicated Strategic Foresight Unit or hub is set up in DG Research and innovation.[21] This would work closely with Member States' foresight and horizon scanning activities and inform the top-level of decision making in the EC. The need for strategic foresight to understand the future risk in an increasing uncertain, complexity and interconnectivity world has probably never been greater and the Strategic Foresight Unit could make an important contribution towards this.

Recommendation 5 – The remit of the proposed Strategic Foresight Unit should include foresight on future disruptive emergencies.

Research Focus

There are major programmes of research being conducted by Member States aimed at increasing the understanding of and ability to manage future disruptive emergencies. DG Research and Innovation also funds major programmes through the Seventh Framework Programme and the planned Horizon 2020 commencing in 2014. There is significant potential for advances across all sectors of science and the financial and social returns from better anticipation and management of disruptive emergencies can be very high. For example, the 2001 outbreak of foot and mouth disease was estimated to have cost the UK economy at least £8 billion[22].

Recommendation 6 – DG Research and Innovation should consider further encouraging application for research aimed at increasing the understanding of and ability to manage disruptive emergencies.

Scientific advice for emergency response

There are many requirements for an effective response to an emergency but a rapid and robust understanding of the scientific issues is generally a central part of this. The lack of such data can have significant consequences. For example, it was not until a scientific advisory group was established under the Chief Scientific Advisor that the above foot and

[21] Enhancing strategic decision-making in the EC with the help of Strategic Foresight, European Forum for Forward Looking Activities, Policy Brief No.1 (April 2012)

[22] Foot and Mouth Disease 2001: Lessons to be Leant Inquiry Report, London, The Stationary Office, 22 July 2002

mouth outbreak started to be brought under control. If this had been available from the very start of the outbreak there could have been very large savings.

The UK now has a Scientific Advisory Group for Emergencies (SAGE)[23], with Scientific and Technical Advisory Cells (STACs) at the local level. These arrangements are managed by a secretariat in the Government Office for Science, in the Department for Business Innovation and Science. The UK's Chief Scientific Advisor is responsible for SAGE, supported by eminent experts. There are set procedures for activating SAGE to ensure coordinated scientific and technical advice during emergency response and recovery. Examples of when SAGE was activated include the 2009 H1N1 influenza pandemic, the 2010 volcanic ash disruption and the Fukushima nuclear incident in 2011.

Case study: SAGE activation – Fukushima nuclear incident

SAGE was activated to provide advice to Cabinet on the implications of a potential radioactive release from the Fukushima plant for British Nationals in Japan. It worked with key government departments, agencies (Health and Safety Executive Nuclear Directorate, Heath Protection Agency, Met Office and others), external academics and international partners to understand the situation on the ground.

A range of possible scenarios were developed to assess their impacts based the likelihood and impact of the reasonable worst case scenarios, including possible core meltdowns in the damaged reactors. Its advice was that there was no significant radiation hazard in Tokyo that would lead to the need to evacuate.

A number of teleconferences were held with the UK Embassy in Tokyo, providing information on the implications of on-going events and answering questions from members of the community. The transcripts of these teleconferences are posted on the Embassy website[24]. This advice attracted significant interest from both National and International press. The SAGE advice was seen as the authoritive source of science information by the broader expat community in Japan and was recommended as an important source of advice by the Japanese authorities.

The advice provided by SAGE was greatly appreciated in Japan.

The EU Chief Scientific Advisor's (Professor Anne Glover) mandate includes reference to being "involved in strategic emergency planning." There may be useful lessons to share from the experience of SAGE.

[23] Enhanced SAGE Guidance, A strategic framework for the Scientific Advisory Group for Emergencies (SAGE), Civil Contingencies Secretariat, Cabinet Office, October 2012

[24] http://ukinjapan.fco.gov.uk/en/news/?view=News&id=572797982

Recommendation 7 – DG Research and Innovation should explore with the EU Chief Scientific Advisor how best to support scientific and technical advice on the response to and recovery from disruptive emergencies.

Conclusions

This report is based is based on the authors experience, on desk research and on interviews with experts. It has not been possible within the scope of this project to undertake an analysis of the current capability of DG Research and innovation to assess the future risks from disruptive emergencies, or to contribute toward the response and recovery from them. The recommendations in this report need to be considered within the context of the current capability.

The views in this report are those of the author and should not be taken as representing the views of any of those consulted as part of this project, nor any individuals and organisations referred to in the report.